

Academic Paper

When is Neuroscience Stretched Too Far? A Spotlight on ‘Coaching to the Pea’

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Abstract

We provide a critical review of a foundational article in neuroscience (Boyatzis & Jack, 2018) which set out to provide the neuroscientific foundations of *Coaching to the PEA*, a coaching model. Our critique questions the validity of the underpinning neuroscientific research; the appropriateness of selectively stimulating specified brain networks; the problematic positioning of the coach working with the brain; the rhetorical effects and paradigmatic challenges of integrating neuroscientific findings alongside other sources of knowledge; the risk of reductionism and of generalising findings from limited empirical research. Our critique questions how far neuroscience can be applied in coaching.

Keywords

coaching, compassion, PEA, neuroscience, neuroreductionism, DMN

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Introduction

Neuroscience has emerged as a contemporary elixir offering seemingly unassailable truths about intrapersonal and interpersonal processes in coaching. However, reducing complex human behaviour to neuronal patterns of activity, readily manipulable by coaches, risks misinforming coaching practice. Designing and interpreting the results of neuroscientific investigations is also open to many pitfalls (Jack, Rochford, Friedman, Passarelli & Boyatzis, 2019). In this conceptual paper, we provide a critique of the neuroscientific evidence of *Coaching to the PEA* (Positive Emotional Attractor), also known as *Coaching with Compassion* (Boyatzis & Jack, 2018), arguably the most well-known, neuroscientifically informed model of coaching. Our critique highlights methodological challenges, interpretive issues, the risk of rhetoric, and broader conceptual challenges relating to reducing complex interpersonal process to identifiable and localised neuronal activity. On the basis of our critique, we argue for caution in making premature assumptions about the neuroscientific evidence-base of coaching and of the possibilities of too readily applying neuroscience in coaching.

Exploring the literature: Hopes and promises

A broad range of books has emerged in recent years advocating the relevance of neuroscience in coaching (e.g., Brann, 2015; Bossons, Riddell & Sartain, 2015; Carson, Tiers & Bickford, 2014; McKay, 2019; O'Connor & Lages, 2019; Paling, 2017; Rock & Page, 2009). Similarly, an increasing number of conceptual overviews has been published (e.g., Bowman, Ayers, King & Page, 2012; Dias, Palmer, O'Riordan, de Freitas, Habib, do Nascimento & Nardi, 2015; McKay & Smith, 2021; Puspa, 2022; Passarelli, van Oosten & Eckert, 2017; Passarelli, 2015; Riddell, 2021). Some literature goes as far as to position neuroscientifically informed coaching approaches as premium products by dint of the alleged capacity of neuroscience to have measurable neural impacts. "Brain-focused" coaching (Puspa, 2022) for example, demonstrates a "significant empirical effect on relevant functional, chemical, or structural change in the brain" (p. 78). There are nonetheless only a small number of peer-reviewed empirical papers readily identifiable in the literature (e.g., Jack, Boyatzis, Khawaja, Passarelli & Leckie, 2013; Jack, Passarelli & Boyatzis, 2023), which suggests a need for tentativeness in claiming a neuroscientific evidence base.

It is argued that there is much hyperbole in coaching and neuroscience (Grant, 2015) and in neuroscience generally (Jarrett, 2015). Nowack and Radecki (2018) note how the term 'neuro' is being added to organisational, team and individual solutions because it is considered to add scientific credibility. While supportive of the potential contribution of neuroscience in coaching, they caution readers to 'peer beyond the current rock and a hard place to discern fact from fiction and advance both research and practice' (p. 9). However, identifying what might appear to be rigorous research in coaching neuroscience is problematic when an article (Boyatzis & Jack, 2018) which is foregrounded in the peer-reviewed literature can be seen to be open to considerable critique as we will argue in our article.

The principles of *Coaching to the PEA* are outlined extensively in the literature (see for example, Boyatzis, Smith & Beveridge, 2013). Briefly, *Coaching to the PEA* requires the coachee to articulate a compelling vision of an ideal self, identify strengths before development needs, establish a plan of action to achieve valued goals and for the coach to build a trusting relationship in a context of compassion for the learner. A key feature of the model is the notion of a positive emotional attractor (PEA) which conceptualises how the coachee, through effective coaching process, is pulled towards change (hence the term, *Coaching to the PEA*) while the Negative Emotional Attractor (NEA) pulls the coachee back to the status quo (*Coaching to the NEA*):

[W]e theorise that the positive emotional attractor (PEA) and negative emotional attractor (NEA) are self-regulating and stabilising states that self-propagate until a tipping point produces a shift from one to the other. That is, a person is pulled into the sphere of influence of one attractor by a tipping point and remains there until another tipping point is reached. (Boyatzis, Smith & Beveridge, 2013: p. 8)

The rigour and development of *Coaching to the PEA* is grounded in Intentional Change Theory (ICT) which builds on a long history of self-directed learning and complexity theory (e.g., Cavanagh, 2006; Howard, 2006). Neuroscience provides one source of support for *Coaching to the PEA*, which is a synthesis of a range of sources of evidence and theorising (Passarelli et al. 2017). If, however, the model draws on evidence and theorising from neuroscience, it is still important to understand the strengths and limitations in the neuroscientific evidence base.

Coaching to the PEA: Critique

Boyatzis & Jack (2018) provide three main sources of mutually supportive neuroscientific evidence for their model. The first is one fMRI investigation (Jack et al., 2013). The second is the supporting neuroscientific literature which has suggested an antagonism between the task positive network

(TPN) and default mode network (DMN) in the brain (see Raichle, 2015 for localising these networks and for a full description; a brief overview follows later). This antagonism suggests that the coach needs to selectively stimulate the DMN of their clients in order to encourage state openness (to experience, emotions, ethical decision-making, etc.), functionalities the authors consider intrinsic to the DMN. The third source of evidence is the purported synthesis of different sources of literature which give weight to, and complement the neuroscientific evidence base. We will critically review each of these sources of evidence in turn.

1. The foundational empirical research (Jack et al., 2013): Limitations in experimental design and interpretation of results

The experiment, described in full in Jack et al. (2013) is summarised in Boyatzis & Jack (2018). Twenty university students took part in two 30-minute sessions, one described as *Coaching to the PEA*; the other as *Coaching to the NEA*. The two coaches involved worked across conditions. In the former condition, the coach encouraged their coachees to imagine a personally inspirational future. They were asked, “If everything worked out ideally in your life, what would you be doing in 10 years?”. In the *Coaching to the PEA* condition, the coach was required to encourage their coachees to maintain a positive mindset. In *Coaching to the NEA*, the coach asked their coachees only about their current difficulties and challenges:

“What challenges have you encountered, or do you expect to encounter in your experience here? How are you doing with your courses? Are you doing all of the homework and readings?” (Jack et al., 2013, p. 374).

While the experimental condition bore some characteristics of a possible effective coaching session (the warmth of the relationship and thinking about a long-term vision), it is open to question as to whether the control condition, *Coaching to the NEA*, would meet the essential requirements of an effective coaching session if assessed for example by the well-known core competencies of the International Coaching Federation (ICF; Core Competencies, ICF, 2022a). For example, there is no indication of the coach in the *NEA condition*, celebrating “the client’s progress and successes”, inviting “the client to generate ideas about how they can move forward” or of showing “support, empathy and concern for the client” (Core Competencies, ICF, 2022a). Coaching is intended to be inspiring and this is emphasised in the ICF’s (2023b) definition of coaching as “a creative process that inspires them [clients] to maximise their personal and professional potential”.

Jack et al. (2013, p.375) argue that the role of the coach in the NEA condition was not intended to create a “hostile or rude environment” but one that might simulate a learning context that students (the coachees) might typically experience with a parent or within a university faculty. These are, of course, non-coaching interactions. In the *coaching to the NEA* condition, coaches were even asked “to induce a negative emotional state, in particular of guilt and defensiveness, in the student” (p. 375) which would not be consistent with ethical coaching practice.

It is possible that some coaches might overly focus on immediate goals (Jinks and Dexter, 2012) following multi-rater feedback or in response to the rigidities of GROW and similar models rather than exploring in-depth personal motivations (Passarelli, 2015). In principle, *Coaching to the PEA* usefully challenges this. We nonetheless suggest that Jack et al. (2013) primarily investigated a social interaction in which a ‘coach’ in an experimental condition (*Coaching to the PEA*) encouraged a sense of hope, possibility and self-efficacy in a supportive relational context which is widely considered important in coaching (e.g., de Haan and Gannon, 2017; de Haan and Stewart, 2008; Molyn, de Haan, van der Veen & Gray, 2021). In the control condition, this supportive and self-affirmatory context was not provided. It is therefore unsurprising that the investigation produced differences in the verbal reports of the participants in each condition (the verbal reports are used to interpret changes in neuronal activity so it is important to consider them). It seems that

it is unjustified therefore to argue that *Coaching to the PEA* provides something unique over any supportive relational exchange based on this single investigation.

Three to five days after the ‘coaching’ sessions, the brains of the participants were scanned (fMRI; see Jack, Rochford, Friedman, Passarelli & Boyatzis, 2019 for a discussion of this method) while the participants were asked to respond to audio and visual images of the coaches, a process intended to simulate the coaching experiences carried out previously. For participants who took part in the *Coaching to the PEA* condition, this stimulus led to a spiking of neural activity (peak activations) in widespread areas of lateral and visual cortex. Boyatzis & Jack (2018) argue that these results demonstrate the importance of visioning in *Coaching to the PEA*. They also report activation of the ventral striatum/nucleus accumbens which they relate to motivational processes and in brain regions involved in parasympathetic modulation of stress responses (the ventral medial prefrontal cortex, vmPFC). They also highlight left-dominant asymmetry in frontal activation that has previously been associated with positive affect and greater approach than avoidance motivation. Finally, the authors report how the PEA condition produced greater activity in medial parietal cortex, a region within the DMN. These results were all interpreted as strong indicators of effective coaching processes given the association of these areas with broader neuroscientific research.

The authors argue that the investigation “reasonably approximated a genuine coaching interaction” (Boyatzis & Jack, 2018, p.12-13). While it is difficult to approximate a genuine coaching interaction, and researchers have to find ways of achieving this, we need to evaluate if being in a scanner some days after an intervention really did evoke a coaching experience. Conceptually, hearing and seeing their coach again likely evoked a memory of the coach and/or a memory of the experience and some affective response toward the coach, as recalled in memory, but this is clearly not the same as re-experiencing coaching.

Even if we accept some similarity between the coaching experience and the stimulus presented in the scanner, it seems unlikely that this stimulus would have recreated the richness and depth of experience which the PEA state is intended to invoke. Howard (2006) for example describes the PEA state as a complex experiential phenomenon:

‘the personal hopes, dreams, possibilities, strengths, optimism and self-directed learning goals that make up our Ideal Self ... i.e. our conception of what we most aspire to be and become’ (p. 258).

Intense experiences such as peak moments have been discussed in the coaching literature. Weijers (2022) describes these moments as involving for example a deep sense of connection between people and self-awareness. These moments are hard earned and infrequent. While the PEA state seems different from a peak moment, it is important to acknowledge that deeply felt experiences do not always come readily in coaching. De Haan, Bertie, Day & Sills (2010) have reported that much everyday coaching is positive and constructive but not necessarily charged with moments of extraordinary engagement (de Haan et al., 2010, p. 115). While Boyatzis & Jack might argue that this is a problem with everyday coaching, the point being made is that in the space of a short conversational exchange with a stranger, achieving a PEA experience seems a tall order if we are to assume that the PEA state is anything more than a general sense of positivity. Boyatzis & Jack (2018) do not actually state that the sessions did create a PEA state but if the argument is made that no PEA state was created, then it simply is not possible to argue that Jack et al. (2013) demonstrated the effectiveness of *Coaching to the PEA*.

A separate concern relates to the experimental design which makes a clear point about the importance of test conditions. In Jack et al. (2013), the two experimental conditions had two specific components to each. In the experimental manipulations related to PEA: (i) participants were asked to contemplate about their future and (ii) contemplate a positive outcome in life. By contrast, the NEA manipulation required participants to (i) focus on their present and (ii) focus on a

negative outcome. It is critical to understand the results from their study in these specific experimental contexts. It would be important to know if contemplating the future together with a negative outcome in life, or having a focus on the present but in terms of a positive outcome would lead to different neural patterns. It cannot therefore be concluded that the brain patterns observed provide clear evidence of brain patterns uniquely associated with contemplating the future and a positive outcome.

We also raise a particular concern about the interpretation of the findings relating to the visioning process and the processing of global/local information. The investigation reported a decrease in activity in visual brain related areas when brain activation was being monitored but when the coach's face was not visible. This could indicate that the presence of visual (face) information was critical in driving visual brain related activities. It seems unlikely that this pattern of activity could therefore confidently be considered "visioning" or imagination related activity. Several research studies (e.g., Killgore & Yurgelun-Todd, 2007; Schmitz, de Rosa & Anderson, 2009) have also shown that early sensory processing in the visual cortex is enhanced for positive affective state. Crucial to interpretation is the sensory signals (stimulus driven), which is not the same as imagination (in the absence of a stimulus). In Jack et al. (2013), the fMRI activity was associated with processing the faces of the two coaches under different conditions (face stimuli; PEA/NEA), therefore the visual cortex activity may simply represent early sensory processing modulated by the emotional state evoked through the coaching intervention. Furthermore, studies have shown that the category specific emotional visual features can be reliably represented in the human visual system (Kragel, Reddan, LaBar & Wager, 2019).

Overall, these studies point out a role of sensory/stimulus driven representation of emotional contents in the visual cortical system. It cannot be argued that the identified patterns of neural activity are imagery related, given their investigational manipulation is not looking at imagery processing. Similarly, Boyatzis & Jack (2018) interpreted differences in activity in lateralized visual brain areas reflecting global/local processing associated with PEA and NEA respectively. It is unclear how this claim could be made where *Coaching to the PEA* (or NEA) did not manipulate global or local processes.

It is also important to recognise that task specific conditions can impact on the areas of the brain affected by visualisation processes (Bellana, Liu, Diamond, Grady & Moscovitch, 2017; Schacter, Benoit & Szpunar, 2017; Szpunar, Spreng & Schacter, 2014;) and can involve several areas of the brain (Pearson, 2019). The parts of the brain associated with future thinking can also be associated with remembering past events (Schacter, Addis & Buckner, 2008) which means that the simple identification of a particular area of the brain is not necessarily an indication of the presence of visioning an inspirational future.

In relation to the study design, we finally raise a concern about interpretation of the BOLD (Blood Oxygenation Level Dependent) signal in the investigation. Logothetis (2008) has previously suggested that an increase in the BOLD signal (indicators of neural activity in the brain during fMRI studies) may occur as a result of a balanced proportional increase in excitatory and inhibitory conductance. While on the one hand, it might be correct to interpret the patterns observed in Jack et al (2013) as spiking of task or stimulus specific neurons (the patterns of activation observed), it is also possible that these patterns could be the result of inhibitory processes in the DMN. How we interpret activation in the DMN is therefore open to question. The neurons in the DMN could be primarily responding in an excitatory or inhibitory manner which leaves open to question the relationship between psychological processes and associated neural activation in the DMN.

In summary, the key arguments we are making are first, that it is very difficult to design ecologically valid methods of investigating the coaching process neuroscientifically and second, that it is important to be cautious in making definitive interpretations of neuroscientific results based on limited investigations. We acknowledge that the authors have tried to find a way of replicating the

coaching process experimentally but it is important that limitations in design and alternative interpretations of results (Jack et al., 2019) are discussed.

2. The antagonism between the task positive network (TPN) and default mode network (DMN); the role of the DMN in state (psychological) “openness” and coach positioning as a free agent stimulating the coachee’s brain

The preferential activation of the DMN network in the brain is considered by Boyatzis & Jack (2018) to be of primary importance in the coaching process and rests on the assumption that activation of the DMN is associated with suppression of activity in the TPN and vice-versa. Boyatzis & Jack (2018) refer to this assumed, fundamental antagonism as ‘Opposing Domains’ theory. In this part of our critique, we will explore the validity of this theory in light of recent research, consider if the notion of antagonism holds and discuss how we might now best understand the DMN neuroscientifically. We will begin this sub-section of our critique by reviewing changes in our understanding of the role of the DMN/TPN (Opposing Domains). We will then argue that the functions Boyatzis & Jack (2018) attribute to the DMN in terms of state (psychological) openness need to be demonstrated empirically and highlight a difficulty associated with reductionism when using neuroscience to explain complex psychological/behavioural constructs. Finally, we will argue that the role of the coach working to activate the DMN, as much as any other brain area is problematic in terms of the role of the coach.

a) ‘Opposing domains theory’ and its re-evaluation

Shulman Fiez, Corbetta, Buckner, Miezin, Raichle & Petersen (1997) first noted that specific areas in the human cerebral cortex consistently reduced levels of activation below a baseline while engaged in a range of novel, non-self-referential and goal-directed tasks. In a follow-up study, Raichle, MacLeod, Snyder, Powers & Gusnard (2001) referred to these areas as a *default mode* of brain activity suggesting that activity in the areas of the brain first identified by Shulman et al. (1997) is normally present as a baseline or default state but is temporarily suspended.

Since its discovery, this area of the brain, the Default Mode Network (DMN) has been extensively researched. Raichle (2015) categorised 3000 papers into task driven studies, disease state DMN relationships, functional connectivity processes, self-referential processing/mind-wandering and finally, neurophysiology and cell biology. The DMN has captured the attention of neuroscientists because it suggests that much of the brain’s operations are intrinsic, involving for example the interpretation of information and the prediction of environmental demands (Raichle, 2010). In particular, the activation of the DMN during self-referential processing indicates the possibility of an identifiable area of the brain associated with the human sense of self (e.g., Davey, Pujol & Harrison, 2016; Vessel, Starr & Rubin, 2013). Mind-wandering and self-referential processing in relation to the DMN has also generated interest in neuroscientific research in major depressive disorder (e.g., Berman, Peltier, Nee, Kross, Deldin & Jonides, 2011) and other mental health conditions such as schizophrenia (e.g., Shin, Lee, Jung, Kim, Jang & Kwon, 2015).

Since the activation of the DMN appears to be attenuated when the brain is engaged in a range of novel, non-self-referential and goal-directed tasks and conversely appears to become more active when the brain is not engaged in these tasks, it has been generally concluded that the brain operates in two different domains. Raichle (2015) coined the parts of the brain associated with novel, non-self-referential and goal directed tasks as the task positive network (TPN), namely, the dorsal attention network (DAN) working together with elements of frontoparietal control networks. He suggests that the relationship between the DMN and the TPN is such that both systems are always active, but the DMN may be attending to the environment non-consciously and adjusts its relationship (decreases its activity) at times of novel stimuli when the TPN becomes more active.

A key argument presented by Boyatzis & Jack (2018) is that the coaching process needs to exploit the assumed antagonistic relationship between the DMN and the TPN. The authors argue that the DMN is associated with a range of processes associated with state (psychological) openness (e.g., openness to emotions, moral decision-making, ideas, learning, relating to others) whereas the TPN is associated with analytic thinking. The argument suggests that the coachee should not focus on both analysis and openness simultaneously so the coach should initially stimulate the DMN of the coachee to promote state openness.

However, in recent years, the notion of antagonism has been re-evaluated. Dixon, Andrews-Hanna, Spreng, Irving, Mills, Girn & Christoff (2017) found that interactions between the DMN, and DAN (part of the TPN) varied across different cognitive states and across time between periods of anticorrelation and positive correlation. Elsewhere, Gerlach, Spreng, Madore & Schacter (2014) found that the DMN is activated during a range of tasks involving goal attainment but as are concurrently other areas of the brain including frontal parietal control regions and reward processing regions. Similarly, Spreng & Grady (2010), found that while the DMN was activated during autobiographical planning, the frontoparietal control network was also activated. These findings demonstrate that the DMN can be involved in goal-directed cognition, an analytical activity. Spreng & Grady (2010) and Spreng (2012) highlight what can in effect be considered a misconceptualisation of the assumed antagonism between the DMN and TPN or, that this is at least, over-specified.

An interesting finding in the literature relates to activity within the DMN during task performances. Although activity within the DMN is decreased during a type of cognitive task, the effective connectivity between the constituent DMN regions is increased to render them more excitable. The connectivity pattern shifts from posterior to anterior regions of the DMN during the task (Li, Wang, Yao, Hu & Friston, 2012). These findings, which reflect increased functional connectivity within the constituent parts of the DMN suggest a change in pattern of activity within the DMN rather than absence of activity. Li et al. (2012) suggest that increased connectivity within the DMN may facilitate faster and large amplitude fluctuations in BOLD signals. These appear as activations in task-related regions and deactivations in the DMN. Increased engagement of the DMN during task performance has been previously reported too (Hampson, Driesen, Skudlarski, Gore & Constable, 2006; Newton, Morgan, Rogers & Gore, 2011). The activity of the DMN reflects facilitation and monitoring of cognitive performance rather than being disengaged during cognitive tasks.

In other studies, the activation of the DMN has been shown to relate to activation in brain areas such as the Reward Network (including thalamus, nucleus accumbens, putamen, and caudate) and Executive Control Network (Zhu, Du, Kerich, Lohoff & Momenan, 2018), the latter being part of the TPN. The left DLPFC has also been implicated in unconscious attention (Ran, Chen, Cao & Zhang, 2016) which calls into question the unique role of the DMN in environmental scanning. In yet another study, Tabibnia (2020) argues that promoting resilience in adults requires the effective interplay between three systems, driven by three different brain systems. The interplay is mediated by 1) the mesostriatal reward network which upregulates the positive feelings, 2) the amygdala, HPA, ANS (autonomic nervous system) which down-regulates the negatives and 3) the DMN which down-regulates mind wandering and rumination. In another study, Treserras, Boulanouar, Conchou, Simonetta-Moreau, Berry, Celsis, Chollet & Loubinoux (2009) found functional connectivity between areas of the DMN and the sensorimotor network during 'movement readiness'.

The role of the DMN therefore appears to be much more integrated and, contingent on the specifics of the task than previously thought. In a very recent review of the past 20 years of research investigating the DMN, Menon (2023) suggests that the DMN might best be understood as a "functional and structural hub in the brain [highly integrated with other networks], assimilating and transmitting representation of salient external and internal events through global brain activity patterns" (p. 11).

It is interesting to note in Menon's (2023) review that the main functions identified which appear to activate the DMN are a) self-referential judgements; b) social cognition; c) episodic memory; d) language and semantic memory and e) mind wandering. This categorisation is derived from over 14,000 studies and leads Menon to emphasise its integrating role, specifically that the DMN serves to integrate self-referential, social, episodic memory, language and semantic memory processes (p. 15). The DMN effectively provides "a coherent internal narrative of our experiences" (p. 11).

b) The DMN and its functionality in state (psychological) openness

The point of departure for Boyatzis & Jack (2018) in advocating the preferential activation of the DMN is the conceptualisation of this brain area as "a non-conscious component that orients us to the predictive regularities of the environment upon which we base most of our behaviours" (Raichle, 2015, p. 443). Boyatzis & Jack (2018) use this neuroscientific understanding of the DMN speculatively to explain human experience at a psychological level of analysis:

[W]e need the DMN to be open to new ideas, scanning the environment for trends or patterns and being open to others and emotions, as well as moral concerns (i.e., being fair and just and promoting well-being, not the more analytic act of judging an action as right or wrong) (p. 16).

They expand the notion of state openness to include being "open and motivated to hear your ideas or insights" (p. 14) and how "in the DMN [coachees can be] "emotionally open...[and] open to new ideas and the possibility of change" (p. 17).

Caution needs to be exercised however in reducing complex psychological phenomena to a neuroscientific level of understanding (Mackenzie, 2005; Bowman et al., 2012). It is also an approach associated with *neuroreductionism* (see for example, Kirmayer & Gold, 2012). Neither Raichle (2015) nor Menon (2023) reference the word "open" which calls into question how far one might legitimately explain psychological experience at a neuroscientific level of analysis.

There is some recent literature exploring the association between the DMN and a notion of "openness" as a personality trait (not a *state* as implicit in Boyatzis & Jack, 2018). Wang, Zhuang, Li & Qiu (2022) for example found that openness to experience (a personality trait) and divergent thinking (a thinking style) are associated with functional activity within the DMN but also within the TPN as well as the primary sensorimotor network and frontoparietal control network. Wang et al. (2022) reason that openness to experience and divergent thinking involve both the DAN (TPN) and DMN since both processes require attention and spontaneous thinking abilities. In relation to openness to emotions, Pessoa (2017) argues that emotion might be better understood "in terms of large-scale network interactions spanning the entire neuroaxis" which seems to call into question the notion of a specific part of the brain associated with emotional experience. Pessoa (2017) supports this assertion with evidence indicating how "both cortical and sub-cortical brain regions are densely interconnected" (p. 2). Similarly, Amft, Bzdok, Laird, Fox, Schilbach & Eickhoff (2015) did find evidence of DMN activation in social, affective and introspective processes. However, their work identified the simultaneous activation of a range of other brain regions interconnected with the DMN and in relation to varying mental processes. Even if it is therefore argued that the DMN might be implicated in some way in a range of psychological processes associated with openness, it seems difficult to argue that the DMN works in isolation of other brain areas.

It is also important to note that emotional processes associated with activation of the DMN could even be unhelpful. Sheline, Barch, Price, Rundle, Vaishnavi, Snyder, Mintun, Wang, Coalson & Raichle (2009) is one of many early articles implicating over-activation of the DMN with depression (note also Raichle's 2015 categorisation of a large literature of psychological dysfunctions associated with the DMN). More recently, a meta-analysis of brain imaging studies (Zhou, Chen, Shen, Li, Chen, Zhu, Castellanos & Yan, 2020) confirmed a hypothesised association between patterns of DMN activation and rumination.

There have been several studies supporting a dual process theory of ethical decision-making whereby emotional decision-making appears to be associated with one set of brain regions considered integral to the DMN (in particular, the ventral medial prefrontal cortex; vmPFC) and a cognitive utilitarian decision-making process (based on the weighted outcomes of decisions made) associated especially with the dorsal lateral prefrontal cortex (dlPFC) and anterior cingulate cortex (ACC) (Koenigs, Young, Adolphs, Tranel, Cushman, Hauser & Damasio, 2007; Koenigs, Young, Adolphs, Tranel, Cushman, Hauser & Damasio 2008; Tassy, Oullier, Duclos, Coulon, Mancini, Deruelle, Attarian, Felican & Wicker, 2012; Thomas, Croft & Tranel, 2011; Young & Dungan, 2012). More recently however, this understanding has been challenged and different patterns of activation have been inferred to reflect primarily intuitive and counter-intuitive rather than ethical decision-making (Kahane, Wiech, Shackel, Farias, Savulescu & Tracey, 2012). The role of the vmPFC is also unclear (Kahane & Shackel, 2008, Koenigs et al., 2007). Sevinc, Spreng & Soriano-Mas (2014) did not identify differences between moral response decision and evaluative judgements. It still therefore remains to be investigated if brain activity differs between these two types of moral decisions (Garrigan, Adam & Langdon, 2016, p. 89). In a recent meta-analytical review of “the moral brain”, Fede & Kiehl (2019) highlight the contribution of structures in the limbic system in the integration of emotional, social, and cognitive elements in ethical decision-making highlighting again limitations in assuming the unique importance of DMN activation.

We acknowledge in this sub-section that Boyatzis & Jack (2018) emphasise state rather than trait openness and it is on the latter we have based many of our comments. However, we were unable to identify neuroscientific research which explores state openness in the context of complex psychological phenomena. Our overarching conclusion is therefore that there is insufficient evidence to suggest the importance of the preferential and selective activation of one part of the brain (the DMN) in coaching in producing experiences associated with complex psychological processes associated with openness.

c) The positioning of the coach as a free-agent manipulating the DMN

In accord with the conclusions drawn in relation to the pivotal role of the DMN and its antagonistic relationship with the TPN, Boyatzis & Jack (2018) make the case that the coach needs to work “... predominantly in the DMN” but should be prepared to choose when to activate the DMN and when the TPN:

Once a change direction or desired end is identified and the person feels renewed, safe, and open—and even curious or eager—then ventures into the TPN with analytic moments and even using stress to adapt are likely wanted. (p.18)

The coach is positioned as a “psych-expert” (Western, 2012, p.18) who no longer works with the person but with the brain of the coachee. Moreover, the notion of the coach being able to empathise with the client at the right time also implies a chameleon-like self-management and capacity to engineer a predictable response from the client.

Hence, the coach selectively uses the TPN, just to get the distance necessary to be most helpful... When positive emotions are being expressed, the coach can then fully empathize and resonate with the client (engaging the DMN and suppressing the TPN). (2018, p.20)

Even if the coach can manage their own feelings and behaviours as well as those of the coachee in the way advocated, the calculated engagement risks manipulating the coachee. It also implies a linearity whereby the coach follows a pre-determined trajectory towards successful client change and is quite different from much coaching process theory which conceptualises coaching as a complex process of meaning-making or of uncertainty (e.g., Bowes & Jones, 2006; Cavanagh, 2006; Myers & Bachkirova, 2020; Stelter, 2007).

3. Synthesising evidence from different sources of literature

The arguments for the underpinning processes and effectiveness of *Coaching to the PEA* are based on a synthesis of findings and theorizing from different bodies of literature. *Coaching to the PEA* is not a neuroscientific model of coaching – it is only partially informed from the literature on neuroscience. However, providing a synthesis in the context of an article on the neuroscientific foundations of a coaching model risks leading a reader to make unfounded inferences. Boyatzis & Jack (2018) draw for example on Epstein et al. (1996) to present a case for the different roles of the TPN/DMN in relation to information-processing styles:

In relation to Epstein, Pacini, Denes-Raj, and Heier's (1996) rational and experiential information-processing styles, those with a high need for cognition (analytic-rational thinking style) tend to rely on the TPN, whereas those with a preference for relying on their feelings (intuitive-experiential thinking style) tend to rely on the DMN. (Boyatzis & Jack, 2018 p.15)

This reference to Epstein et al. (1996) might easily be inferred to provide empirical evidence for the different roles of the DMN/TPN. However, it is important for the reader to be aware that there is no discussion of the DMN/TPN in Epstein et al. (1996). Boyatzis & Jack (2018) are only making a speculative argument for what they argue to be the likely and different roles of the DMN/TPN in information-processing styles. Similarly, Boyatzis & Jack (2018) refer to Kolb (2015) to argue that the DMN/TPN are activated differentially in experiential learning:

In Kolb's (2015) experiential learning theory, those with a preference for abstract conceptualization as a learning style tend to rely on the TPN, whereas those with a preference for concrete experience as a learning style tend to rely on the DMN. (Boyatzis & Jack, 2018, p.16)

Kolb (2015) proceeds in his book to cite Boyatzis, Rochford & Jack (2014) to support his argument for the different roles of the DMN/TPN. However, Boyatzis et al. (2014) provide no empirical neuroscientific evidence to support the DMN/TPN in learning styles. There is therefore an apparent circular reasoning (a logical fallacy/ no external evidence) to support the conclusions drawn. At best, Boyatzis & Jack (2018) can only claim to be speculating that the DMN/TPN might be involved in the way described.

Boyatzis & Jack (2018) cover so many different theoretical sources of evidence to argue a case for the role of the DMN in *Coaching to the PEA* that rhetorically, what might be readily construed as neuroscientific evidence appears overwhelming. An interested reader necessarily has to conduct an archaeological exploration of the citations provided to establish whether the arguments being made by the authors are based in literature outside of neuroscience or are based on robust empirical neuroscientific evidence.

Arguably the most important challenge the authors face in integrating different sources of knowledge is determining the ontological status of the PEA and NEA. The PEA and NEA, theorised from the literature on intentional change theory are not neural regions unlike the DMN/TPN (notwithstanding debates on boundaries and functionalities). There are however 43 mentions of the PEA and 24 references to the NEA juxtaposed in their 2018 article alongside the DMN and TPN (mentioned 42 and 40 times respectively). However, rhetorically, this juxtaposition presents the PEA/NEA as scientifically equivalent in foundational status to the DMN/TPN. While it is important to develop new constructs, there is a need for readers to be mindful of the tentative and more limited theoretical status of the PEA/NEA as well as their essential nature.

The PEA/NEA states incorporate the notion of attractors derived from complexity science and for which there are no clearly identifiable neural equivalents. Boyatzis & Jack (2018) argue that the PEA and NEA are psycho-physiological states which vary along three dimensions, or axes. One of those is neural network activation: task positive network (TPN) versus default mode network (DMN)

or analytic versus empathic; a second axis is sympathetic versus parasympathetic nervous system arousal, which are hormonal systems; the third axis is positive versus negative affect (personal correspondence, July 2023). It is these overall processes which are purported to become self-reinforcing and create a shift in the client.

Boyatzis & Jack, (2018) are not therefore arguing that a mechanism which acts as an attractor or a tipping point is localised in the brain. The authors are rather making the case that if we consider the neurological, physiological and psychological evidence alongside theoretical argumentation from complexity science (the notion of attractors), then we can conceptualise how *Coaching to the PEA* might work. However, in not being able to account for concepts in complexity science at a neuroscientific level of understanding (and we are not arguing that the authors should try to do this), we are arguing that this illustrates a limitation in establishing the neuroscientific foundations of a model of coaching in which the notion of attractors is fundamental. This gap in their neuroscientific evidence base points to the difficulty in integrating evidence and theory from different domains of knowledge and paradigms (Bowman et al., 2012; Mackenzie, 2005).

It is also unclear in what way the PEA/NEA states are actually different from the autonomic nervous system (ANS) or at least these differences are not explained. It is well established for example that the ANS involves neural and hormonal activity and is associated with affective responses (Svorc, 2018). We are unaware of any research which demonstrates differences empirically between the ANS and PEA/NEA states.

Toward the end of the article, Boyatzis & Jack (2018) reference a second research investigation (Passarelli, 2015) in which they claim to have found evidence of a “clear dose-dependent effect of prior PEA coaching” (p.22), the suggestion being that *Coaching to the PEA* has a cumulative but finite benefit over a series of coaching sessions. They further expand the implications for neuroscience at an organisational level in relation to creating a coaching culture. Given the concerns we have expressed in relation to the evidence for the claims made, which are based primarily on one research investigation (or a second if we include Passarelli, 2015) and as part of an overall synthesis rather than an extensive neuroscientific evidence base, we argue that there is a need for caution before generalising findings. It is also very much open to debate how far it is possible to explain culture change at a neuroscientific level of understanding. This again raises issues of reductionism in neuroscience (see for example, Berntson & Cacioppo, 2011 or Kirmayer & Gold, 2012).

Conclusions

Establishing a neuroscientific evidence base for coaching is complex. Neuroscience is a paradigm associated with laboratory-based experiments when small changes in task specific conditions, even when stimuli remain constant can lead to significant changes in brain activity. Researchers need to be cautious in using results from specific and isolated experiments in neuroscience and in drawing general conclusions about human behaviour and experience. Moreover, laboratory research exploring neuronal or sub-neuronal activity provides a very different level of analysis and takes place in research environments which are very different from those which might typically explore complex psychological and interpersonal processes.

Making a case for preferential neurological activation within a coaching session to support a particular model of coaching is in our opinion stretching neuroscience too far. It is also stretching neuroscience too far when authors try to use research from different paradigms to support neuroscientific arguments or, at the very least, theorists need to qualify the complexities in trying to do this. Coaches do of course need to help their coachees feel positive about themselves, help them realise they can find ways of addressing their challenges and gain a sense of future possibilities but we would argue that this is inherent in all effective coaching. Furthermore, the

issues coachees present and how the coach works with their coachees over time cannot be reduced to a simple step-by-step, formulaic activation of parts of the brain as much as the interpersonal process cannot be reduced to a simple, sequential, behavioural repertoire.

References

- Amft, M., Bzdok, D., Laird, A. R., et al., (2015). Definition and characterization of an extended social-affective default network. *Brain Structure and Function*, 220(2), 1031–1049. DOI: [10.1007/s00429-013-0698-0](https://doi.org/10.1007/s00429-013-0698-0).
- Bellana, B., Liu, Z.-X., Diamond, N. B., et al., (2017). Similarities and differences in the default mode network across rest, retrieval, and future imagining. *Human Brain Mapping*, 38(3), 1155–1171. DOI: [10.1002/hbm.23445](https://doi.org/10.1002/hbm.23445).
- Berman, M. G., Peltier, S., Nee, D. E., et al., (2011). Depression, rumination and the default network. *Social Cognitive and Affective Neuroscience*, 6(5), 548–555. DOI: [10.1093/scan/nsq080](https://doi.org/10.1093/scan/nsq080).
- Berntson, G. G. & Cacioppo, J. T. (2012). Reductionism. In: L'Abate, L. (Ed.) *Paradigms in Theory Construction*. Springer: New York. DOI: [10.1007/978-1-4614-0914-4_19](https://doi.org/10.1007/978-1-4614-0914-4_19).
- Bossons, P., Riddell, P., & Sartain, D. (2015). *The neuroscience of leadership coaching: Why the tools and techniques of leadership coaching work*. London: Bloomsbury Information.
- Bowes, I., & Jones, R. L. (2006). Working at the edge of chaos: understanding coaching as a complex, interpersonal system. *The Sport Psychologist*, 20(2), 235–245. DOI: [10.1123/tsp.20.2.235](https://doi.org/10.1123/tsp.20.2.235).
- Bowman, M., Ayers, K. M., King, J. C., & Page, L. J. (2012). The Neuroscience of Coaching. In J. Passmore. (Ed.), *The Wiley-Blackwell Handbook of the Psychology of Coaching and Mentoring*, (pp. 127-155). DOI: [10.1002/9781118326459.CH6](https://doi.org/10.1002/9781118326459.CH6).
- Boyatzis, R. E., & Jack, A. I. (2018). The neuroscience of coaching. *Consulting Psychology Journal*, 70(1), 11–27. DOI: [10.1037/cpb0000095](https://doi.org/10.1037/cpb0000095).
- Boyatzis, R. E., Rochford, K., & Jack, A. I. (2014). Antagonistic neural networks underlying differentiated leadership roles. *Frontiers in Human Neuroscience*, 8, 114. DOI: [10.3389/fnhum.2014.00114](https://doi.org/10.3389/fnhum.2014.00114).
- Boyatzis, R. E., Smith, M. L., & Beveridge, A. J. (2013). Coaching with compassion: Inspiring health, well-being, and development in organizations. *The Journal of Applied Behavioral Science*, 49, 153–178. DOI: [10.1177/0021886312462236](https://doi.org/10.1177/0021886312462236).
- Brann, A. (2015). *Neuroscience for coaches: How to use the latest insights for the benefit of your clients*. London: Kogan Page.
- Carson, S., Tiers, M., & Bickford, L. C. (2014). *Keeping the brain in mind: Practical neuroscience for coaches, therapists, and hypnosis practitioners*. Warrington: Changing Mind Publishing.
- Cavanagh, M. (2006). Coaching from a systematic perspective: a complex adaptive conversation. In D.R. Stober, & A. Grant (Eds.), *Evidence based coaching handbook: putting best practices to work for your clients* (pp. 313-355). Chichester: John Wiley & Sons.
- Davey, C. G., Pujol, J., & Harrison, B. J. (2016). Mapping the self in the brain's default mode network. *Neuroimage*, 132, 390–397. DOI: [10.1016/j.neuroimage.2016.02.022](https://doi.org/10.1016/j.neuroimage.2016.02.022).
- de Haan, E., Bertie, C., Day, A., & Sills, C. (2010). Critical moments of clients and coaches: a direct-comparison study. *International Coaching Psychology Review*, 5(2), 109–128. DOI: [10.53841/bpsicpr.2010.5.2.109](https://doi.org/10.53841/bpsicpr.2010.5.2.109).
- de Haan, E., & Gannon, J. (2017). The coaching relationship. In T. Bachkirova, G. Spence, & D. Drake (Eds.), *The SAGE handbook of coaching* (pp. 195–217). London: Sage.
- de Haan, E., & Stewart, S. (2008). *Relational coaching: journeys towards mastering one-to-one learning*. Chichester: J. Wiley.
- Dias, G.P., Palmer, S., O'Riordan, S., et al., (2015). Perspective and challenges for the study of brain responses to coaching: Enhancing the dialogue between the fields of neuroscience and coaching psychology. *The Coaching Psychologist*, 11(1), 1748-1104. DOI: [10.53841/bpstcp.2015.11.1.11](https://doi.org/10.53841/bpstcp.2015.11.1.11).
- Dixon, M. L., Andrews-Hanna, J. R., Spreng, R. N., et al., (2017). Interactions between the default network and dorsal attention network vary across default subsystems, time, and cognitive states. *Neuroimage*, 147, 632–649. DOI: [10.1016/j.neuroimage.2016.12.073](https://doi.org/10.1016/j.neuroimage.2016.12.073).
- Epstein, S., Pacini, R., Denes-Raj, V., & Heier, H. (1996). Individual differences in intuitive-experiential and analytical-rational thinking styles. *Journal of Personality and Social Psychology*, 71, 390–405. DOI: [10.1037/0022-3514.71.2.390](https://doi.org/10.1037/0022-3514.71.2.390).
- Fede, S. J., & Kiehl, K. A. (2019). Meta-analysis of the moral brain: patterns of neural engagement assessed using multilevel kernel density analysis. *Brain Imaging and Behavior*, 14(2), 534–547. DOI: [10.1007/s11682-019-00035-5](https://doi.org/10.1007/s11682-019-00035-5).

- Garrigan, B., Adlam, A.L.R., & Langdon, P.E. (2016). The neural correlates of moral decision-making: A systematic review and meta-analysis of moral evaluations and response decision judgements. *Brain and Cognition*, 108, 88–97. DOI: [10.1016/j.bandc.2016.07.007](https://doi.org/10.1016/j.bandc.2016.07.007).
- Gerlach, K. D., Spreng, R. N., Madore, K. P., & Schacter, D. L. (2014). Future planning: default network activity couples with frontoparietal control network and reward-processing regions during process and outcome simulations. *Social Cognitive and Affective Neuroscience*, 9(12), 1942–1951. DOI: [10.1093/scan/nsu001](https://doi.org/10.1093/scan/nsu001).
- Grant, A. M. (2015). Coaching the brain: Neuro-science or neuro-nonsense? *The Coaching Psychologist*, 11(1), 31-37. DOI: [10.53841/bpstcp.2015.11.1.21](https://doi.org/10.53841/bpstcp.2015.11.1.21).
- Hampson, M., Driesen, N. R., Skudlarski, P., et al., (2006). Brain connectivity related to working memory performance. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, 26(51), 13338–13343. DOI: [10.1523/JNEUROSCI.3408-06.2006](https://doi.org/10.1523/JNEUROSCI.3408-06.2006).
- Howard, A. (2006). Positive and negative emotional attractors and intentional change. *The Journal of Management Development*, 25(7), 657–670. DOI: [10.1108/02621710610678472](https://doi.org/10.1108/02621710610678472).
- International Coaching Federation. (2023a). *ICF Core Competencies*. Available at: <https://coachingfederation.org/credentials-and-standards/core-competencies>.
- International Coaching Federation, (2023b). *All things coaching*. Available at: <https://coachingfederation.org/about>.
- Jack, A. I., Boyatzis, R. E., Khawaja, M. S., et al., (2013). Visioning in the brain: An fMRI study of inspirational coaching and mentoring. *Social Neuroscience*, 8, 369 –384. DOI: [10.1080/17470919.2013.808259](https://doi.org/10.1080/17470919.2013.808259).
- Jack, A. I., Rochford, K. C., Friedman, J. P., et al., (2019). Pitfalls in organizational neuroscience: A critical review and suggestions for future research. *Organizational Research Methods*, 22: 421-458.
- Jack, A. I., Passarelli, A. M., & Boyatzis, R. E. (2023). When fixing problems kills personal development: fMRI reveals conflict between Real and Ideal selves. *Frontiers in Human Neuroscience*, 17, 1128209. DOI: [10.3389/fnhum.2023.1128209](https://doi.org/10.3389/fnhum.2023.1128209).
- Jarrett, C. (2015). *Great myths of the brain*. Chichester: Wiley Blackwell.
- Jinks, J. & Dexter, J. (2012). What do you really want: an examination of the pursuit of goal setting in coaching. *International Journal of Evidence Based Coaching and Mentoring* 10(2), 100-110. Retrieved 2nd May 2024. Available at: <https://radar.brookes.ac.uk/radar/items/59a166d6-9d8f-4d0b-80b9-bc1930c1aa85/1/>.
- Kahane, G., & Shackel, N. (2008). Do abnormal responses show utilitarian bias? *Nature*, 452(7185), 5–6. DOI: [10.1038/nature06785](https://doi.org/10.1038/nature06785).
- Kahane, G., Wiech, K., Shackel, N., et al., (2012). The neural basis of intuitive and counterintuitive moral judgement. *Social Cognitive and Affective Neuroscience*, 7(4), 393–402. DOI: [10.1093/scan/nsr005](https://doi.org/10.1093/scan/nsr005).
- Killgore, W., & Yurgelun-Todd, D.A. (2007). Positive affect modulates activity in the visual cortex to images of high calorie foods. *International Journal of Neuroscience*. 117(5), 643-653. DOI: [10.1080/00207450600773848](https://doi.org/10.1080/00207450600773848).
- Kirmayer, L. J. & Gold, I. (2012). Re-socializing psychiatry: critical neuroscience and the limits of reductionism. In S. Choudhury, & J. Slaby (Eds.), *Critical neuroscience: a handbook of the social and cultural contexts of neuroscience* (pp. 307-330). Chichester: Wiley-Blackwell.
- Koenigs, M., Young, L., Adolphs, R., et al., (2007). Damage to the prefrontal cortex increases utilitarian moral judgements. *Nature*, 446(7138), 908–911. DOI: [10.1038/nature05631](https://doi.org/10.1038/nature05631).
- Koenigs, M., Young, L., Adolphs, R., et al., (2008). Reply: Damage to the prefrontal cortex increases utilitarian moral judgements. *Nature*, 446(7138), 908–11.
- Kolb, D. A. (2015). *Experiential learning: experience as the source of learning and development* (2nd ed.). New Jersey: Pearson Education.
- Kragel, P. A., Reddan, M. C., LaBar, K. S., & Wager, T. D. (2019). Emotion schemas are embedded in the human visual system. *Science Advances*, 5(7), 4358. DOI: [10.1126/sciadv.aaw4358](https://doi.org/10.1126/sciadv.aaw4358).
- Li, B., Wang, X., Yao, S., et al., (2012). Task-dependent modulation of effective connectivity within the default mode network. *Frontiers in Psychology*, 3. DOI: [10.3389/fpsyg.2012.00206](https://doi.org/10.3389/fpsyg.2012.00206).
- Logothetis, N. K. (2008). What we can do and what we cannot do with fmri. *Nature*, 453(7197), 869–878. DOI: [10.1038/nature06976](https://doi.org/10.1038/nature06976).
- Mackenzie, A. (2005). The problem of the attractor: a singular generality between sciences and social theory. *Theory, Culture & Society*, 22(5), 45–65. DOI: [10.1177/0263276405057190](https://doi.org/10.1177/0263276405057190).
- McKay, S.M., Smith, S. (2021). Towards a Neuroscience-Informed Coaching Practice: Opportunities and Limitations. In: W.A. Smith, I. Boniwell, S. Green (Eds.), *Positive Psychology Coaching in the Workplace*. Cham, Switzerland: Springer.
- McKay, G. (2019). *Stuck: Brain smart insights for coaches*. Fritton: Rethink Press.

- Menon, V. (2023). 20 years of the default mode network: A review and synthesis. *Neuron*. Advance online publication. DOI: [10.1016/j.neuron.2023.04.023](https://doi.org/10.1016/j.neuron.2023.04.023).
- Molyn, J., de Haan, E., van der Veen, R., & Gray, D. E. (2021). The impact of common factors on coaching outcomes. *Coaching: An International Journal of Theory, Research and Practice*, 15(2), 214–227. DOI: [10.1080/17521882.2021.1958889](https://doi.org/10.1080/17521882.2021.1958889).
- Myers, A., & Bachkirova, T. (2020). The rashomon effect in the perception of coaching sessions and what this means for the evaluation of the quality: a grounded theory study. *Coaching: An International Journal of Theory, Research and Practice*, 13(1), 92–105. DOI: [10.1080/17521882.2019.1636840](https://doi.org/10.1080/17521882.2019.1636840).
- Newton, A. T., Morgan, V. L., Rogers, B. P., & Gore, J. C. (2011). Modulation of steady state functional connectivity in the default mode and working memory networks by cognitive load. *Human Brain Mapping*, 32(10), 1649–1659. DOI: [10.1002/hbm.21138](https://doi.org/10.1002/hbm.21138).
- Nowack, K., & Radecki, D. (2018). Introduction to the special issue: neuro-mythconceptions in consulting psychology-between a rock and a hard place. *Consulting Psychology Journal*, 70(1), 1–10. DOI: [10.1037/cpb0000108](https://doi.org/10.1037/cpb0000108).
- O'Connor, J. & Lages (2019). *Coaching the brain: practical applications of neuroscience to coaching*. London: Routledge.
- Paling, R. (2017). *Neurolanguage coaching: Brain friendly language learning*. Gloucester: Choir Press.
- Passarelli, A. (2015). Vision-based coaching: optimizing resources for leader development. *Frontiers in Psychology*, 6. Article 412. DOI: [10.3389/fpsyg.2015.00412](https://doi.org/10.3389/fpsyg.2015.00412).
- Passarelli, A., van Oosten, E., & Eckert, M. A. (2017). Neuroscience in Coaching Research and Practice. 610 - 626. In T. Bachkirova, G. Spence & D. B. Drake (Eds.), *The Sage handbook of coaching* (pp.157-169). London: Sage.
- Pearson, J. (2019). The human imagination: the cognitive neuroscience of visual mental imagery. *Nature Reviews Neuroscience*, 20, 624–634. DOI: [10.1038/s41583-019-0202-9](https://doi.org/10.1038/s41583-019-0202-9).
- Pessoa, L. (2017). A network model of the emotional brain. *Trends in Cognitive Sciences*, 21(5), 357–371. DOI: [10.1016/j.tics.2017.03.002](https://doi.org/10.1016/j.tics.2017.03.002).
- Puspa, L. (2022). Brain-Focused Coaching. In: S. Greif, H. Möller, W. Scholl, et al. (Eds.), *International Handbook of Evidence-Based Coaching: theory, research and practice*. Cham, Switzerland: Springer.
- Raichle, M. E. (2015). The brain's default mode network. *Annual review of neuroscience*, 38, 433-447. DOI: [10.1146/annurev-neuro-071013-014030](https://doi.org/10.1146/annurev-neuro-071013-014030).
- Raichle, M. E. (2010). Two views of brain function. *Trends in Cognitive Sciences*, 14, 180–190. DOI: [10.1016/j.tics.2010.01.008](https://doi.org/10.1016/j.tics.2010.01.008).
- Raichle, M. E., MacLeod, A. M., Snyder, A. Z., et al., (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences of the United States of America*, 98(2), 676–682. DOI: [10.1073/pnas.98.2.67](https://doi.org/10.1073/pnas.98.2.67).
- Ran, G., Chen, X., Cao, X., & Zhang, Q. (2016). Prediction and unconscious attention operate synergistically to facilitate stimulus processing: An fMRI study. *Consciousness and Cognition*. 44, 41-50. DOI: [10.1016/j.concog.2016.06.016](https://doi.org/10.1016/j.concog.2016.06.016).
- Riddell, P. (2021) Neuroscience of coaching: theory, research, and practice. In J. Passmore & S. Leach (Eds.), *Third Wave Cognitive Behavioural Coaching: Contextual, Behavioural and Neuroscience Approaches for Evidence Based Coaches* (pp. 215-254). Shoreham-by-sea: Pavilion Publishing and Media Ltd.
- Rock, D., & Page, L. J. (2009). *Coaching with the brain in mind: Foundations for practice*. Chichester: John Wiley & Sons.
- Schacter, D. L., Addis, D. R., & Buckner, R. L. (2008). Episodic simulation of future events: concepts, data, and applications. *Annals of the New York Academy of Sciences*, 1124(1), 39–60. DOI: [10.1196/annals.1440.001](https://doi.org/10.1196/annals.1440.001).
- Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: mechanisms and functions. *Current Opinion in Behavioral Sciences*, 17, 41–50. DOI: [10.1016/j.cobeha.2017.06.002](https://doi.org/10.1016/j.cobeha.2017.06.002).
- Schmitz, T.W., de Rosa, E., & Anderson, A.K. (2009). Opposing Influences of Affective State Valence on Visual Cortical Encoding. *Journal of Neuroscience* 29(22), 7199-7207.
- Sevinc, G., Spreng, R. N., & Soriano-Mas, C. (2014). Contextual and perceptual brain processes underlying moral cognition: a quantitative meta-analysis of moral reasoning and moral emotions. *Plos One*, 9(2). DOI: [10.1371/journal.pone.0087427](https://doi.org/10.1371/journal.pone.0087427).
- Sheline, Y. I., Barch, D. M., Price, J. L., et al., (2009). The default mode network and self-referential processes in depression. *Proceedings of the National Academy of Sciences*, 106(6), 1942–1947. DOI: [10.1073/pnas.0812686106](https://doi.org/10.1073/pnas.0812686106).
- Shin, D.-J., Lee, T. Y., Jung, W. H., Kim, et al., (2015). Away from home: the brain of the wandering mind as a model for schizophrenia. *Schizophrenia Research*, 165(1), 83–89. DOI: [10.1016/j.schres.2015.03.021](https://doi.org/10.1016/j.schres.2015.03.021).
- Shulman, G. L., Fiez, J. A., Corbetta, M., et al., (1997). Common blood flow changes across visual tasks: II. Decreases in cerebral cortex. *Journal of Cognitive Neuroscience*, 9, 648–663. DOI: [10.1162/jocn.1997.9.5.648](https://doi.org/10.1162/jocn.1997.9.5.648).
- Spreng, R. N. (2012). The fallacy of a “task-negative” network. *Frontiers in Psychology*, 3(145), 1-5. DOI: [10.3389/fpsyg.2012.00145](https://doi.org/10.3389/fpsyg.2012.00145).

- Spreng, R. N., & Grady, C. L. (2010). Patterns of brain activity supporting autobiographical memory, prospection, and theory of mind, and their relationship to the default mode network. *Journal of Cognitive Neuroscience*, 22(6), 1112–1123. DOI: [10.1162/jocn.2009.21282](https://doi.org/10.1162/jocn.2009.21282).
- Stelter, R. (2007) Coaching: A process of personal and social meaning making. *International Coaching Psychology Review*, 2(2), 191-201.
- Svorc, P. (2018). *Autonomic Nervous System*. In DOAB Directory of Open Access Books. InTech.
- Szpunar, K. K., Spreng, R. N., & Schacter, D. L. (2014). A taxonomy of prospection: introducing an organizational framework for future-oriented cognition. *Proceedings of the National Academy of Sciences*, 111(52), 18414–18421. DOI: [10.1073/pnas.1417144111](https://doi.org/10.1073/pnas.1417144111).
- Tabibnia, G. (2020). An affective neuroscience model of boosting resilience in adults. *Neuroscience and Biobehavioral Reviews*, 115, 321–350. DOI: [10.1016/j.neubiorev.2020.05.005](https://doi.org/10.1016/j.neubiorev.2020.05.005).
- Tassy, S., Oullier, O., Duclos, Y., (2012). Disrupting the right prefrontal cortex alters moral judgement. *Social Cognitive and Affective Neuroscience*, 7(3), 282–288. DOI: [10.1093/scan/nsr008](https://doi.org/10.1093/scan/nsr008).
- Thomas, B. C., Croft, K. E., & Tranel, D. (2011). Harming kin to save strangers: further evidence for abnormally utilitarian moral judgments after ventromedial prefrontal damage. *Journal of Cognitive Neuroscience*, 23(9), 2186–2196. DOI: [10.1162/jocn.2010.21591](https://doi.org/10.1162/jocn.2010.21591).
- Treserras, Boulanouar, K., Conchou, F., et al., (2009). Transition from rest to movement: brain correlates revealed by functional connectivity. *Neuroimage*, 48(1), 207–216. DOI: [10.1016/j.neuroimage.2009.06.016](https://doi.org/10.1016/j.neuroimage.2009.06.016).
- Vessel, E. A., Starr, G. G., & Rubin, N. (2013). Art reaches within: aesthetic experience, the self and the default mode network. *Frontiers in Neuroscience*, 7, 258. DOI: [10.3389/fnins.2013.00258](https://doi.org/10.3389/fnins.2013.00258).
- Wang, X., Zhuang, K., Li, Z., & Qiu, J. (2022). The functional connectivity basis of creative achievement linked with openness to experience and divergent thinking. *Biological Psychology*, 168, 1-10. DOI: [10.1016/j.biopsycho.2021.108260](https://doi.org/10.1016/j.biopsycho.2021.108260).
- Weijers, K. (2022). Peak moments: the experience of coaches. *International Journal of Evidence Based Coaching and Mentoring*. Retrieved 2nd May 2024. DOI: [10.24384/8xqy-pv21](https://doi.org/10.24384/8xqy-pv21).
- Western, S. (2012). *Coaching and mentoring: a critical text*. London, Sage.
- Young, L., & Dungan, J. (2012). Where in the brain is morality? Everywhere and maybe nowhere. *Social Neuroscience*, 7(1), 1–10. DOI: [10.1080/17470919.2011.569146](https://doi.org/10.1080/17470919.2011.569146).
- Zhou, H.-X., Chen, X., Shen, Y.-Q., et al., (2020). Rumination and the default mode network: meta-analysis of brain imaging studies and implications for depression. *Neuroimage*, 206. DOI: [10.1016/j.neuroimage.2019.116287](https://doi.org/10.1016/j.neuroimage.2019.116287).
- Zhu X, Du X, Kerich M, et al., (2018). Random forest-based classification of alcohol dependence patients and healthy controls using resting state MRI. *Neurosci Lett*, 676, 27-33. DOI: [10.1016/j.neulet.2018.04.007](https://doi.org/10.1016/j.neulet.2018.04.007).

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