Joy and Calm: How an Evolutionary Functional Model of Affect Regulation Informs Positive Emotions in Nature

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Abstract

Key theories of the human need for nature take an evolutionary perspective and many of the mental wellbeing benefits of nature relate to positive affect. As affect has a physiological basis, it is important to consider these benefits alongside regulatory processes. However, research into nature and positive affect tends not to consider affect regulation and the neurophysiology of emotion. This brief systematic review and meta-analysis presents evidence to support the use of an existing evolutionary functional model of affect regulation (the three circle model of emotion) that provides a tripartite framework in which to consider the mental wellbeing benefits of nature and to guide nature based wellbeing interventions. The model outlines drive, contentment and threat dimensions of affect regulation based on a review of the emotion regulation literature. The model has been used previously for understanding mental wellbeing, delivering successful mental health care interventions and providing directions for future research. Finally, the three circle model is easily understood in the context of our everyday lives, providing an accessible physiological based narrative to help explain the benefits of nature.

Keywords: affect regulation, positive affect, neurophysiology of emotion, nature, wellbeing.

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Biophilia takes an evolutionary perspective that humans have a biologically based innate need to affiliate with life in the natural world and to recognise and seek out the resources the natural world provides (e.g. food, water, shelter) (Wilson, 1984; Kellert, 1993). The human brain is also a product of evolution, and difficulties including mental health can arise when we become ignorant of our origins as part of nature (Wilson, 1992). Following the functional-evolutionary perspective of Ulrich (1983), affective emotions are often considered in research concerning our connection to nature, and the benefits people derive from nature. Such work often focusses on positive affect (e.g. McMahan & Estes, 2015), but does not tend to consider an evolutionary functional view of affect regulation and the neurophysiology of emotion. As our connection to, and the benefits of nature are affective, and affect has a physiological basis, it is important to consider the wellbeing benefits of nature within a model of affect regulation. This review considers the emotion regulation literature before presenting evidence from empirical work in natural environments to support the application of an existing evolutionary functional model of affect regulation, namely the three circle model of emotion (Gilbert, 2005), to this domain. This model provides a useful framework in which to consider positive affect and the mental wellbeing benefits of nature.

Neurophysiology of Emotion

Affect is the constant companion of sensation, with feelings, rather than thoughts, coming first when encountering nature; Ulrich’s functional-evolutionary perspective suggests that encounters with nature can induce wakeful relaxation and positive emotional reactions (Ulrich, 1983). Emotions provide the impetus for action and motivation, impacting the body in a manner that cognition alone cannot (Gilbert, 2014). Emotions have a biological basis and analysis of emotion should not exclude regulatory processes; emotions and their regulation should be considered as one (Kappas, 2011). For wellbeing these emotions need to be balanced as affect-regulation systems control our heart, muscles and the way our brain functions in order to achieve balance (Kappas, 2011).

Taking an evolutionary perspective, origins of the scientific approach to emotion are largely credited to Darwin (1872) and the idea that emotions have evolved as solutions to nature that promote survival. Termed ‘serviceable association habits’ Darwin suggested that emotions and their expressions evolved because they are reliable antecedents of particular behaviours, with Frijda (1987) suggesting a relatively small set of such action tendencies. According to Frijda, these action tendencies allow us to establish, maintain or disrupt a relationship with the environment. This is perhaps not too dissimilar to the arguments of Gray (1982) who suggested that three fundamental emotion systems exist in the brain to enable situation specific responses (primarily to resolve anxiety): a fight or flight system (F/FLS); a behavioural activation system (BAS) and a behavioural inhibition system (BIS). Based upon research in rats, Gray suggested a number of brain circuits and roles involved in these different systems. Albeit simplified, the F/FLS system (amygdala, hypothalamus, central gray) serves to enable defensive reactions, the BAS (basal ganglia, dopaminergic tracts) to enable approach to signals of reward and non-punishment and the BIS (septo-hippocampal circuits) can be thought of as a mediator when conflict arises in situations of approach-avoidance conflict. At the level of the rat, the latter could be considered conflict between the presence of food (appetitive & rewarding) and the scent of a cat (predatory & feared).

Of note much research has focused on the F/FLS system drawing, for example, from the early work of Papez (1937) and Maclean (1949). Emerging from such literature great emphasis has been given to the limbic system and regions such as the amygdala in emotion and threat processing. Largely based upon the research of LeDoux (2014; 1998), the amygdala is well-established as playing a key role in the processing of emotional information, regulating emotional responses and controlling fear reactions in a range of species (see for example Fox et al., 2015 & Phelps & LeDoux, 2005 for reviews). Indeed, much recent research still supports the notion that a phylogenetically old subcortical pathway provides rapid, but coarse, threat-related signals in humans via the amygdala (Mendez-Berolo et al., 2016; Maratos et al. 2009). However, this approach isn't without criticism and Pessoa (2014) suggests that given its rich connectivity the amygdala is arguably a processing hub belonging to a minimum of at least three networks pertaining to: visual processing; autonomic awareness & the generation of bodily states; and, a values network in which the value of a current state and future reward is evaluated relatively. This values network arguably arises given the rich connectivity between the amygdala and almost all regions of prefrontal cortex (PFC) (Averbeck & Seo, 2008). Certainly, the PFC (commonly referred to as the 'seat of reasoning') is now well established in emotion regulation processes (see Oschner, Silvers & Buhle, 2012 for review), with disrupted connectivity between limbic and prefrontal brain regions implicated in a number of affective disorders such as anxiety (Etkin, 2009) and depression (de Almeida et al. 2009)

A different, but no less valid, perspective to approach emotion and emotion regulation is via identification of the neurochemical systems that influence emotional responding. Here, prominence should be given to Panksepp (1998) whose research gave rise to the importance of different neurotransmitters for particular affective systems/states. Again applying a tripartite model or the notion of a 'triune' brain (Maclean, 1990), Panksepp proposed that affective processes can be divided into reflective affects such as pain or pleasure (brain stem regions), grade A emotions such as fear or joy (mid brain regions) and higher sentiments such as shame, guilt, empathy etc. (frontal cortex). Importantly, however Panksepp noted that all such emotions were sub-served by a number of neurotransmitters - from serotonin and noradrenaline (norepinephrine) more generally across all levels, to dopamine, oxytocin and opioids more specifically involved in seeking, reward, play/pleasure and care.

For example, dopamine is key in reward processes (Bressan & Crippa, 2005), with dopamine producing neurons in the substantia nigra connecting to the basal ganglia. In a second pathway, dopamine producing neurons in the ventral tegmental area (VTA) connect with the hypothalamus and basal ganglia (collectively named the ‘pleasure centre’ by Olds, 1956), as well as the amygdala and frontal regions. Oxytocin has been suggested to be key in maternal care and romantic care, with receptors for oxytocin, located in high numbers, for example, in the central nucleus of the amygdala. Additionally, in rats, blocking receptors for oxytocin in the VTA leads to the blocking of maternal behaviours (Pedersen et al. 1994) and in Prairie voles the blocking of oxytocin leads to decreased pair-bonding and increased promiscuity (Cho et al., 1999). Human research also appears to demonstrate the central role of oxytocin in affiliative relationships spanning kin, romantic bonding and trust (Graustella & MacLeod, 2012), but this research is not without its critics (Nave & McCullough, 2015). Finally, opioids are well established in the relief of pain, with research suggesting both opioid and dopamine systems are important in modulating both pain and pleasure (Leynes & Tracey, 2008).

Gilbert (2005; 2014) attempted to assimilate such research from these varied approaches to emotion regulation into an accessible model. It is of note that whilst this is not the only recent model of emotion regulation (see for example Etkin, Buchel & Gross, 2016; Lindquist et al., 2012), the approach taken by Gilbert is to draw literature from beyond the neuroimaging literature as well as place greater emphasis on positive emotions in any such model. In doing so, Gilbert (2014) outlines a ‘three circle model of emotion’ and affect regulation (see Figure 1). This model, not only draws from existing theory and literature such as that above, but also takes into account advances made with regard to our understanding of affiliative and positive emotions with respect to reward pathways, dopamine and oxytocin (see also Depue and Morrone-Strupinsky, 2005 for review); as well as research into the balance between the sympathetic and parasympathetic nervous system by Porges (2009; 2007; 1995). The three circle of this model represent drive, threat and contentment, and are easily understood in the context of our everyday lives. Drive: resource focus, wanting, pursuing, achieving and consuming is associated with feelings of excitement, joy and pleasure and notably linked to dopaminergic systems. The function of this system is to drive us toward resources and rewards. Contentment: safeness, connection and affiliative focus is associated with feelings of contentment, safeness, calm and notably linked to oxytocin and opiate systems. The function of this system is to ‘turn-off or tone-down’ drive and threat systems and to restore energy. This system also evolved to enable attachment, and functions to provide a calming soothing process when affiliative signals are present so that individuals can engage with affiliation and attachment behaviours. Threat: anxiety focus, protection, safety seeking, activating and inhibiting is associated with feelings of anxiety, anger and sadness and notably linked to adrenaline, as well as cortisol and also noradrenlaine. The function of this system is defensive and protective, to keep us alert to threats and to seek safety.

When considering responses to natural environments, Ulrich (1983) noted that drive and contentment can be seen to correspond with positive and relaxing reactions. From such a perspective, the balance between drive and contentment can also be compared to the long-standing account of two phases of positive states, appetitive activity ‘doing’ and consummatory response ‘being’ (Tinbergen, 1951). Once a goal has been achieved (e.g. a resource such as food has been obtained), drive systems need to be ‘turned off or toned down’ (down-regulated) to balance energy expenditure and provide positive affect in the form of contentment. This is not dissimilar to the approach of Gray (1982), but in the nature example described here the contentment system is seen as affect-regulating (Depue & Morrone-Strupinksy, 2005) although, comparatively, as distinct from the drive system and feelings of excitement (Gilbert et al., 2008).

This stated it is important to note that the above brief description of the model in terms of emotions to nature is an accessible simplification. Presented in such a manner allows for the quick understanding, explanation and framing of research findings related to how nature affects our mood states, our physiology and also acts an emotional regulator. Of note in reference to the three circle model (i.e. Gilbert, 2014), the model is more complex and dynamic then as described above with each of the three systems regulating each other to produce blended affects. For example, affiliation is not just linked with the contentment system, it can be linked to the drive system (e.g. excitement about a social event or relationship), or the threat system (e.g. anxiety when a loved one becomes ill), just as both opioids and dopamine are linked to pleasure and pain.

Importantly, it has recently been argued that evolutionary aspects of human connection to nature have modern clinical relevancy and nature should be part of established mental health care (Mantler & Logan, 2015). The three circle model of affect regulation presented provides a foundation for Compassion Focused Therapy (Gilbert, 2009b; Gilbert, 2014), thus showing its utility for improving the understanding of mental wellbeing and delivering successful mental health care interventions. Certainly, the three circle model is used successfully in both clinical and non-clinical settings alike to explain the ‘tricky brain’ scenario and how the complexity of evolved and dynamic brain systems interplays with our physical and mental health. Its accessibility, for example, has led to its appearance not only in research papers and training manuals but in popular web forums such as ‘Netmums’, as a model to improve health and happiness (Netmums, 2016). This same model of affect-regulation can be applied to explain the benefits derived from nature (e.g. promotion of soothing affect) and to guide interventions (e.g. ecotherapy) which aim to increase wellbeing through our connection with nature.

Considering Types of Positive Affect

Despite the models of affect regulation presented above (most notably the three circle model), and although Ulrich (1983) outlined two types of positive affect (wakeful relaxation and positive emotional reactions to nature), the majority of studies into the benefits of nature, and a connection to nature, have focused on and found increases in a single dimension of positive affect (see McMahan & Estes, 2015 for review), without considering specific types of positive affect or regulatory processes. Howell & Passmore (2013) note that research into positive affect and nature has had some mixed results and this may be because aspects of hedonic wellbeing vary in their relationship to nature affiliation, but also because positive affect can be seen to cover vitality or drive and positive soothing or contentment. They conclude that nature can elicit feelings of ecstasy and wonder, and foster feelings of comfort. Similarly, whilst the main approach in the emotion literature is to apply a categorical approach to the structure of affect, the above highlights the potential benefits of dimensional approaches where experience is much more than a single emotion but *felt* core affect where importance is placed upon continuums of pleasure and arousal (see for instance Russell, 2003).

Moreover, often overlooked is that neurophysiology research has demonstrated two types of positive affect which drive actions that go hand in hand with physiological changes and autonomic support (Fredrickson, 2001). The three circle model also indicates two types of positive affect - drive and/or contentment (Gilbert et al., 2008; Gilbert, 2014). Drive is stimulating and activating, accompanied by joy, fun and excitement (high pleasure, high arousal), but is also involved in competitive drives. Drive seeking is linked to the sympathetic nervous system, and over reliance can increase vulnerability to depression, particularly where individuals are striving to achieve in order to avoid inferiority or when individuals experience failures to obtaining a goal (Gilbert et al., 2007; Gilbert et al., 2009; Gilbert, 2014). The second type of positive affect, contentment, affiliation and safeness can often be overlooked. These calming and soothing emotions (high pleasure, low arousal) are regulating and can bring balance, toning down the sympathetic threat and drive systems. This contentment and affiliation system is linked to the parasympathetic nervous system which is sometimes referred to as the ‘rest and digest’ arm (Porges, 2007) and is associated with opiates and oxytocin. This system is focused on restoration and affiliation and can be compared to a mindful ‘being’, rather than 'doing' mode – and feeling more ‘connected’ (Gilbert, 2014). As highlighted above, considering positive affect within the context of the three circle model reveals two types of positive affect. One associated with drive and feelings of excitement and the other contentment and feelings of safeness and connectedness.

Beyond Ulrich (1983), a search of the literature that considered terms including natural environment, positive affect, affect regulation and neurophysiology, found few papers that considered the neurophysiology of emotion and models of affect regulation within the context of the natural environment. For example, Van den Berg, Koole and Wulp (2003) consider cognitive (e.g. Kaplan, 1995) and affective (e.g. Ulrich, 1983) processes and provide a useful introduction to affect and restoration with reference to regulation, without moving into neurophysiology beyond mention of physiological indicators of stress. Parsons (1991) considers the influence of the natural environment on wellbeing within the context of Henry’s (1980) model of neuro-endocrine responses and LeDoux’s (1986) model of subcortical affective processing. This work supports a proposal for two types of affect initiation response systems within the context of immediate affective responses to environmental stressors. Thus, their approach provides insight into the impact of stressors in urban environments, rather than positive affect of natural environments but is rather dated.

Within the context of responses to nature, Ulrich et al. (1991) note that activation of sympathetic nervous system relates to readiness for action, consumes energy and is therefore non-restorative. The parasympathetic system functions to restore and maintain energy and has a central role in attention and restoration. They recognize the need to disentangle the two systems when considering responses to nature.

This entanglement is complex, as suggested above, affective emotions combine valence (positive-neutral-negative) and arousal (activation-inhibition) (Russell, 2003; Russell & Feldman Barrett, 1999), previously Watson and Tellegan (1985) also suggested two related dimensions of positive affect, pleasantness or activation. Activation refers to an arousal or engagement continuum including relaxation, through alertness to excitement. Pleasure relates to how well a person is doing and can be viewed from differing conceptual stances, for example positive-negative or approach-avoidance (Russell, 2003; Russell & Feldman Barrett, 1999). Thus these two proposed dimensions cover similar aspects as the three circle model above, but utilise differing continuums, this and aspects of the discussion above are included in Figure 2 to provide further context to the three circle model. Affective pleasantness forms part of hedonic wellbeing, along with a cognitive component related to satisfaction of desires, and this form of well-being is most often considered in nature connection and wellbeing studies (Capaldi et al., 2014). Hedonic wellbeing can be seen to include aspects of vitality and contentment, illustrating that the three circle model of affect regulation, is a simplification of complex inter-relationships, but nonetheless useful for framing results and explaining the benefits of nature to various stakeholders, many of whom, given the continued focus on the biomedical and neurological basis, welcome reference to underlying physiology when explaining the benefits of nature.

In summary, the three circle model of affect regulation presented provides a new perspective for the wellbeing benefits of nature, interpretation of results and directions for future research into understanding the benefits we find in nature. We know that nature, and a connection to it, is restorative, bringing the vitality we need in life – but given the role of mindful attention and self-reflection (Authors, 2015), part of the story is about affiliation, soothing and contentment and explicit assessment of this has often been neglected in previous research.

Sympathetic-parasympathetic balance

Underpinning the affect regulation systems are the physiological systems which bring about these states (of drive, contentment & threat). The sympathetic nervous system is activating and tends to be associated with states of threat or drive, in contrast the parasympathetic system is inhibitory but restorative and soothing and associated with states of contentment. According to Porges (2009; 2007; 1995), there are two branches of the vagal nerve which feed into the sympathetic and parasympathetic system, one is phylogenetically primitive and therefore unmyelinated. This branch acts as a quick route for stimulation of the sympathetic nervous system in response to threats. The other branch of the vagus nerve feeds into the parasympathetic nervous system and (in mammals) myelination of the vagus nerve evolved to function as a ‘break’ to tone-down sympathetic activity (threat & drive), bringing about parasympathetic activity and contentment. This adaptation allowed humans to engage with attachment and affiliative behaviours which are key for social engagement (Porges, 2009, 2007) and, crucially, allow more soothing/affiliative emotion-regulation to take place. The balance between these two branches is adaptive and beneficial to health and wellbeing, as it reflects a system that is balanced between threat, drive and contentment, with no single system (e.g. threat) dominating. However, the interplay between these two branches can be complex and produce blended patterns of positive affect (e.g. feeling content but also excited; which is consistent with a dimensional approach to emotion). It is not a simple case of as one system increases the other decreases, nor are the systems mutually exclusive; rather it is the *balance* and dynamicity between both systems that produces different physiological and mood states.

One way of investigating the balance between sympathetic and parasympathetic systems, or between drive and contentment, is heart rate variability (HRV). HRV is an established scientific method for indicating changes in the autonomic nervous system, in particular excitatory sympathetic and inhibitory parasympathetic activity that control the heart. It has been used to study physiological changes related to exposure to nature (Brown et al., 2013; Gladwell et al., 2012). In general, high total HRV indicates good dynamic balance between the sympathetic and parasympathetic system, whereas low total HRV suggests that the sympathetic system dominates. Low HRV is linked to poor health and wellbeing outcomes (Carney et al 2005; Thayer et al., 2010). Further, sympathetic mediators, such as threat, appear to exert their effects quickly and are reflected in the low frequency power of the HRV spectrum (Pomeranz et al., 1985). In contrast, vagal mediators, such as contentment, exert their influence more quickly on the heart and principally affect the high frequency power of the HRV spectrum. Therefore, this review will now consider previous research into the benefits of nature using HRV indicators to demonstrate sympathetic-parasympathetic activity and by association, well-being (and emotions), to nature. The results are tabulated to show the extent to which they concur with the outcomes predicted by the three circle model. Specifically, that: i) drive seeking (and threat) are linked to the sympathetic nervous system and will be lower in nature; and, ii) contentment is linked to the parasympathetic nervous system and will be higher in nature.

Literature Search and Inclusion Criteria

A systematic search of the literature (Khan et al., 2003) was used to locate studies for inclusion without any date restrictions. Database searching considered combinations of a number of keywords including: *natural environment*, *HRV*, *physiological*, *positive affect* and *affect regulation*. The reference sections of relevant papers were studied and citation searches completed in order to widen the search process. This process identified many papers that discuss and review research. Criteria were set to identify those papers that reported primary research into nature exposure while measuring HRV in comparison to an urban control. The 14 nature exposure papers that met the inclusion criteria are listed in Table 1 with details of sample size, design and support for the three circle model. A review study that reports a number of primary studies is included. A book chapter and two foreign language studies cited in English language papers were not included as the design or number of participants could not be ascertained.

Meta-analysis

All analyses were performed using Meta-Essentials (Van Rhee, Suurmond, & Hak, 2015). Thirteen eligible studies with a total of 871 participants were included in the meta-analysis. First, analyses were conducted and effect sizes calculated for each study (Table 3). Specifically, we calculated d and Confidence Interval (upper and lower) for studies that examined differences in HRV indicators of parasympathetic activity (rMSSD, HF, lnHF, SD1) and sympatho:parasympathetic balance (LF:HF ratio; LF/LF+HF; LF; lnLF, SDRR, SD2). Then, for each a combined effect size was calculated and examined using Forest plot. Finally, publication bias was examined by calculating the fail safe N (Rosenthal, 1979); because fail safe N is biased towards overestimating the number of null studies required to render the overall effect size nonsignificant (Carson, Schriesheim, & Kinicki, 1990), a funnel plot of the standard error by the standard mean differences was generated.

For parasympathetic activity, the Forest plot revealed a combined effect size of Hedge's g = 0.71 (CI 0.42 to 0.99, $p<0.001$, one-tailed) representing a medium effect (Table 2). The overall effect size was somewhat heterogenous Q (13) = 57.64, $p<0.001$; $I^2 = 79.18$ thus indicating that there are substantial heterogeneity issues, although no study reported effects in the contra-expected direction. Publication bias analyses were undertaken first by calculating fail safe N (Rosenthal, 1979). The fail-safe N was 157, suggesting that even if a great number of additional relevant studies with null results were included, the overall effect size would remain significant. The distribution of the funnel plot is symmetrical, suggesting no issues regarding publication bias (see Figure 3).

For sympatho:parasympathetic balance, the Forest plot revealed a combined effect size of Hedge’s g = 0.14 (CI -0.05 to 0.33, p=0.05, one-tailed) representing a small effect (Table 3). The overall effect size was somewhat homogenous Q (13) = 27.24, p<0.001; I^2 =55.95 thus indicating that there are some heterogeneity issues. Publication bias analyses were undertaken first by calculating fail safe N (Rosenthal, 1979). The fail-safe N was 148. The distribution of the funnel plot is symmetrical, suggesting no issues regarding publication bias (see Figure 4).

Nature and HRV Research Discussion

Importantly, the review of each study revealed that they do not consider their results in the context of affect regulation; indeed many of the studies do not consider affect, having an autonomic nervous system or Stress Reduction Theory (SRT) focus. Many of the studies identified consider forest bathing in Japan (Shinrin-yoku). Although the forest based studies lack the control of the laboratory, Kappas (2011) is critical of lab-based research into emotional response and McMahan & Estes (2015) found that across 32 studies there was no significant difference in positive affect responses to real nature vs lab-based nature images/videos. Of the studies identified, all provide full or partial support for the three circle model, with the meta-analysis confirming greater parasympathetic activity and somewhat lower sympathetic activity in the nature exposure conditions compared with the urban control conditions. Partial support occurs where significant differences in sympathetic nervous activity were not found, which is a point of discussion below.

In terms of the three circle model, the vast majority of results show that natural environments promote greater parasympathetic nerve activity (contentment), and lower sympathetic nerve activity (drive) than urban environments, with medium and small effect sizes found in the meta-analyses, respectively. An issue in the current context with such comparison to control studies is the observation that HRV in nature could remain the same, with urban environments stimulating sympathetic activity. It could then be argued that changes within the urban environments are actually responsible for the production of significant differences. Of importance here however, while few of the included studies consider temporal analysis, three studies do indicate within group temporal changes for components of HRV (Tsunetsugu 2007; Song 2015; Lee 2014). The excluded book chapter also reported significant differences in changes in HRV (Lee 2012). Therefore, there can be confidence that it is in fact nature bringing benefits, rather than urban environments removing them.

Recent results by Kobayashi et al. (2015) reveal interesting detail. Mirroring the medium and small effect sizes found in the meta-analysis, they noted that approximately 80% of participants showed an increase in the parasympathetic indicator of HRV, and 64% showed decreases in the sympathetic indicator of HRV; the remaining participants showed opposite responses. This raises the question as to the role of threat, anxiety and phobias in natural environments (e.g. some environments contain features which may have been a threat to survival in our evolutionary history). Certainly it is known that evolution has provided us with a set of ‘primed’ emotional responses which result in rapid selective learning and great difficulty in extinguishing such responses (see for example the seminal work of Mineka et al., 1984). Not surprisingly, therefore, Kobayashi et al. (2015) note that some people with biophobia (Kellert, 1993) report a strong dislike for natural environments, this includes specific phobias such as arachnophobia. People with arachnophobia showed increased heart rate during presentation of images or thoughts of spiders.

It can further be seen that eight of the studies measured anxiety, most often using POMS, all finding lower anxiety in the natural environment. However, those studies did not report analysis on anxiety as a potential barrier to positive HRV changes which may prove essential for our further understanding of the relationship between nature and positive emotions (especially given selective learning of primed emotions). Further, the three circle model presented, albeit simple, extends a number of emotion regulation models that have come before it, by including physiological indices of sympathetic activity and indicating that such activity can also be linked to stimulation, joy and excitement. Therefore there is the potential for increased sympathetic activity, rather than a decrease, in more connected individuals who report increased vitality in nature (Capaldi et al., 2014). Finally, the approach to sympathetic related measures varied considerably. These confounding factors could lead to the smaller differences in the sympathetic measurements, which achieved one-tailed significance with a smaller effect size in the meta-analysis.

Subsequently, there is a need for further consideration of individual differences and physiological responses. People who are more connected with nature, experience greater psychological benefits from contact with nature (Hartig, et al. 2011). With mindful attention and self-reflection being two further aspects associated with greater connection to nature (Authors, 2015). Further, it has been shown that spirituality (Kamitsis and Francis, 2013) and engagement with natural beauty (Zhang, Howell and Iyer 2014) are involved in the relationship between nature connectedness and wellbeing. It is worth noting that Berridge (2009) proposes that positive emotions may use sensory pleasure circuits, bringing about a link between aesthetic enjoyment and positive consummatory states (Kappas, 2011). Whilst the idea of pleasure circuits is not new and has been briefly reviewed prior to the presentation of the three circle model, this could well explain Zhang's finding that engaging with nature's beauty was required for wellbeing benefits. Last but not least, there may also be differences in those who come from rural or urban environments, differences based on individual's motivations for visiting green spaces (e.g. rest and relaxation, adventure, challenge, work) and what activities they engage in there. This could all influence the blend of emotions derived from being in nature and attests to the importance of dimensional approaches when considering emotions in nature. None of the studies in the meta-analysis explicitly explore these factors. Here therefore we are in agreement with Van den Berg (2015) who argues that more research taking in different scenarios, different types of green and blue settings, and different groups of participants is needed to gain further understanding of the physiological and psychological pathways between natural spaces and wellbeing.

In sum, the three circle model provides a framework for considering the benefits of nature and provides direction for further research. It is drawn from preceding emotion regulation literature and has been shown to fit with literature on a dimensional approach to emotion and positive affect. Albeit presented here in a simplified accessible format, there is scope for the model to explain the varying HRV results by considering the role of anxiety in reducing benefits. Further, nature connectedness mediates the wellbeing benefits of nature (Authors et al., 2016) and will therefore mediate benefits revealed by HRV measurements. Finally, engagement with natural beauty, self-reflection and mindful attention may also explain the differences in individuals' response to natural environments, but can all be accounted for in terms of the three circle model.

Conclusions

The purpose of this brief review was to highlight the need to link emotional responses to affect regulation (Kappas, 2011) and present evidence to support the application of an existing and accessible evolutionary functional three circle model of emotion and affect regulation within the context of the wellbeing benefits of nature. A key outcome of this process is the reminder to focus on the two types of positive affect that can explain previous mixed results (Howell & Passmore, 2013), as well as consider a dimensional approach to emotion in nature.

It is also possible to consider previous nature and wellbeing research using subjective measures within the context of the three circle model. A further review of the nature and wellbeing literature placing it into the context of the model is beyond the scope of the current review which focusses on proposing and evidencing the three circle model with relevant HRV studies. Therefore, examples broadly considering the three main aspects of the model, including the two types of positive affect, are used to illustrate its wider utility. For example, there has been a body of research that considers positive outcomes of nature engagement, such as improved vitality (Capaldi et al., 2014). This body of work can be mapped onto the drive aspect within the context of stimulation, joy and high arousal/ high pleasure. In contrast work on mindful attention and reflection (e.g. Authors, 2015; Howell et al., 2011) can be mapped onto the contentment aspect within the context of calm and low arousal/high pleasure. Finally, barriers to nature such as rumination and neuroticism (Authors, 2015) as well as potential selectively learnt anxieties can be mapped onto the threat dimension.

The model can also be considered within the context of existing theories regarding the benefits of nature. Psycho-evolutionary stress recovery theory (SRT) focuses on restoration after stress (Ulrich et al., 1991). SRT suggests increased positive affect, with the three circle model highlighting the need to consider both contentment and drive. The model can also be seen to include physiological arousal based on physiological adaptation to natural environments. Further, Mantler and Logan (2015) note that emotion is central to SRT, hence following Kappas (2011) there is a need to consider affect regulation.

Attention Restoration Theory (Kaplan, 1995) focusses on directed attention which requires non-salient distracters to be ignored, which brings cognitive effort. Directed attention, which can be compared to drive and sometimes threat, is common in modern life and ART proposes that natural environments are restorative. Its soft-fascination provides involuntary attention which facilities calm, rest and contemplation (Beute, 2013), thereby bringing the desired balance between the three aspects of the three circle affect-regulation model.

ART and SRT are both based on restoration, but Beute and Kort (2014) used HRV as an indicator of exertion of self-control and challenged the proposition that nature primarily provides restorative benefits, as results showed beneficial effects of nature when resources had not been depleted. The three circle model of affect regulation supports this account and encourages a perspective of wellness through balance. Nature can bring both joy and excitement *and* contentment and affiliation. Both are argued to bring a balanced emotional state and it is known that imbalance can lead to affective disorders (e.g. mania is associated with excessive drive, arousal and extreme euphoria). In terms of general well-being, the model allows for nature to be restorative and reduce stressors, while also highlighting that natural environments may not feel safe to some.

The three circle model also provides a tested framework in which to consider positive affect and the mental wellbeing and the benefits of nature. For example, stimulation of our contentment system is a goal of psychological therapies such as Compassion Focused Therapy. If natural environments can be used to stimulate this type of positive affect regulation system, nature can potentially be used to tone-down the threat system and bring about positive physiological change in the body. This would improve parasympathetic-sympathetic balance as indicated by the HRV literature above. Adding support for this argument, it is now well recognized that exercises used within CFT influence brain and bodily responding (see for example Duarte et al., 2015; Longe et al., 2010).

Finally, the three circle model can be easily understood in the context of our everyday lives and the model is accessible to all. Crucially the model in its present state provides a narrative for the lay person to understand the benefits of nature, while providing a convincing physiological basis for those not convinced by more subjective emotional accounts.

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Table 1. Nature exposure studies that measure HRV.

Study	**Pps**	**Design**	**Greater Parasympathetic**	**Lower sympathetic**	**Supports Three Circles**	**Lower Anxiety**
Brown et al. 2013	25	Lab based Nature v Urban Control	Higher than Control	Not tested	P	n/a
Gladwell et al. 2012	29	Lab based Nature v Urban Control	Higher than Control	Not tested	Y	n/a
Horiuchi et al. 2014	15	Forest View v no view control	Not Sig. v control, but Sig. effect of time	Not Sig	P	Y
Kobayashi et al. 2015	625	Forest v Urban Control	80% Higher than Control	64% Lower than Control	Y	n/a
Lee et al. 2011	12	Forest v Urban Control	Higher than Control	Lower than Control	Y	Y
Lee et al. 2014	40-44	Forest v Urban Control	Higher than Control	Lower than Control	Y	Y
Lee et al. 2015	12	Rural v Urban Control	Higher than Control	Lower than Control	Y	Y
Park et al. 2008	12	Forest v Urban Control	Higher than Control	Not Sig	P	n/a
Park et al. 2009	9	Forest v Urban Control	Higher than Control	Lower than Control	Y	n/a
Park et al. 2010	n/a	Review	Higher than Control	Lower than Control	Y	Y
Song et al. 2013	36	Forest v Urban Control	Higher than Control	Not Sig	P	n/a
Song et al. 2013b	13	Park v Urban Control	Higher than Control	Not Sig ($p = 0.06$)	P	Y
Song et al. 2015	19	Lab based Nature v Urban Control	Higher than Control	Not Sig	P	Y
Tsunetsugu et al. 2007	5-12	Forest v Urban Control	Higher at selected time points	Lower than Control	Y	n/a
Tsunetsugu et al. 2013	41-44	Forest v Urban Control	Higher at selected time points	Lower than Control	Y	Y

Results support ARM: Y = Yes; P = Partial; N = No.

Table 2: Parasympathetic Studies

Study name	Hedges' g	CI Lower limit	CI Upper limit	Weight
Brown et al. 2013	0.57	0.14	1	8.54%
Gladwell et al. 2012	0.24	-0.13	0.62	9.08%
Horiuchi et al. 2014	0.22	-0.3	0.75	7.79%
Kobayashi et al. 2015	0.97	0.87	1.06	11.21%
Lee et al. 2011	0.65	-0.12	1.42	6.16%
Lee et al. 2014	0.47	0.14	0.8	9.47%
Lee et al. 2015	1.17	0.38	1.95	5.77%
Park et al. 2008	0.59	-0.05	1.23	6.90%
Park et al. 2009	0.63	-0.09	1.35	6.43%
Song et al. 2013	1.48	0.82	2.15	6.44%
Song et al. 2013b	0.63	0.01	1.26	7.02%
Song et al. 2015	1.92	1.14	2.69	5.56%
Tsunetsugu et al. 2013	0.3	-0.01	0.62	9.61%

Table 3: Sympathetic:Parasympathetic Balance Studies

Study name	Hedges' g	CI Lower limit	CI Upper limit	Weight
Brown et al. 2013	0	-0.4	0.4	8.35%
Gladwell et al. 2012	0.25	-0.12	0.63	8.80%
Horiuchi et al. 2014	0.22	-0.3	0.75	6.34%
Kobayashi et al. 2015	0.32	0.24	0.4	16.33%
Lee et al. 2011	0	-0.68	0.68	4.95%
Lee et al. 2014	0.44	0.11	0.76	9.83%
Lee et al. 2015	-0.98	-1.72	-0.25	4.16%
Park et al. 2008	0	-0.59	0.59	5.73%
Park et al. 2009	0.63	-0.09	1.35	4.46%
Song et al. 2013	0	-0.45	0.45	7.49%
Song et al. 2013b	0.31	-0.26	0.89	5.76%
Song et al. 2015	0	-0.45	0.45	7.49%
Tsunetsugu et al. 2013	0.03	-0.28	0.34	10.32%

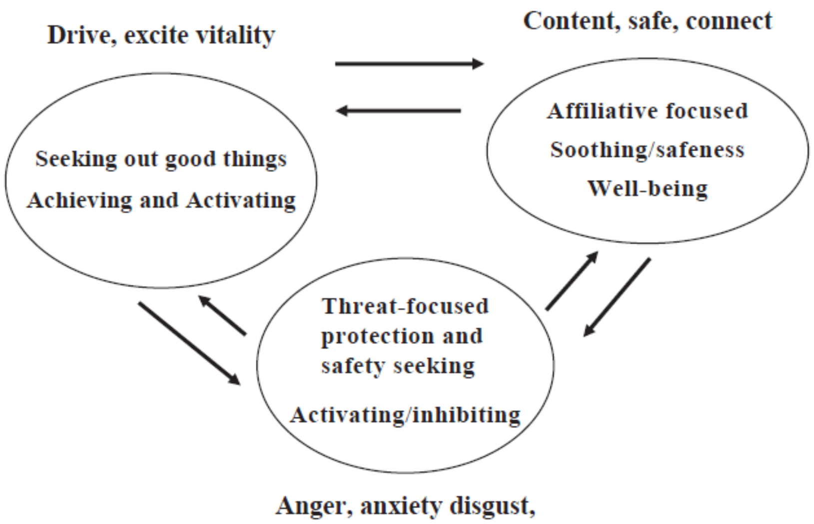

Figure 1. Three Circles of Emotion and the affect regulation system. From P. Gilbert (2009), The Compassionate Mind. With permission from Constable-Robinson.

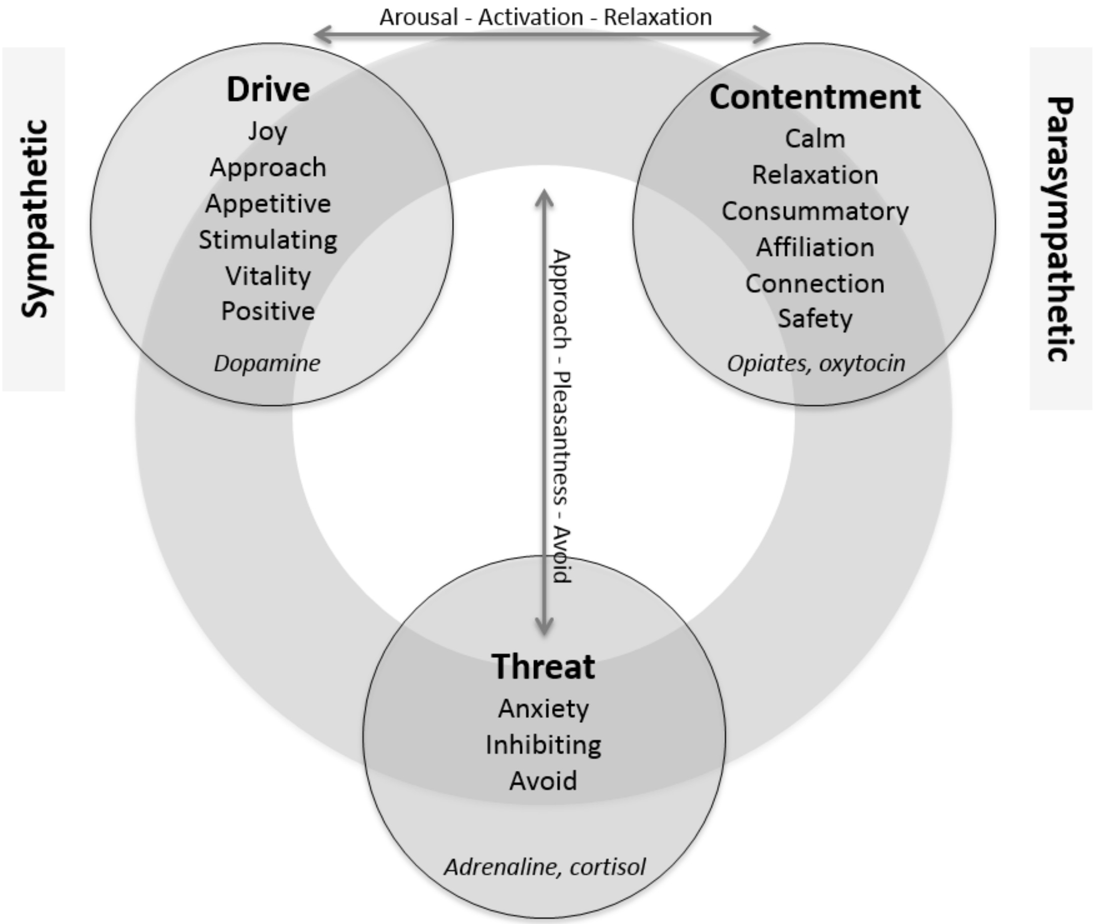

Figure 2. Three Circle Model of Affect Regulation with Dimensions of Positive Affect (informed by Gilbert, 2014; Depue and Morrone-Strupinsky, 2005; Russell, 2003; Watson & Tellegan 1985; Tinbergen, 1951).

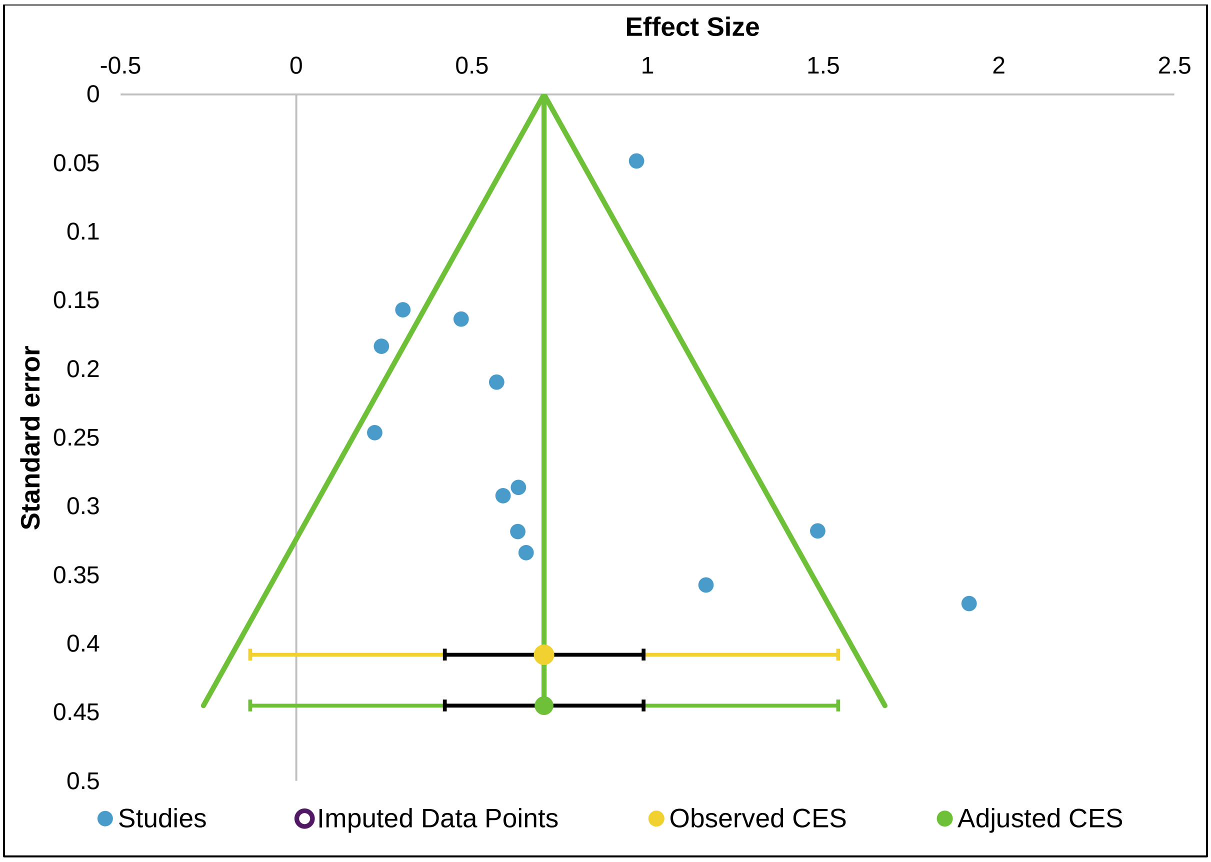

Figure 3. Funnel Plot of Standard Error by Standard differences in means of parasympathetic measures

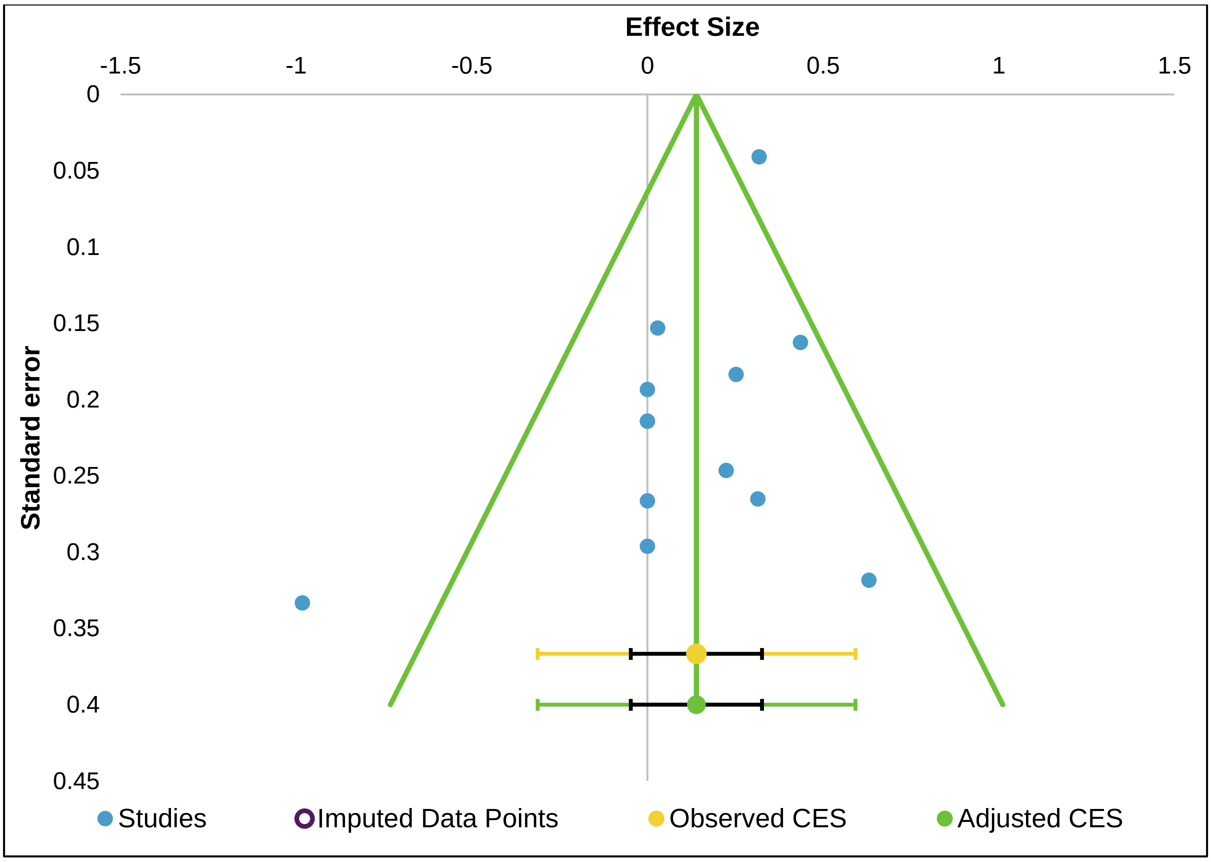

Figure 4. Funnel Plot of Standard Error by Standard differences in means of sympathetic:parasympathetic balance measures