References supporting the Positive Mental Training animation.

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Firstly, athletes are well documented to be optimistic and have high levels of positive emotions, they are highly resilient and tend to see a failure as a learning situation; see the positives in their performance (reappraisal). They also display a leftward cerebral dominance (as per left insula in the animation)[1]. Our programme is based on instilling an Olympic Sports mindset. For memory and mood see Emily Holmes' work, a good review of the field.[2]

The Firewall. This is based on the self-memory system as proposed by Conway & Pleydell-Pierce in 2000 [3] and still regarded by many as the most comprehensive model for understanding many of the phenomena of memory. This model divides memories into 3 categories. There is Lifetime Memory, General Memory, and Event Specific Knowledge (ESK). In the trauma situation portrayed in the animation, for instance, the Lifetime and General memories would be 'when I was working in the office for Mrs B' (lifetime) and 'it was stressful working with Mrs B' (General) and the ESK memory would be 'one day I'd just started a coffee break when she started shouting at me for no reason', although the ESK memory would remain non-verbal and be more be a series of flashback images These memories are not automatically linked and for trauma, or just unpleasant memories, the ESK memory is often excluded – firewalled – so the person is unaware of the damage it has caused and the negative effect it continues to exercise. This model is generally accepted as a useful working model of stress triggered memory, accounting for memory defences as a mechanism for exclusion of very intense emotions so that their thinking processes remain intact. So someone might remember that their parents argued when they were small but will not recall specific arguments and the powerful distress they felt at the time, feeling helpless and frightened. They might think they are over it all, but certain ways their current partner or a work colleague has of speaking/behaving may act as an unconscious cue, making them feel helpless and angry without knowing why.

'A fundamental premise of our approach is that autobiographical memories are transitory dynamic mental constructions generated from an underlying knowledge base. This knowledge base, or regions of it, is minutely sensitive to cues, and patterns of activation constantly arise and dissipate over the indexes of autobiographical memory knowledge structures. Such endogenous patterns of activation may not coalesce into "memories," nor do they necessarily or even usually enter into consciousness' Conway & Pleydell-Pierce (2000) page 261.

Adverse Childhood Experiences (ACEs) are recognised now as having a major impact on our wellbeing, and of being a major factor in depression and probably most mental and many physical health disorders. Recalling a feeling of helplessness and incompetence and lack of relatedness is guaranteed to lower our self-esteem long term. We need a mechanism to deal with it.

These findings are reflected in the experiences in our collaborating researchers in Canada, led by Fred Philippe, who have formulated a theory of episodic memory networks (single event rather than general memories), linked thematic episodic memories that may support or thwart our ability to cope in certain situations and looked at the influence these networks have on key negative memories.[4] [5] They found that people do not recognise the effect of negative memories (doubtless because they do not come into consciousness):

'....people may not be aware of the actual effect that their episodic memories may have on their well-being. Indeed people appear to falsely believe that need-satisfying memories exert the most influence on their well-being, but not need-thwarting memories…… it would appear that people are not aware of the actual effect of their memories on their well-being.' P 509 -510 [6]

Here also a personal communication from Fred Philippe Oct 2017:

'obviously memories are not always activated implicitly (although it is probably the most frequent case scenario), but they can also be activated explicitly, either deliberately or involuntary (as when a memory pops in people's mind without a previous deliberate intent to retrieve it).'

Philippe's group looked at freely associated memories that are linked to peoples' stressful memories or events and found that the first 3 memories in the memory network, recalled in free association, were the most important in terms of the positive or negative effect on coping and situational and long-term wellbeing. Our own work with Philippe, verified his model of coping, resilience and memory networks and in our joint study we found that we could change one of the 3 core memories from negative to positive[7]. This flipped the students into a 'coping' state with

feelings of autonomy, competence and relatedness (self-determination) they were able to visualise a good future outcome in which they are coping and competent, and this would then be triggered in the relevant situation. This fits well with our previous research which showed a significant increase in quality of life and decrease in depression.[8] One phenomenon of memory which can be retrospectively explained by these ideas of Conway & Pleydell-Pierce (2001) and Philippe, Dobbin et al (2017) is the early work of Freud as seen in the case of Emma[9].

The Body Switch. The concept of the parasympathetic 'relax and relate' system switching off the sympathetic 'fight or flight' system, a concept called **opponent inhibition**, is summarised by Arthur Craig. (Craig A (2015) 'How do you feel? An Interoceptive Moment with your Neurobiological Self' Princeton University Press 2015: Chapter 8 and Fig 21 plate 16). He has established over a lifetime of innovative research in functional neuroanatomy, that the pathways he discovered from body to brain show that certain bodily sensations (affiliative touch, oxygen and nutrient levels, circulatory flow, pain and more) in particular those that take the contralateral spinal pathway (up the spinothalamic tract) are in fact ***not*** sensations in the way medical students have traditionally been taught; they are part of an autonomic afferent system that flow directly to the 2 **insula**s, left and right, which brain centres activate the parasympathetic and the sympathetic systems respectively, with, for instance, affiliative touch and signals of bodily health flowing to the left insula while pain and signals of inflammation and body *dis*-ease flow to the right insula. The left and right insulas are associated with emotional activity, they activate different behavioural strategies through robust connections to their respective anterior cingulates, and the whole emotional system and its feedforward and feedback pathways, connected to the body by the spinothalamic tract and the vagus nerve, is very separate from the somatosensory cortex. As the sympathetic system is associated with withdrawal (fight or flight) behaviour and the parasympathetic system with approach (relax and relate) which promote diametrically opposed behavioural strategies, Craig suggests and demonstrates that there are brain pathways that switch the balance between one and the other, he suggests the pathway of inhibition is probably the anterior commissure (private communication) from rat experiments. To understand more about these ideas see Craig (2009)[10] and a useful video[11] .

Stephen Porges came up with a theory of how the parasympathetic system changed our physiology and behaviour, affecting all the cranial nerves to make us more receptive to approach by others switching into an 'automatic' affiliation mode, linking us to a positive upward spiral of affiliation and good feelings [12] Porges' early work established the effect of respiration on the parasympathetic nervous system and mental health (panic) [13] showing that changes in the homeostasis of gas and electrolyte control decreases parasympathetic activity and can cause panic. Others have found that slow breathing increases the end tidal CO_2, and indeed slowing the breathing is a recognised way of controlling panic and anxiety[14]. CO_2 is the key factor controlling arteriole dilatation and oxygen release from haemoglobin (Bohr Effect), increasing the oxygenation and nutrition of all body tissues, increasing autonomic feedback up the spinothalamic tract (the pathway identified by Bud Craig) increasing activity in the left insula while simultaneously diminishing activity in the right insula. This essentially means we can calm the mind with the body, as Craig says:

'bodily awareness, or more accurately interoceptive awareness, has a crucial role in emotional awareness, in other words, the neural substrates responsible for subjective awareness of your emotional state are based on the neural representation of your body's physiological state.' [15]

So slow deep breathing will calm the mind [16] and isometric Jacobson relaxation also has an added positive effect. A second useful outcome is that focussing attention on the bodily sensations associated with specific breathing patterns, may cause thalamic blocking of attention to threat cues, reducing distressing and distracting sympathetic arousal from cues that may arise from firewalled memories. The result is an intense parasympathetic state from the physiological exercises which also switches off the sympathetic system by opponent inhibition, along with the removal of attention from negative environmental cues. We regularly demonstrate this in our workshops (we have a video of this) measuring heart rate variability in real time combined with emotional observation of trauma memory and recovery. Additionally, an anatomical pathway of mammalian calming by slow breathing has recently been established; a link between a nucleus that controls breathing rate and the locus coerulus, the centre that promotes mammalian arousal[17]. Although the relationship between breathing science and emotional regulation is complex, there is no doubt that it has been known about since antiquity and now has a validated scientific basis for emotional

and physiological control. The upshot is that as humans we are aware of our feelings and *we can choose how we want to feel* in a way that is possibly independent of our genetic and epigenetic experience.

So paying attention to our breathing **1)** removes the insidious effect of unconscious negative environmental cues engendered by ESK memories, but **2) also** stops us rejecting more positive and functional explanations of unpleasant events (i.e. that event was 'not your fault it was just a random event') that we might normally reject by paying attention[18] because the rise in positive self-regard might challenge our safe level in the social status quo, our social homeostasis. A third useful outcome is that the act of following a visualization of a past event also changes our attentional focus, and puts us into an altered mental state which has been likened to a state of mindfulness[19], and this state has been shown to help us positively reappraise past negative events; it also drives the process of attentional distraction and thalamic inhibition still deeper, and Positive Mental Training also drives:

' visualisations of situations displaying traits, mindsets, and actions characteristic of resilience, such as self-control, hardiness, taking on challenges, experiencing growth as result of difficulties, strong personality, high self-esteem, trust in abilities, being energetic, and positive meaning finding.'(Philippe et al 2017 p3)'

Finally the cycle of the animation takes us back to Olympic Sports: The students in our study listening to the resilience programme *all* had an average increase in needs satisfying coping memories by 1 out of 3, even the ones who had good psychological adjustment (i.e. 2 needs satisfying memories) in their network to start with. This may explain how the programme can simultaneously increase the performance at the top level of sport and aid recovery from the social defeat of depression and anxiety; increasing performance in both the sports *and the social* arena. This brings us back to the origin of Positive Mental Training, as an Olympic sports development programme, created from the study of the mental and physiological skills and mindset of Olympic gold medal winners.

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