From Co-Emergence Dynamics to Human Perceptual Evolution: The Role of Neuroplasticity during Mindfulness Training

Bruno A. Cayoun

Psychology Centre (TAS)
& University of Tasmania

Mindfulness has been defined as a state in which one pays attention "on purpose, from moment to moment and nonjudgementally" (Kabat-Zinn, 1994, p. 4). The training of mindfulness has a long history in Eastern cultures dating at least 26 centuries. Historical texts tell us that its early proliferation in Asia had improved the way of life of ancient societies for centuries.

It is generally accepted that the aim of mindfulness training is to develop greater objectivity, acceptance and detachment with each experience. Using a standard delivery structure, daily practice of mindfulness meditation teaches the trainee to perceive thoughts merely as thoughts and body sensations as body sensations, with an attempt to not identify with the experience. The training promotes reliance on perceptual, rather than judgmental, appraisal of information, resulting in greater ability for experiential acceptance.

Since its inception in Western therapy programs, mindfulness training has been adapted to various clinical populations (e.g., Cayoun, 2004; Kabat-Zinn, 1982, 1990; Kristeller & Hallett, 1997; Linehan, 1993; Orsillo, Roemer & Barlow, 2003; Schwartz, 1996; Segal, Teasdale, & Williams, 2002; Witkiewitz, Marlatt, & Walker; in press). There is evidence that the association of mindfulness skills with cognitive and behavioural models of therapy can generate greater therapeutic benefits than applying some of these models alone (see Baer, 2003, for a review).

Attempts to account for change following mindfulness training have brought forward the notion of embodied cognition, whereby the continuous interaction of thoughts and body sensations plays a central role in emotional reactivity and the reinforcement of psychopathology. For example, Teasdale and colleagues proposed that people's emotion-related models are produced by patterns of sensorily-derived input, maintained by self-perpetuating processing configurations via feedback loops (Teasdale, Segal, & Williams, 1995). Teasdale and Barnard's (1993) Interactive Cognitive Subsystems (ICS) approach integrates top-down and bottom-up processing with an ecological notion of self-organised systems.

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The Co-emergence Model of Reinforcement

The Co-emergence model of reinforcement emphasises the central role of embodied cognition in the reinforcement of common and maladaptive responses in terms of their neurophenomenology. It is a non-dualistic conceptualisation of how mind and matter co-emerge to produce an experience and the learning that derives from it (Cayoun, 2004).

The non-pathological functioning of the overall information system necessary for reinforcement is presented in Figure 1. Within a few hundred milliseconds, the stimulus is perceived, evaluated according to past experiences, needs, personality, expectation, values, etc, leading to the manifestation of body sensations to which one may react with a learned response when these reach a sufficient level of intensity. Reactions tend to occur even though body sensations may remain below awareness level, i.e., in absence of arousal.

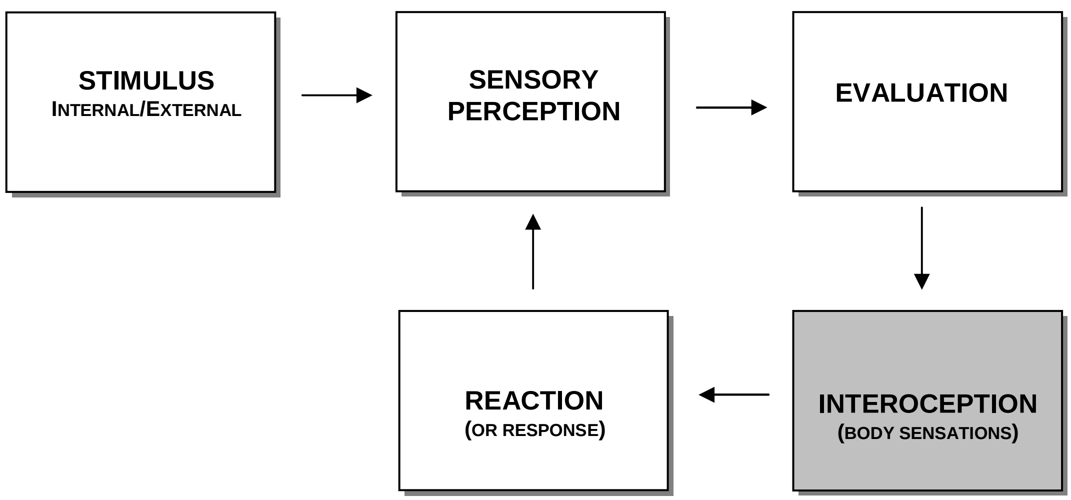


Figure 1. Functional components in the co-emergence model of reinforcement.

These four generic components function in equilibrium when mental health is optimum and in disequilibrium when normal functioning is challenged. This conceptualisation points to the inherent coupling of Evaluation and Interoception, the co-emerging components of the system. Despite the apparent hierarchy of the model, input into the perceptual component (Sensory Perception) may also be generated by the person’s thoughts, body sensations or reactions. In this case, they constitute an internal stimulus.

Maintaining Mental Illness

Although the reactive component is an innate phenomenon linked to the CNS, its excessive and sustained activation leads to disequilibrium in the system. Central to this model is the notion that psychopathologies cannot coexist with a well-balanced information-processing mechanism. Psychopathologies are facilitated and maintained when the disequilibrium is established as the predominant (stable) state. It follows that equilibrium between the four functions may predict the likelihood of mental health and, to a lesser extent, physical health (see Langer, 1989, for the relationship between mindfulness and longevity).

Figure 2 displays the system in the most common state of disequilibrium. The reliance on perceptual (more realistic) features of stimuli and awareness of physiological states is minimised, whereas reliance on evaluative and reactive habit patterns is maximised. This is consistently observed during the early stage of mindfulness training. It seems that the more a person is stressed by a psychological condition, the less he or she is able to feel common body sensations, such as feeling the weight or touch of the hands on the armchair's sides or pressure under the feet. On the other hand, more relaxed individuals, although untrained, seem to be able to access common body sensations with little difficulty.

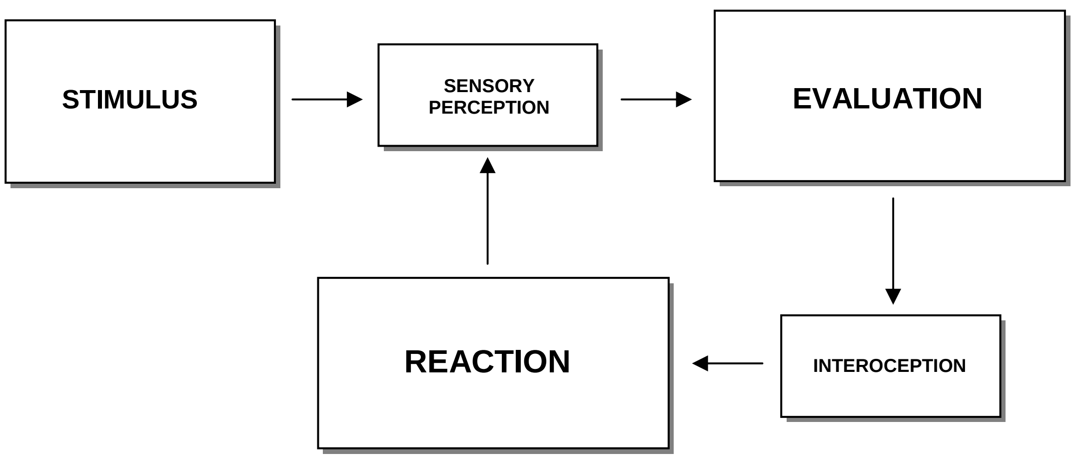


Figure 2. Disequilibrium in the information processing system.

This pattern may be best explained in terms of differences in the allocation of attention. Using a biological view as an example, in an unsafe environment, since the processing of the perceptual aspects of stimuli and body sensations is time consuming and not crucial in the presence of a serious threat, the organism gains processing speed by altering the deployment of attention resources. A decrease in mental effort to process Sensory Perception and Interoception, and an increase in mental effort to process Evaluation (schematic models/established memory networks) and Reaction (rapid automatic decision), can make the difference between life and death. At increased levels of disequilibrium, this attention shift coincides with sympathetic physiology and the flight or fight response.

The differential distribution of attention across the components is also the result of avoidance strategies consisting of distracting oneself from processing aversive body sensations caused by negative mindsets. Moreover, this intentional 'mindlessness' (Langer, 1989) may be learned, and learned disequilibrium keeps the individual in a cycle of maladaptive reinforcement (as shown in Figure 2). This view fits with what others have called "experiential avoidance" (Hayes, Wilson, Gilford, Follette, & Strosahl, 1996).

To regain equilibrium in the system, new parameters must be set. By learning to attend to all body sensations and co-emerging thoughts indiscriminately, without evaluating or reacting to any, more attention is made available for the processing of Sensory Perception and Interoception and less is allocated to Evaluation and Reaction, bringing back greater balance between components (as in Figure 1).

A Neurophenomenological Rationale for Mindfulness Training

A central assertion of this approach is that learned disequilibrium can lead to psychopathology. The more stable the imbalance, the more chronic the condition. On the other hand, a system in equilibrium acts as a buffer and 'resists' psychopathology. More healthy and relaxed individuals tend to feel subtler body sensations more readily and have a greater ability for metacognitive awareness. Since mindfulness training plays a role in promoting balance in the system, which in turns increases resilience, its use alone or as an adjunct to other models for decreasing a broad range of psychopathologies is justified (Cayoun, Sauvage, & van Impe, 2004).

The Role of Neuroplasticity

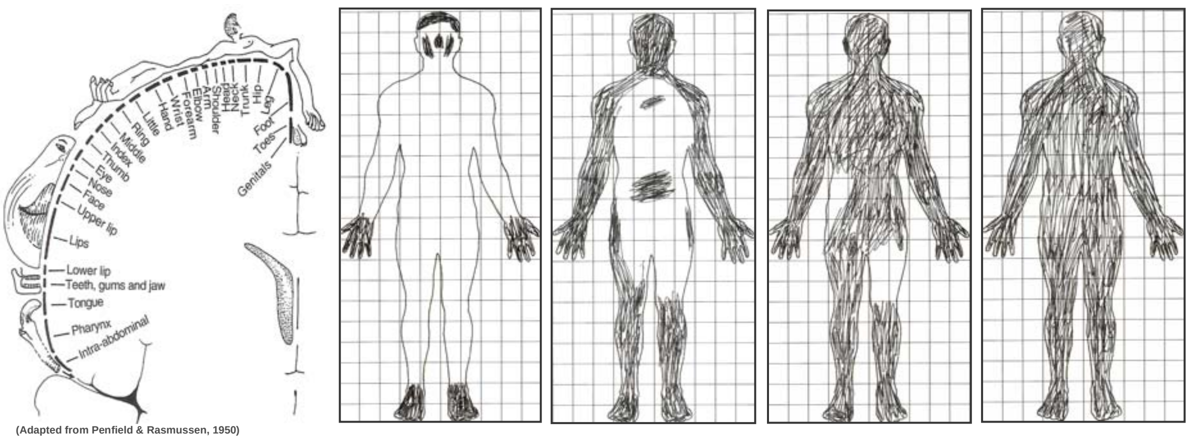
Regions of the frontal lobe play a major role in the control of "online" attention that enables metacognitive awareness. It enables executive processes, including the inhibitory control of reactive behaviour, to facilitate the decision and execution of deliberate action. Additionally, the parietal lobe plays a major role in the overall allocation of attention, enabling the monitoring of, and increase sensitivity to, body sensations (Interoception). In particular, the somatosensory cortex is the region in which most body parts are represented.

Studies investigating the neurophysiology of mindfulness training have attempted to map out possible changes in brain pathways associated with changes in behaviour, the neuroplasticity of mindfulness. Neuroplasticity is the capacity of neurons to adapt to a changed environment (FitzGerald & Folan-Curran, 2002). According to Hebbian learning, pre-synaptic terminals change in numbers according to usage and each learning experience strengthens existing neuronal connections (Hebb, 1949).

A recent randomised controlled study by Davidson et al. (2003) measured the effects of mindfulness training on brain and immune function in healthy employees of a biotechnology firm. The group trained with mindfulness showed significant increases of activation in the left prefrontal region at post-treatment which lasted up to four months following post-treatment. As shown by previous research (Sutton & Davidson, 1997), regions of the left prefrontal cortex are associated with arousal of pleasant emotions, such as fun, kindness, and compassion, whereas the right prefrontal cortex is associated with arousal of unpleasant emotions (anger, fear, sadness, etc). There was no such effect in the control group. The maintenance of this change highlights the role of mindfulness training in inducing neuroplasticity in pathways necessary for the self-regulation of emotions.

In the clinical environment, when clients learn to practise the body scan techniques as part of mindfulness training (Kabat-Zinn, 1990; Cayoun, 2004), they usually report an increased ability to feel sensations throughout the body, including those that were previously below awareness threshold; i.e., increased perception of internal states or Interoception (see also Kabat-Zinn, 2005). What is most remarkable is the persistence of this ability following long periods during which training has stopped. This effect is usually termed “between-session plasticity” (Sanes & Donoghue, 2000).

Figure 3 shows the increase of plasticity in somatosensory networks across the first four weeks of mindfulness training during an 8-week program using a 4-satge model of MCBT (Cayoun, 2004). In each weekly consultation, the client is asked to colour parts of a small silhouette printed on an A4 sheet according to the body areas they can feel. The grid facilitates the quantitative analysis of weekly progressions. Although the weekly progression in Figure 3 is that of a 42 year-old depressed male, it is representative of most males and females who adhere to the treatment protocol (approx. 30 minutes practice twice daily).



SENSORY HOMUNCULUS WEEK 1 WEEK 2 WEEK 3 WEEK 4

Figure 3. The relationship between the representation of the body in the somatosensory cortex and the progressive ability to feel body sensation using body-scanning techniques in a 42 year-old male.

Not surprisingly, the baseline in interoceptive ability at Week 1 corresponds to the initial delineation of the body in the primary somatosensory cortex, pictorially represented by the Sensory Homunculus (Penfield & Rasmussen, 1950). Since the face, hands and feet have disproportionately more connections in the brain, these body parts are usually easier to feel at the start of training. As practice develops with various scanning methods (see Cayoun, 2004, for detail), more connections are facilitated across the entire somatosensory cortex, enabling greater ability to feel sensory cues across the entire body.

With improvement in Interoception, the client feels subtle cues co-emerging with thoughts considerably earlier in a sequence of events. The benefits which derive from early cue detection include early appraisal of negative thinking and greater time and choice for responding.

Conclusion

The cognitive and behavioural sciences acknowledge increasingly that taking into account the embodiment of cognition in clinical models is a therapeutic asset. Recent research and clinical observations also show that mindfulness training promotes the enhancement of perceptual ability through brain plasticity in prefrontal and parietal regions, resulting in greater degrees of self-understanding and sense of control.

Besides the clinical implications that derive from these observations, the impact of the proliferation of mindfulness training in clinical services is also likely to be notable at the societal level. What if large numbers of individuals suffering from a chronic disorder or a problematic personality were to experience rapid growth in awareness and self-regulation of affect? I let the reader appreciate the positive impact of such global change on families, school environments, mental health services and the governments that fund them. As clinicians and educators, much like ancient teachers of mindfulness in the East, we might then come to realise the greater part we could play in the betterment of modern society.

References

Baer, R. A. (2003). Mindfulness training as a clinical intervention: A conceptual and empirical review. *Clinical Psychology: Science and Practice, 10,* 125-143.

Cayoun, B. A. (2004). *A four-stage model of Mindfulness-based Cognitive Behaviour Therapy: A training manual for crisis intervention and relapse prevention*. Manuscript submitted for publication.

Cayoun, B. A., Sauvage, V., & van Impe, M. (2004). *A non diagnosis-specific application of Mindfulness-based Cognitive-Behaviour Therapy (MCBT): A pilot study*. Annual report to The Hobart Clinic, Rokeby, TAS, Australia.

Davidson, R. J., Kabat-Zinn, J., Schumacher, J., Rosenkrantz, M., Muller, D., Santorelli, S. F. et al. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine, 65,* 564-570.

FitzGerald, M. J. T. , & Folan-Curran, J. (2002). *Clinical neuroanatomy and related neurosciences* (4^{th} ed.). London: Saunders.

Hayes, S. C., Wilson, K. W., Gilford, E. V., Follette, V. M., & Strosahl, K. (1996). Experiential avoidance and behavioural disorders: A functional dimensional approach to diagnosis and treatment. *Journal of Consulting and Clinical Psychology, 64,* 1152-1168.

Hebb, D. O. (1949). *Organization of behavior*. New York: Wiley.

Kabat-Zinn, J. (1982). An outpatient program in behavioural medicine for chronic pain patients based on the practice of Mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry, 4,* 33-42.

Kabat-Zinn, J. (1990). *Full catastrophe living: The program of the Stress-Reduction Clinic at the University of Massachusetts Medical Center*. New York: Delta.

Kabat-Zinn, J. (1994). *Wherever you go, there you are: Mindfulness meditation in everyday life*. New York: Hyperion.

Kabat-Zinn, J. (2005). *Coming to our senses: Healing ourselves and the world through mindfulness*. New York: Hyperion.

Kristeller, J., & Hallett, C. (1999). An exploratory study of a meditation-based intervention for binge eating disorder. *Journal of Health Psychology, 4,* 357-363.

Langer, E. J. (1989). *Mindfulness*. New-York: Addison-Wesley.

Linehan, M. (1993). *Cognitive-behavioral treatment of borderline personality disorder*. New York: Guilford Press.

Orsillo, S. M., Roemer L., & Barlow, D. H. (2003). Integrating acceptance and mindfulness into existing cognitive-behavioral treatment for GAD: A case study. *Cognitive and behavioural practice, 10,* 222-230.

Penfield, W., & Rasmussen, T. (1950). *The cerebral cortex of man*. New York: MacMillan.

Posner, M. I., & Raichle, M. E. (1997). *Images of mind*. New York: Scientific American Library.

Sanes, J. N. & Donoghue, J. P. (2000). Plasticity and primary motor cortex. *Annual Review of Neuroscience, 23,* 393-415.

Schwartz, J. M. (1996). *Brain lock*. New York: Harper Collins.

Segal, Z. V., Williams, J. M. G., & Teasdale, J. D., (2002). *Mindfulness-based cognitive therapy for depression: A new approach to preventing relapse*. New York: Guilford Press.

Sutton, S.K. & Davidson, R.J. (1997). Prefrontal brain asymmetry: A biological substrate of the behavioral approach and inhibition systems. *Psychological Science*, 8, 204-210.

Teasdale, J. D. & Barnard, P. J. (1993). Interacting cognitive subsystems: A systematic approach to cognitive-affective interaction and change. *Cognition and Emotion, 5,* 1-39.

Teasdale, J. D., Segal, Z. V., Williams, J. M. G. (1995). How does cognitive therapy prevent depressive relapse and why should attentional control (Mindfulness) training help? *Behaviour Research and Therapy, 33,* 25-39.

Witkiewitz, K., Marlatt, G. A., & Walker, D. D. (in press). Mindfulness-based relapse prevention: The meditative tortoise wins the race. *Journal of Cognitive Psychotherapy*.