The (In)flexible self

Giommi, Fabio; Bauer, Prisca R.; Berkovich-Ohana, Aviva; Barendregt, Henk; Brown, Kirk Warren; Gallagher, Shaun; Nyklíček, Ivan; Ostafin, Brian; Raffone, Antonino; Slagter, Heleen A.

Published in:
International Journal of Clinical and Health Psychology

DOI:
10.1016/j.ijchp.2023.100381

Publication date:
2023

International Journal of Clinical and Health Psychology 23 (2023) 100381

Contents lists available at ScienceDirect

International Journal of Clinical and Health Psychology

journal homepage: www.elsevier.es/ijchp

The (In)flexible self: Psychopathology, mindfulness, and neuroscience

Fabio Giommi [a,b,1,*], Prisca R. Bauer [c,1], Aviva Berkovich-Ohana [d,e,f,g,1], Henk Barendregt [h], Kirk Warren Brown [i], Shaun Gallagher [j], Ivan Nyklíček [k], Brian Ostafin [l], Antonino Raffone [m,n], Heleen A. Slagter [o], Fynn-Mathis Trautwein [c], David R. Vago [p]

[a] NOUS-School of Specialization (PsyD) in Psychotherapy, Milano, Italy
[b] Insight Dialogue Community [insightdialogue.org/teachers]
[c] Department of Psychosomatic Medicine and Psychotherapy, Medical Center – University of Freiburg, Faculty of Medicine, University of Freiburg, Freiburg im Breisgau, Germany
[d] Edmond Safra Brain Research Center, Faculty of Education, University of Haifa, Israel
[e] Faculty of Education, Department of Learning and Instructional Sciences, University of Haifa, Israel
[f] The Integrated Brain and Behavior Research Center (IBBRC), University of Haifa, Israel
[g] Faculty of Education, Department of Counseling and Human Development, University of Haifa, Israel
[h] Faculty of Science, Radboud University, Nijmegen, the Netherlands
[i] Carnegie Mellon University, USA
[j] Department of Philosophy, University of Memphis, USA and SOLA, University of Wollongong, Australia
[k] Department of Medical and Clinical Psychology, Tilburg University, the Netherlands
[l] Department of Clinical Psychology, University of Groningen, the Netherlands
[m] Department of Psychology, Sapienza University of Rome, Italy
[n] School of Buddhist Studies, Philosophy and Comparative Religions, Nalanda University, India
[o] Vrije Universiteit Amsterdam, the Netherlands
[p] Contemplative Sciences Center, University of Virginia

ARTICLE INFO

Keywords:
Rigidity
Pattern theory of self (PTS)
Neuroimaging
Cognitive neuroscience
Transdiagnostic processes

ABSTRACT

Clinical and neuroscientific evidence indicates that transdiagnostic processes contribute to the generation and maintenance of psychopathological symptoms and disorders. Rigidity (inflexibility) appears a core feature of most transdiagnostic pathological processes. Decreasing rigidity may prove important to restore and maintain mental health. One of the primary domains in which rigidity and flexibility plays a role concerns the self. We adopt the pattern theory of self (PTS) for a working definition of self. This incorporates the pluralist view on self as constituted by multiple aspects or processes, understood to constitute a self-pattern, i.e. processes organized in non-linear dynamical relations across a number of time scales. The use of mindfulness meditation in the format of Mindfulness Based Interventions (MBIs) has been developed over four decades in Clinical Psychology. MBIs are promising as evidence-based treatments, shown to be equivalent to gold-standard treatments and superior to specific active controls in several randomized controlled trials. Notably, MBIs have been shown to target transdiagnostic symptoms. Given the hypothesized central role of rigid, habitual self-patterns in psychopathology, PTS offers a useful frame to understand how mindfulness may be beneficial in decreasing inflexibility. We discuss the evidence that mindfulness can alter the psychological and behavioral expression of individual aspects of the self-pattern, as well as favour change in the self-pattern as a whole gestalt.

We discuss neuroscientific research on how the phenomenology of the self (pattern) is reflected in associated cortical networks and meditation-related alterations in cortical networks. Creating a synergy between these two aspects can increase understanding of psychopathological processes and improve diagnostic and therapeutic options.

* Corresponding author at: NOUS-School of Specialization (PsyD) in Psychotherapy, via G.B. Piranesi 10, 20137, Milano, Italy Milano, Italy.
E-mail address: fabiomario.giommi@gmail.com (F. Giommi).

[1] These authors contributed equally to this work. The manuscript was written primarily by FG, PRB and AB-O, after taking into account multiple rounds of comments, integrations and revisions from all co-authors (the authorship list is in alphabetical order in the segments after AB-O).

https://doi.org/10.1016/j.ijchp.2023.100381
Received 1 November 2022; Accepted 14 February 2023

Introduction

Converging clinical and neuroscientific evidence indicates that some common (transdiagnostic) processes contribute to the generation and maintenance of psychopathological symptoms (Uddin, 2021). Rigidity (inflexibility) appears to be one such a core feature of psychopathology. Decreasing rigidity may be important to restore and maintain mental health. It is therefore important to understand where rigidity comes from and how flexibility can be brought about. One of the primary domains in which rigidity and flexibility plays a role concerns the self. We adopt the pattern theory of self (PTS) for a working definition of self. This incorporates the pluralist view on self as constituted by multiple aspects or processes, which constitute a self-pattern, processes that form a dynamical gestalt, i.e., processes organized in non-linear dynamical relations across a number of time scales.

Mindfulness meditation and its application in the form of Mindfulness Based Interventions (MBIs) has developed over four decades in the field of Clinical Psychology (Crane, et al. 2018). MBIs, manualized weekly group-based sessions in which participants are trained in metacognitive skills such as present-moment awareness, decentering and acceptance, are promising as evidence-based interventions, and have been shown to be equivalent to gold-standard treatments and superior to specific active controls in several randomized controlled trials (Wielgosz et al., 2019; Goldberg et al., 2022b) Notably, MBIs have been shown to target transdiagnostic symptoms (Compen & Speckens, 2021; Greeson, et al., 2018).

Evidence from neuroimaging studies from the last decades revealed that contemplative practices, including mindfulness meditation, are linked to alterations in connectivity patterns between major brain networks that have traditionally been associated with general cognitive functions such as attention, self-processing, rumination, and interoception. Contemplative training thus seems to be accompanied by plasticity in and between cortical networks. These changes may reflect a reorganization of the self-pattern that corresponds to a decrease in rigidity and reduced psychological symptomatology.

The PTS offers a useful lens through which to understand how mindfulness practices may be beneficial in clinical settings. Given our hypothesized central role of rigid, habitual self-patterns in psychopathology, a different psychological relationship between narrative, cognitive, and other elements of the self is likely required for clinical improvement. Mindfulness-based interventions may thus not be symptom-specific but target common transdiagnostic processes. This may help to explain their broad spectrum of application in clinical psychology. The causal relationship with observed cortical changes remains to be tested, but we hypothesize that the changes in neural network dynamics linked to contemplative practices may reflect changes in the more flexible reorganization of the PTS. We discuss the implications of this idea and directions for future research.

Rigidity/inflexibility as a transdiagnostic psychopathological core process and PTS

Clinicians might agree that persons suffering from some forms of psychopathology share core features, notably *automaticity* and *inflexibility*. This was evident to the founding fathers of modern clinical psychology. Sigmund Freud introduced the concept of "repetition compulsion" (*Wiederholungszwang*) as an unconscious compulsion whereby people endlessly repeat thought patterns and behavior that were difficult or distressing earlier in life. Similarly, Pierre Janet described the crucial relation between awareness and different levels of automatic mental processes in several pathological phenomena, including "dissociation", a term coined in his 1889 study *l'Automatisme Psychologique* (Ellenberger, 1970).

The idea that different forms of psychopathology share core features has gained interest from several converging lines of research in the last two decades. Evidence from genetic, neurophysiological, personality, and cognitive-behavioral studies suggest that current diagnostic categories do not consider the deeper underlying factors that cause and maintain psychopathology (Buckholtz & Meyer-Lindenberg, 2012). Yet a substantial body of research has identified cognitive, emotional and behavioral processes that are "transdiagnostic," defined as processes that contribute to the maintenance of symptoms of psychological distress and disability across a wide range of psychopathological disorders across the lifespan (Cludius, et al., 2020; McLaughlin, et al., 2020; Nolen-Hoeksema & Watkins, 2011). There is increasing support for a "transdiagnostic" approach that cuts across traditional diagnostic boundaries or, more radically, sets them aside altogether, to provide novel insights into the understanding of psychopathology (Dalgleish, et al., 2020; Roefs, et al., 2022).

There is also growing evidence that several transdiagnostic processes are associated with psychological distress and disability only under certain conditions. They do not invariably generate distress or disability; rather the feature that seems responsible is the "rigid" or "inflexible" way that they behave (Morris & Mansell, 2018; Bickhard, 1989; Schultz & Searleman, 2002; Carhart-Harris et al., 2022). *Rigidity* is what makes these transdiagnostic processes problematic and eventually pathologic. The rigidity of thought, emotion, and behavior seen in many psychological disorders indicates a lack of contextual sensitivity (Kashdan & Rottenberg, 2010). Rigidity has been defined as "the tendency to develop and perseverate in particular cognitive emotional or behavioral patterns, and such patterns being continuously employed in situations where the pattern is no longer effective" (Morris & Mansell, 2018, pg. 3). It encompasses both the tendency to perseverate, to repeat a pattern/process over and over again, regardless of context, and the tendency of these patterns to become unintentional, with limited volitional control and often automatically.

Conversely, *flexibility* has been defined as the ability to "disengage from an initial pattern if the initial pattern of responding is no longer effective for the specific situation". The constructs of rigidity and flexibility are pointing to the same dimension and are not conceptually distinct. They are "mirror images" of each other; rigidity can be considered synonymous with inflexibility (Morris & Mansell, 2018, pg. 4).

Rigidity is often defined in terms of a difficulty in switching from one way of responding to a different one, and can be synonymous with set/task switching difficulties. Flexibility can be considered interchangeable with switching abilities. Both switching and inhibition processes are included in the concept of flexible executive control (Koch, et al., 2010). In clinical literature flexibility is often defined in terms of how effective a response is, i.e. whether it involves disengaging from processes that are not in accordance with an individual's goals or values (Doorley et al., 2020).

There is thus converging clinical evidence that transdiagnostic processes contribute to the generation and maintenance of a wide range of psychopathology (Astle, et al., 2022; East-Richard et al., 2020; Uddin, 2021). Rigidity (inflexibility) appears to be a core feature that makes these transdiagnostic processes pathological. The implication is that decreasing rigidity likely decreases the pathological impact of transdiagnostic processes. It is therefore key to understand where rigidity comes from and how flexibility can be brought about. One of the core domains in which rigidity and flexibility play a role is in the operation of the self.

The pattern theory of self (PTS) offers a working definition of self. According to PTS, the human self is a pattern of dynamically related processes or factors that pertain to an individual. This is close to an enactive-process view, most closely associated with Francisco Varela and a growing number of others (Hutto & Myin, 2017; Varela, et al., 2017). On this view, the self is not reducible to any one of these factors, but rather is equated with the pattern of factors/processes and their dynamical relations. A *self-pattern* integrates a heterogeneous set of temporally extended processes (e.g. bodily, affective, behavioral, cognitive, narrative, see below). A pattern is understood here as a system of factors or processes that lacks any strictly necessary conditions but rather consists of several jointly sufficient conditions. A self-pattern may lack some

typical elements, and psychopathologies may be understood as involving conflicts between, disruptions of, or the elimination of one or more of these elemental processes (Gallagher & Daly 2018). Importantly, there is no element that operates as an agent within a self-pattern, understood as a dynamical gestalt, much like a self-organizing system. This means there is no a self within a self-pattern. A self, of the sort that humans have, just is a pattern.

An important question is how heterogeneous elements or processes can be coherently integrated. The idea that all of these factors involve *processes* may provide a common denominator (Tognoli, et al. 2020). Elemental processes are dynamically integrated such that an intervention on any one process, above a certain threshold, will affect the others and the whole. PTS components that are dynamically interrelated in a self-pattern or *gestalt* arrangement include *Embodied processes, Prereflective experiential processes, Affective processes, Behavioral/action processes, Psychological/cognitive processes, Reflective processes, Narrative processes, Social/intersubjective processes, Ecological (Extended/situated) processes, Normative processes* (details in Gallagher, 2017; Gallagher & Daly, 2018).

Many mental health disorders can be seen as disorders of the self (e.g., Davey & Harrison, 2022; Sass et al., 2018; Sui & Gu, 2017). The PTS proposes a theoretical framework for analyzing and tracking the evolution of self-disorders. Importantly, the self cannot be reduced to any of its components: "one or more its elements can be disrupted as we may find in various psychopathological disorders. But a pattern, that is a self, persists as long as there are a sufficient number of elements remaining in dynamical relations. [. . .] For psychiatric purposes it is more relevant to ask under what circumstances any particular aspect gets disrupted, and how that disruption changes the whole dynamical pattern itself" (Daly & Gallagher, 2019, pg. 7).

PTS offers a way to conceive of rigidity implicated in the self. Disruptions of self-pattern dynamics can impact the flexible nature of the self-pattern as a whole. The question then is whether increased rigidity/inflexibility can by itself contribute to psychopathological distress or disability, through a diminished capacity or readiness of the self-pattern as a whole to change and adapt to different contexts. This question expands the focus of PTS toward a process-oriented perspective on psychopathology, and therefore a process-oriented approach to psychotherapies, where increasing flexibility is central (Hayes, et al., 2020).

For example, rigidity in the self-pattern has been proposed to characterize three major psychopathological disorders. *Major Depression* has been described as strongly implicating self processes (e.g., Lin et al., 2018; Sui & Gu, 2017). The PTS proposes that *all* self-processes described by the model are affected in depression (Daly & Gallagher, 2019). Thus, PTS characterizes depression as a disturbance of the self-pattern as a whole, marked by a rigidity or lack of flexibility in all the elements of the self-pattern. Another example is *psychological (complex) trauma.* According to Nijenhuis & van der Hart (2011, pg. 418-22) "Personality and dissociative parts of the personality are dynamic systems and dynamic subsystems, respectively. However, dissociative parts are excessively stable, involving a lack of systemic complexity.[..] As overly stable (sub) systems, dissociative parts often engage in fixed actions that may have worked previously but that do not fit transformed conditions" Despite the difference in terminology, this view is consistent with PTS: rigidity appears a primary feature in this pathology, as it is the lack of flexibility between sub-personalities, that induces the dissociative lack of integrative capacity. *Substance use and Addiction disorders* are a third example of which inflexible behavior is the hallmark (e.g. Miller & Hormes, 2022; Stalnaker et al., 2009); notably Garland et al. (2022) have shown the role of aberrant self-referential processes in addiction.

Mindfulness meditation as altering self-patterns in clinical contexts

PTS shares several aspects with the Buddhist psychological view on the nature of the self. Both agree that unhealthy habits and attitudes can lead to an experienced rigidity/inflexibility - in Buddhist terminology unhealthy "attachment" or overinvestment (Gombrich, 2009) - in a particular aspect of the self-pattern or in its whole dynamic. Self-narrative can reflect and reinforce this rigidity – leading to a reiteration or elaboration of thoughts running through many cycles of conceptualization (Nanananda, 1997). This inflexibility can be addressed by mindfulness meditation practices, with the aim of introducing more meta-awareness, so that the dynamics of the self-pattern become aware. We have developed these arguments more thoroughly elsewhere (see Gallagher et al. (under review); Berkovich-Ohana et al. (under review)). Here we will focus on mindfulness induced changes in the self-pattern in clinical contexts. We consider Mindfulness Based Interventions (MBIs) as short-term basic mindfulness meditation training, and long-term contemplative mindfulness meditation training. Three main aspects of mindfulness practice are commonly investigated separately: focused attention (FA), open monitoring (OM) and Loving-kindness/benevolence (LK), though in actual meditation practice these are usually blended.

The evidence supporting the clinical application of mindfulness is extensive and supports the promise of MBIs as evidence-based treatments. They were shown to have similar or superior effect to specific active controls and other evidence-based treatments (Goldberg, et al. 2022b). With respect to specific conditions, the evidence in support of MBIs for depression, pain conditions, smoking, and addictive disorders has been the most consistent (Goldberg, et al., 2018). Notably, MBIs have been shown able to target transdiagnostic symptoms (Compen & Speckens, 2021; Greeson, et al., 2018). Britton et al. (2021) have reviewed specifically how self-related processes may be key mechanisms of MBIs, and found that MBIs consistently seem to reduce rumination, a transdiagnostic process with clear rigidity. They concluded however that the evidence supporting these theories is currently unclear, as few such processes have been measured in MBIs, and additional research using well-validated measures is needed.

Even if MBIs have been adapted to "secular" conditions, the core mindfulness practices – which include: present moment awareness by attending to different "objects" (breathing, bodily sensations, sounds, thoughts, open awareness), body-scan, walking meditation and mindful movement - remain the same. There is no a specific "mindfulness" for a specific disorder. It thus seems compelling that mindfulness practice targets transdiagnostic processes, or a core factor at the root of psychopathology. Our suggestion is that mindfulness practices may reduce rigidity/inflexibility.

The PTS offers a useful lens through which to understand how mindfulness practice may be beneficial in clinical settings. Given the central role of rigid, habitual self-patterns in psychopathology, a different psychological relationship between narrative, cognitive, and other elements of the self is likely required for clinical improvement.

We discuss: a) how mindfulness may introduce greater flexibility into the self-pattern; b) the evidence that mindfulness can alter the psychological and behavioral expression of individual elements of the self-pattern; c) the way mindfulness can favour change in the self-pattern as a whole.

(a) Several studies have shown that mindfulness may weaken maladaptive links between elements of the self, thereby creating opportunities for more flexible interactions between those elements. For instance, a high level of self-reported dispositional mindfulness was associated with a subsequent, weaker association between self-perceived disability (reflecting a behavioral element) and self-perceived distress (reflecting an affective element) across a period of 12 months among rheumatoid arthritis patients (Nyklíček et al., 2015). Additionally, in an experience sampling study, those with higher self-reported mindful states on a day-to-day basis showed a weaker association between rumination (cognitive element) and both negative and positive affect (affective element); also, a higher level of self-acceptance (considered by some to be a feature of mindfulness) was related to a weak linkage between reflection (reflective element) and affect (Blanke et al., 2020). Finally, in a sample of patients with three or more previous depressive episodes, those scoring lower on both mindfulness and memory specificity showed a positive

association between self-reflection (reflective element) and depressive symptoms (cognitive and affective elements) not found in other subgroups (Brennan et al., 2015). These studies are correlational rather than experimental, but provide initial evidence that mindfulness may increase flexibility in the self-pattern.

(b) There is some evidence that mindfulness can alter the psychological and behavioral expression of individual elements of the self-pattern:

Psychological/cognitive processes. The monitoring and acceptance processes in clinical mindfulness training may affect cognitive processing through what has been described as cognitive defusion or decentering. This metacognitive capacity essentially involves a shift in experiential perspective from mental absorption in an experience, with a running mental commentary about the experience, to simple observation of that experience. When people decenter, they "step out of" the immersive world of self-referential thought (Bernstein et al., 2019; Vago et al., 2022). This was linked to reduced worry and rumination (e.g. Shapiro et al., 2011), both of which are important contributing factors to anxiety and depression (Segal, Teasdale & Williams, 2018).

Affective processes. It is conceivable that mindfulness leads to enhanced emotional well-being, and since the early study of mindfulness training research with patients suffering from anxiety disorders (Kabat-Zinn et al., 1995), there has been an abundance of research showing beneficial effects of mindfulness training on affective processes, particularly in anxiety and depression. Several meta-analyses have shown medium-sized effects in reducing these symptoms (Goldberg, 2022a; 2018). In addition, studies have shown enhanced positive affect and quality of life after mindfulness training (e.g., Lindsay et al., 2019).

Behavioral processes. Behavioral processes are central in a number of disorders, such as avoidance in anxiety disorders, approach and consumption in substance use disorders, and both restricted eating and over-eating in eating disorders. MBIs have been shown to reduce avoidance of anxiety-inducing stimuli (Levitt, et al., 2004), and to reduce addiction-related behaviors (Li, et al., 2017) and eating disorder behaviors (Turgon, et al., 2019). Several studies have also begun to examine how mindfulness interventions may influence inflexible, automatic mental processes that contribute to clinical disorders and have found initial evidence that mindfulness may reduce an automatic appetitive approach to food (Papies, et al., 2012) and also weaken the relation between automatic appetitive motivation for alcohol and actual alcohol consumption (Ostafin et al., 2012; Zgierska et al, 2019).

Intersubjective processes. Among the earliest studies of mindfulness training in the interpersonal sphere was a randomized controlled trial with romantic partners which showed that the training enhanced a number of relationship quality outcomes, including closeness and relationship satisfaction (Carson et al., 2004). Other studies have examined the role of present-centered attention in relationship stress contexts. For example, in research examining the processes and outcomes of couple conflict discussions, present-centered attention improved communication during the discussion and reduced anxiety and anger-hostility toward the partner (Barnes et al., 2007). At a wider social level, studies of mindfulness training have also demonstrated lower levels of interpersonal bias, rendering social relations more sensitive and less prejudicial (see Berry & Brown, 2017 for review; Lindsay et al., 2019). Research in this area has also demonstrated that mindfulness training can enhance compassion and prosocial behavior toward strangers (Berry et al., 2018) and reliably so, as revealed through a recent meta-analysis (Donald et al., 2019; but see also Kreplin et al., 2018).

(c) How mindfulness may change the self-pattern as a whole.

Given the dynamical links among the different processes that contribute to the self-pattern, a change in, or intervention on one or more elements can alter the functioning of the self-pattern as a whole. In this respect, meditation practices can lead to a higher degree of flexibility within the self-pattern (Berkovich-Ohana et al. (under review)), indicating its importance for therapeutic practices, and its impact on mental health more generally.

One specific area of research concerns how the effects specifically linked to mindfulness and meditation contribute to increasing the effects attributed to the common factors in psychotherapy (Wampold 2015; Wampold & Ulvenes, 2019; Goldberg, 2022a; Goldberg et al., 2018) highlights the importance of situating mindfulness as experienced by participants in the MBIs within the broader psychotherapy research literature from a common factors perspective emphasizing the commonalities rather than the differences between MBIs and other therapies. He summarizes the evidence for MBI efficacy in general, and for the specific effect of MBIs on psychological transdiagnostic mechanisms. One common factor in MBIs is the unique role of group processes. Well-functioning group processes foster the therapeutic effects yielded by common factors. The specific and distinctive modalities by which group processes are guided in MBIs (Griffith, et al., 2019), for example through the mindfulness practice of *inquiry*, invite a change in the self-pattern as a whole. Group processes help individuals become aware of common humanity and shared suffering and this encourages a less self-centred and self-absorbed perspective. MBIs thus appear to promote a change in the PTS as a whole in the direction of hypo-egoicism (Brown & Leary, 2016). Group processes in MBIs support the cultivation of well-being not only on a personal level, but also on a collective level, and creates awareness of the social and ecological dimensions of psychiatric interventions (Kirmayer, 2019).

The neuroscience of self and its flexibility

Much neuroscientific research has been done into the effects of mindfulness training and long-term contemplative training. Evidence shows that contemplative training correlates with an alteration of the function of neural regions and networks supporting self-related and self-specifying processes (Dahl et al., 2015; Laukkonen & Slagter, 2021; Hölzel et al., 2011; Millière et al., 2018; Tang et al., 2015; Vago & Silbersweig, 2012). In what follows, we attempt to link aspects of the self-pattern with neural processes identified through the network approach of cognitive neuroscience. Then we review the evidence for possible effects of contemplative training on these neural regions and networks.

Recent work (Uddin et al. 2019), has outlined six functional networks referred to by anatomical names (in parentheses we refer to the broad cognitive domains with which a given anatomical system is most commonly associated): the occipital network (ON, Visual), pericentral network (PN, Somatosensory), dorsal frontoparietal network (D-FPN, Attention), lateral frontoparietal network (L-FPN, Control), midcingulo-insular network (M-CIN, Salience), and medial frontoparietal network (M-FPN, Default).

Phenomenology of the self (pattern) reflected in related cortical networks

The cortical-network approach reiterates an early distinction between two phenomenological aspects of the self-pattern: experiential/minimal self-awareness and the narrative-self (Gallagher, 2000). Briefly, the narrative-self is a conceptual, autobiographic identity with continuity across time, while the minimal-self is a momentary, experiential-embodied self. This distinction is rough and oversimplified, but it has enabled a fruitful dialogue with cognitive neuroscience. Importantly, the two notions of self have been related to two types of processes linked to distinct brain regions and networks (Christoff et al., 2011; Legrand & Ruby, 2009). The first, *self-related processing*, requires one to evaluate or judge some feature in relation to one's perceptual image or mental concept of oneself, hence it is thought to support the narrative self. The second, *self-specific processing*, specifies the self as subject and agent by implementing a functional self/non-self distinction (Christoff et al., 2011; Seth, 2013), and thus supports the minimal self.

Self-related processes have been studied extensively within the growing interest in the Default Mode Network (DMN), using functional magnetic resonance imaging (fMRI). The DMN is involved in a plethora of introspection-related functions including self-reflection, episodic

memory, future planning, theory of mind, and personal moral reasoning (Buckner et al., 2008), supporting the suggested connection between its neural activity and subjective content of self-related processing (Gusnard et al., 2001; Northoff et al., 2006; Qin & Northoff, 2011). The DMN was shown to involve (at least) three distinct subsystems with potentially different functions (Andrews–Hanna et al., 2014): (1) a core subsystem (the anterior medial PFC (amPFC) and the posterior cingulate cortex) involved in self-referential processing; (2) a dorsomedial prefrontal subsystem (comprised by the dorsal medial PFC, the temporoparietal junction, the lateral temporal cortex, and the temporal pole) involved in semantic processing and mentalizing (3) a medial temporal lobe subsystem (comprised of the hippocampus, the parahippocampal cortex, the retrosplenial cortex, the posterior inferior parietal lobe, and the ventromedial pre-frontal cortex involved in retrieving and binding together contextual details during the recollection of episodic memories and simulation of future events.

It is likely that activation of the DMN across these subsystems are differentially involved in cognitive, reflective, intersubjective and narrative processes of the self-pattern – the first core subsystem possibly supporting cognitive and reflective aspects, the second, dorsomedial prefrontal subsystem in part relating to intersubjective processes, and the third, medial temporal lobe subsystem possibly supporting the mnemonic aspect constituting narratives.

In contrast to these higher-order, narrative and cognitive self-related processes, pre-reflective self-specifying processes associated with the experiential/minimal self are less well-understood. According to Christoff & colleagues (2011), self-specifying processes implement a functional self/non-self distinction in bodily (sensorimotor), homeostatic, emotional and cognitive domains. Central to this approach is the idea that an organism constantly integrates efferent (outgoing) and afferent (incoming) signals in a way that distinguishes fundamentally between incoming signals produced by self actions (reafferent), and signals not produced by the self's actions. By implementing this functional self/non-self distinction, efferent–reafferent integration implicitly specifies the organism as an agent.

The embodied self-pattern processes, including homeostatic regulation, may involve a vertically integrated, interoceptive system (Damasio, 1999), including brainstem nuclei and midbrain structures; modulated by the hypothalamus, mid/posterior insula (sensory) and anterior cingulate (motor) cortices as part of the Salience network. Similarly, accumulating evidence implicates the anterior cingulate cortex in emotional processing (Etkin et al., 2011; Rainville et al., 1997), and the anterior insular cortex in processing interoceptive signals and emotional awareness (Craig, 2009; Seth, 2013). Reflective self-pattern processes may be supported by the lateral frontoparietal (Control) network. This can be explicit or implicit, or externally-driven (involving perception) and internally-driven (involving, e.g., self-image) (Christoff et al. 2011) corroborating with our perspective that a key locus for the effects of meditative training is a shift in the reflective aspects of the self-pattern, transitioning from propositional and intermittent meta-awareness to 'mindful meta-awareness' as non-propositional and sustained (Dunne et al., 2019), hence becoming implicit and reflexive.

Correlating PTS to brain networks is necessarily incomplete. For example, the behavioral aspect of the self-pattern is a very broad concept, encompassing behavioral habits that contribute to the constitution of one's character. Such an aspect cannot hinge on any one brain region or network, as it inevitably involves the complex relationship between brain-body-environment. Rather, all these factors and networks dynamically interact to create a sense of an 'integrative self' (Sui & Humphreys, 2015). Neuroscientifically, transformations in the self-pattern following meditative practice should be best sought in the changes within the network dynamics.

Meditation-related alterations in cortical networks

In this section, we review the current evidence for meditation-related changes in network activity and dynamics. This evidence is generally consistent with the notion that a primary mechanism of contemplative training is the enhancement of engagement in present-moment awareness. This induces a shift in self-awareness, away from focusing on self-related processing towards a more embodied self-specific mode of processing and heightened perceptual awareness. This appears to be linked to changes in the connectivity and interplay between the DMN, Attention, Salience and Control networks. While neuroimaging advanced the understanding of individual brain regions involved in meditative processes, it is the dynamic interactions between these regions that probably best capture the effects of progressive contemplative training (Tang et al., 2015).

Based on previous research summarized below, we hypothesize that the networks that support self-specific processing (Attention; Somatosensory; Salience; and Control) are more active during meditation, while the network supporting self-related processing (DMN) becomes less active. In deep meditative states when the distinction between self/non-self diminishes, and attention changes from object-directed/effortful to bare/effortless, the activity in networks supporting self-specific processes may be reduced. We propose that as meditation expertise increases, the functional connectivity (FC) during practice (state effect) or rest (trait effect) within the DMN is altered, while the FC within or between networks supporting self-specific processing is enhanced. In addition, the FC between the DMN and the networks supporting self-specific processing generally becomes stronger.

We focus on evidence from meta-analyses or studies that have examined network dynamics. Due to space constraints we do not separate cross-sectional from longitudinal studies, and only briefly touch upon the issue of state or trait changes. By taking this birds-eye view, we aim to propose a wider perspective on network alterations.

Meditation-related flexibility in network activity

An early activation likelihood estimation (ALE) study, which meta-analyzed 150 peak foci from 24 fMRI studies (Tomasino et al., 2012), and reported results pertaining to FA meditation (and mantra meditation, not reported here) highlighted that FA consistently triggered activations in the Control network (superior medial gyrus) and Attention (right SMG and left superior parietal) Somatosensory (right SMA) and Salience (left IPL and right insula) networks. Neural activity in the DMN (angular gyrus, medial frontal gyrus and precuneus) decreased. A later ALE meta-analysis systematically reviewed 78 fMRI studies and meta-analyzed 257 peak foci from 31 experiments (Fox et al., 2016). Consistent with the first meta-analysis, FA meditation was associated with activations in regions within the Control network (including the premotor cortex, the posterior DLPFC, and dACC), consistent with more effortful initial stages of FA practice (with increasing expertise, ability to sustain attention should become effortless, see Brefczynski-Lewis et al. (2007). Deactivations were observed in two major hubs of the DMN (PCC and posterior IPL), suggesting that FA meditation, like other effortful tasks, may diminish spontaneous thoughts regarding past and future events.

In the same study (Fox et al., 2016), OM was associated with activation in the Control network (regions involved in the voluntary regulation of thought and action, including inferior frontal gyrus, posterior DLPFC/pre-motor cortex, and dACC/pre-SMA), as well as activation in the Salience network (insula). Given that OM meditation typically involves a broad, non-judgmental attention to any and all mental content, it is congruous that this practice recruits numerous areas from the Control network, at least in its early stages, before letting go of directed attention. Deactivation was observed in the thalamus, a key relay center for most incoming sensory information. As increased intensity of sensory gating appears to be correlated with increased activity in the thalamus, these deactivations suggest decreased sensory gating, an interpretation consistent with the goal of being open and receptive to sensory stimuli.

LK meditation was associated (Fox et al., 2016) with activation in the Somatosensory network, extending into the IPL. These regions are

involved in somatosensory processing and in creating a unified sense of the body, but both regions have also been implicated in empathy in a recent meta-analysis (Lamm et al., 2011). Activation was also significant in the right anterior insula, previously implicated in interoception (Craig, 2009; Seth, 2013), as well as identified as the neural correlate of empathy (Lamm et al., 2011). We hypothesize that these specific activations reflect increased flexibility and a functional reorganization of cortical networks.

While the previous meta-analyses mostly included cross-sectional studies and enabled uncovering the effects of long-term meditation practice compared to control participants, two meta-analyses provide evidence for specific flexibility effects of short-term practice. The first, an ALE meta-analysis of 21 studies (Falcone & Jerram, 2018), reported consistent activity in contrasts utilizing long-term and novice participants related to mindful meditation in the Control and Salience networks. In contrasts based on the data of only novice participants, only the insula was activated, suggesting that the cultivation of concentrative skills (Salience) might take place prior to enhancing the reflective process (Control). In support of that, the second ALE meta-analysis of 39 studies (Young et al., 2018) assessed flexibility in brain functioning associated with 8-session mindfulness interventions, and the most consistent longitudinal effect observed was increased insular cortex activity (Salience network), while less consistent activations included the ACC and DLPFC (Control network).

Flexibility in network functional connectivity (FC)

We hypothesize that meditation in general, regardless of the type, alters FC (as a state or trait) within the network supporting self-related processing, while enhancing the FC within or between networks supporting self-specific processing, and the FC between self-specific and related networks. These processes represent meditation-related flexibility in the habitual connectivity between the major cortical networks. A change in activation or connectivity patterns does not necessarily imply increased flexibility. Yet meditation seems to be linked to specific activation patterns or connectivity patterns which in some cases persist also in resting state, potentially reflecting a functional reorganization of connectivity and brain plasticity.

We hypothesize the following alterations in FC: 1) generally reduced self-related processing, i.e. reduced FC within the DMN, 2) generally enhanced self-specific processing, i.e. enhanced FC within and between the self-specific supporting networks (Salience, Somatosensory, Control), 3) generally enhanced mindful awareness, i.e. enhanced FC between Control network and other networks, and 4) generally reduced anti-correlation between the networks supporting self-related and self-specific processing (enhanced non-dual awareness), i.e. enhanced FC between self-related (DMN) and self-specific supporting networks.

We briefly summarize fMRI-FC literature, which supports our four propositions, related to alteration of self-processing linked to mindfulness meditation.

Firstly, meta-analyses of FC changes related to meditation are unfortunately lacking. A few studies reported increased FC within the DMN (Jang et al., 2011; Taylor et al., 2013; Yang et al., 2016), ample studies reported reduced FC within the DMN, either during meditation (Brewer et al., 2011; Farb et al., 2007) or resting-state (Berkovich-Ohana et al., 2016; Garrison et al., 2013; Hasenkamp & Barsalou, 2012; Kilpatrick et al., 2011; Taylor et al., 2013), supporting our first hypothesis.

Secondly, within and between the self-specific supporting networks, several studies report mostly enhanced FC resting state effects in meditators. Enhanced rsFC was shown in the Attention network (Froeliger et al., 2012; Hasenkamp & Barsalou, 2012), and the Salience network (Farb et al., 2013; Hernández et al., 2018). These connectivity patterns can be interpreted as enhancing 'online' attention to representation of body awareness. Between specific networks, several studies show enhanced FC between the Control and Salience networks (Farb et al., 2007; Hasenkamp & Barsalou, 2012; Hölzel et al., 2013). Given the important role attributed to the Salience network in switching between Control and DMN (Sridharan et al., 2008), this can be interpreted to suggest that individuals with more meditation experience may have an enhanced awareness of present moment experience and more access to internal bodily states, as well as an enhanced ability to switch between states of self-related focus, and states of self-specific focus. This would reflect a more flexible self-pattern.

Thirdly, in line with our proposal of enhanced mindful meta-awareness as a core mechanism for mindfulness-induced transformation, several studies provide evidence for a shift in the functioning of the Control network. Specifically, increased FC between Control and DM networks was reported during both meditation and resting state (Brewer et al., 2011; Creswell et al., 2016; Farb et al., 2007).

Fourthly, many studies report altered FC between the DMN and self-specific supporting networks. Such alterations were shown both during practice, and resting state. During mindfulness-related meditation, FC between DMN and Attention (Froeliger et al., 2012), Salience (Farb et al., 2007), or Somatosensory (Berkovich-Ohana et al., 2016; Farb et al., 2007; Josipovic et al., 2012; Kilpatrick et al., 2011) is increased. This can be interpreted to show that during meditation one may have enhanced capacity for disengagement of (self-related) thought content, and for shifting attention to affective, interoceptive and sensory awareness, respectively, again an indication of enhanced flexibility.

Limitations

Although these FC studies provided ample insights into how meditation influences the functional network of the brain, there are three critical limitations. First, the brain networks were defined a priori, precluding the possibility of finding that meditation practice can alter the architecture of the primary brain networks themselves. Second, most of the research employed a pre-post longitudinal effects, or cross-sectional comparisons, and compared the conditions after aggregating the data across heterogeneous participants, which might mask important intra-individual changes in the composition of the brain networks (e.g., participant-specific network architectures may be canceled out). In answering these concerns, a recent publication (Kajimura et al., 2020) studied the effect of FA meditation practice on intra-individual changes in the composition of whole-brain networks, using intensive longitudinal data from a single-case fMRI design. The results showed a significant change in the interplay between the Default and Control networks. Specifically, immediately after meditation the separation between the networks seems to be loosened, as a number of regions in the Control network were merged into the Default network. This raises the intriguing possibility that, in addition to altering specific network FC, meditation leads to reconfiguration of whole-brain network architecture. Obviously future studies are warranted to replicate and extend this initial finding to provide fruitful information about the neural mechanisms of meditation and the possible reconfiguration of community architecture in the brain.

A third limitation of our overview is that we did not follow a systematic approach and did not take into account the methodological quality of studies. Especially some of the early neuroimaging studies included small sample sizes, many studies were not preregistered, and some could have important biases (e.g. placebo effect, motivation).

Future directions Our scoping overview is indented to generate novel, testable hypotheses. Theoretically, the model of rigidity versus flexibility would be most relevant for those specific forms of psychopathology where rigidity is most prominent, such as depression and obsessive-compulsive disorder. Yet, we hypothesise that rigidity is a core feature of (almost) all forms of psychopathology. One recommendation for future research therefore is to identify differences in rigidity between different forms of psychopathologies, or alternatively, whether it is a necessary element which causes or maintains any form of psychopathology. To the best of our knowledge there are no validated diagnostic tools to assess

mental rigidity in psychopathology. This would clearly also be a direction for further research.

Regarding the application of mindfulness interventions, existing data do not allow to make recommendations for which particular disorders these therapies hold most promise. The clearest evidence to date is that mindfulness training has a positive effect on depression, chronic pain and eating disorders (Goldberg et al., 2018, page 58). Tentatively this would be coherent with our suggestion that depression is accompanied by strong rigidity. In our view, mindfulness can be complementary to psychotherapy because it specifically strengthens interoceptive awareness for cognitive, emotional and somatic patterns so that they can be brought to the fore in therapy and then worked with in the light of awareness, increasing mental flexibility.

As neuroimaging methods improve, network dynamics during meditative states and at rest will improve our understanding of mental states related to meditation practice and how such activities translate to more enduring well-being and associated neurophysiological changes.

Two key questions raised by our review are a) the need for a better definition of psychological flexibility, b) whether there is a link between psychological flexibility and brain plasticity and how this in turn is linked to well-being.

Conclusion

We have argued that rigidity of the self-pattern is a transdiagnostic marker of psychopathology, and that mindfulness can be helpful in increasing flexibility within the self-pattern. We reviewed evidence from neuroimaging that is generally consistent with the notion that a primary mechanism of mindfulness interventions is to enhance engagement in present-moment awareness, inducing a shift in self-awareness away from focusing on self-related processing into a more embodied self-specific mode of processing and heightened perceptual awareness. This may explain why mindfulness-based interventions have been successful in reducing symptoms of different forms of psychopathology.

Author contributions

The manuscript was written primarily by FG, PRB and AB-O, after taking into account multiple rounds of comments, integrations and revisions from all co-authors (the authorship list is in alphabetical order in the segments after AB-O). All the authors will approve the final version of the manuscript. The manuscript is based on ideas initially raised by all the authors – except F-M. T. – at the Lorentz Workshop on the "Mechanisms of meditation and applications in clinical practice" in Leiden (Netherlands) on December 9 - 13, 2019, organized by Prisca Bauer and Marieke van Vugt. These ideas were later collectively developed by all the authors.

References

Andrews–Hanna, J. R., Smallwood, J., & Spreng, R. N. (2014). The default network and self–generated thought: Component processes, dynamic control, and clinical relevance. *Annals of the New York Academy of Sciences*, *1316*(1), 29–52.

Astle, D. E., Holmes, J., Kievit, R., & Gathercole, S. E. (2022). Annual research review: The transdiagnostic revolution in neurodevelopmental disorders. *Journal of Child Psychology and Psychiatry*, *63*(4), 397–417.

Barnes, S., Brown, K. W., Krusemark, E., Campbell, W. K., & Rogge, R. D. (2007). The role of mindfulness in romantic relationship satisfaction and responses to relationship stress. *Journal of Marital and Family Therapy*, *33*(4), 482–500.

Berkovich-Ohana, A., Harel, M., Hahamy-Dubossarsky, A., Arieli, A., & Malach, R. (2016). Default network reduced functional connectivity in meditators negatively correlates with meditation expertise. *Data in Brief*, *8*, 910–914.

Berkovich-Ohana, A., Warren Brown, K., Gallagher, S., Barendregt, H., Bauer, P., Giommi, F., Nyklíček, I., Ostafin, B., Raffone, A., Slagter, H., Trautwein, F.-M., & Vago, D. (under review). From self to selflessness: How meditation transforms the self-pattern.

Bernstein, A., Hadash, Y., & Fresco, D. M. (2019). Metacognitive processes model of decentering: Emerging methods and insights. *Current Opinion in Psychology*, *28*, 245–251.

Berry, D. R., & Brown, K. W. (2017). Reducing separateness with presence: How mindfulness catalyzes intergroup prosociality. *Mindfulness in Social Psychology* (pp. 153–166). Routledge.

Berry, D. R., Cairo, A. H., Goodman, R. J., Quaglia, J. T., Green, J. D., & Brown, K. W. (2018). Mindfulness increases prosocial responses toward ostracized strangers through empathic concern. *Journal of Experimental Psychology: General*, *147*(1), 93.

Bickhard, M. H. (1989). The nature of psychopathology. *International psychotherapy: Theories, research, and cross-cultural implications* (pp. 115–140).

Blanke, E. S., Schmidt, M. J., Riediger, M., & Brose, A. (2020). Thinking mindfully: How mindfulness relates to rumination and reflection in daily life. *Emotion*, *20*(8), 1369.

Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(27), 11483–11488.

Brennan, K., Barnhofer, T., Crane, C., Duggan, D., & Williams, J. M. G. (2015). Memory specificity and mindfulness jointly moderate the effect of reflective pondering on depressive symptoms in individuals with a history of recurrent depression. *Journal of Abnormal Psychology*, *124*(2), 246.

Brewer, J. A., Worhunsky, P. D., Gray, J. R., Tang, Y. Y., Weber, J., & Kober, H. (2011). Meditation experience is associated with differences in default mode network activity and connectivity. *Proceedings of the National Academy of Sciences of the United States of America*, *108*(50), 20254–20259.

Britton, W. B., Desbordes, G., Acabchuk, R., Peters, S., Lindahl, J. R., Canby, N. K., … Moitra, E. (2021). From self-esteem to selflessness: An evidence (gap) map of self-related processes as mechanisms of mindfulness-based interventions. *Frontiers in Psychology*, *12*, 730972.

Brown, K. W., & Leary, M. R. (2016). *The Oxford handbook of hypo-egoic phenomena*. Oxford University Press.

Buckholtz, J. W., & Meyer-Lindenberg, A. (2012). Psychopathology and the human connectome: Toward a transdiagnostic model of risk for mental illness. *Neuron*, *74*(6), 990–1004.

Buckner, R. L., Andrews–Hanna, J. R., & Schacter, D. L. (2008). The brain's default network: anatomy, function, and relevance to disease. *Annals of the new York Academy of Sciences*, *1124*(1), 1–38.

Carhart-Harris, R. L., Chandaria, S., Erritzoe, D. E., Gazzaley, A., Girn, M., Kettner, H., … Friston, K. J. (2022). Canalization and plasticity in psychopathology. *Neuropharmacology*, *226*. doi:10.1016/j.neuropharm.2022.109398.

Carson, J. W., Carson, K. M., Gil, K. M., & Baucom, D. H. (2004). Mindfulness-based relationship enhancement. *Behavior Therapy*, *35*(3), 471–494.

Christoff, K., Cosmelli, D., Legrand, D., & Thompson, E. (2011). Specifying the self for cognitive neuroscience. *Trends in Cognitive Sciences*, *15*(3), 104–112.

Cludius, B., Mennin, D., & Ehring, T. (2020). Emotion regulation as a transdiagnostic process. *Emotion*, *20*(1), 37.

Compen, F. R., & Speckens, A. E. (2021). Putting mindfulness-based cognitive therapy to the test in routine clinical practice: A transdiagnostic panacea or a disorder specific intervention? *Journal of Psychiatric Research*, *142*, 144–152.

Craig, A. D. (2009). How do you feel—Now? The anterior insula and human awareness. *Nature Reviews Neuroscience*, *10*(1), 59–70.

Crane, R., Brewer, J., Feldman, C., Kabat-Zinn, J., Santorelli, S., Williams, J., & Kuyken, W. (2018). What defines mindfulness-based programs? The warp and the weft. *Psychological Medicine*, *47*(6), 990–999. doi:10.1017/S0033291716003317.

Creswell, J. D., Taren, A. A., Lindsay, E. K., Greco, C. M., Gianaros, P. J., Fairgrieve, A., Marsland, A. L., Brown, K. W., Way, B. M., Rosen, R. K., & Ferris, J. L. (2016). Alterations in resting-state functional connectivity link mindfulness meditation with reduced interleukin-6: A randomized controlled trial. *Biological Psychiatry*, *80*(1), 53–61. doi:10.1016/j.biopsych.2016.01.008.

Dahl, C. J., Lutz, A., & Davidson, R. J. (2015). Reconstructing and deconstructing the self: Cognitive mechanisms in meditation practice. *Trends in Cognitive Sciences*, *19*(9), 515–523. doi:10.1016/j.tics.2015.07.001.

Dalgleish, T., Black, M., Johnston, D., & Bevan, A. (2020). Transdiagnostic approaches to mental health problems: Current status and future directions. *Journal of Consulting and Clinical Psychology*, *88*(3), 179.

Daly, A., & Gallagher, S. (2019). Towards a phenomenology of self-patterns in psychopathological diagnosis and therapy. *Psychopathology*, *52*(1), 33–49.

Damasio, A. R. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. Harcourt Brace.

Davey, C. G., & Harrison, B. J. (2022). The self on its axis: A framework for understanding depression. *Transl Psychiatry*, *12*, 23. doi:10.1038/s41398-022-01790-8.

Donald, J. N., Sahdra, B. K., Van Zanden, B., Duineveld, J. J., Atkins, P. W., Marshall, S. L., & Ciarrochi, J. (2019). Does your mindfulness benefit others? A systematic review and meta-analysis of the link between mindfulness and prosocial behaviour. *British Journal of Psychology*, *110*(1), 101–125.

Doorley, J. D., Goodman, F. R., Kelso, K. C., & Kashdan, T. B. (2020). Psychological flexibility: What we know, what we do not know, and what we think we know. *Social and Personality Psychology Compass*, *14*(12), 1–11.

Dunne, J. D., Thompson, E., & Schooler, J. (2019). Mindful meta-awareness: Sustained and non-propositional. *Current Opinion in Psychology*, *28*, 307–311. doi:10.1016/j.copsyc.2019.07.003.

East-Richard, C., R-Mercier, A., Nadeau, D., & Cellard, C. (2020). Transdiagnostic neurocognitive deficits in psychiatry: A review of meta-analyses. *Canadian Psychology/Psychologie canadienne*, *61*(3), 190.

Ellenberger, H. F. (1970). *The discovery of the unconscious: The history and evolution of dynamic psychiatry*. New York: Basic books.

Etkin, A., Egner, T., & Kalisch, R. (2011). Emotional processing in anterior cingulate and medial prefrontal cortex. *Trends in Cognitive Sciences*, *15*(2), 85–93. doi:10.1016/j.tics.2010.11.004.

Falcone, G., & Jerram, M. (2018). Brain activity in mindfulness depends on experience: A meta-analysis of fMRI studies. *Mindfulness*, *9*(5), 1319–1329. doi:10.1007/s12671-018-0884-5.

Farb, N. A. S., Segal, Z. V., Mayberg, H., Bean, J., McKeon, D., Fatima, Z., & Anderson, A. K. (2007). Attending to the present: Mindfulness meditation reveals distinct neural modes of self-reference. *Social Cognitive and Affective Neuroscience*, *2*, 313–322.

Farb, N. A., Segal, Z. V., & Anderson, A. K. (2013). Mindfulness meditation training alters cortical representations of interoceptive attention. *Social Cognitive and Affective Neuroscience*, *8*(1), 15–26.

Fox, K. C., Dixon, M. L., Nijeboer, S., Girn, M., Floman, J. L., Lifshitz, M., Ellamil, M., Sedlmeier, P., & Christoff, K. (2016). Functional neuroanatomy of meditation: A review and meta-analysis of 78 functional neuroimaging investigations. *Neuroscience & Biobehavioral Reviews*, *65*, 208–228.

Froeliger, B., Garland, E. L., Kozink, R. V., Modlin, L. A., Chen, N.-K., McClernon, F. J., Greeson, J. M., & Sobin, P. (2012). Meditation-state functional connectivity (msfc): Strengthening of the dorsal attention network and beyond. *Evidence-Based Complementary and Alternative Medicine, 2012*, 1–9. doi:10.1155/2012/680407.

Gallagher, S. (2000). Philosophical conceptions of the self: Implications for cognitive science. *Trends in Cognitive Sciences*, *4*(1), 14–21.

Gallagher, S. (2017). Phenomenological approaches to consciousness. The Blackwell companion to consciousness (pp. 711–725).

Gallagher, S., & Daly, A. (2018). Dynamical relations in the self-pattern. *Frontiers in Psychology*, 664.

Garland, E. L., Hanley, A. W., Hudak, J., Nakamura, Y., & Froeliger, B. (2022). Mindfulness-induced endogenous theta stimulation occasions self-transcendence and inhibits addictive behavior. *Science Advances*, *8*(41), eabo4455.

Gallagher, S., Raffone, A., Berkovich-Ohana, A., Barendregt, H., Bauer, P., Brown, K. W., Giommi, F., Nyklíček, I., Ostafin, B., Slagter, H., Trautwein, F.-M., & Vago, D. (under review). The self-pattern and Buddhist psychology.

Garrison, K. A., Scheinost, D., Worhunsky, P. D., Elwafi, H. M., Thornhill, T. A., Thompson, E., Saron, C., Desbordes, G., Kober, H., Hampson, M., Gray, J. R., Constable, R. T., Papademetris, X., & Brewer, J. A. (2013). Real-time fMRI links subjective experience with brain activity during focused attention. *NeuroImage*, *81*, 110–118. doi:10.1016/j.neuroimage.2013.05.030.

Goldberg, S. B. (2022a). A common factors perspective on mindfulness-based interventions. *Nature Reviews Psychology*, *1*(10), 605–619.

Goldberg, S. B., Riordan, K. M., Sun, S., & Davidson, R. J. (2022b). The empirical status of mindfulness-based interventions: A systematic review of 44 meta-analyses of randomized controlled trials. *Perspectives on Psychological Science*, *17*(1), 108–130.

Goldberg, S. B., Tucker, R. P., Greene, P. A., Davidson, R. J., Wampold, B. E., Kearney, D. J., & Simpson, T. L. (2018). Mindfulness-based interventions for psychiatric disorders: A systematic review and meta-analysis. *Clinical Psychology Review*, *59*, 52–60.

Gombrich, R. F. (2009). *What the Buddha thought*. Equinox Publ.

Greeson, J. M., Zarrin, H., Smoski, M. J., Brantley, J. G., Lynch, T. R., Webber, D. M., … Wolever, R. Q. (2018). Mindfulness meditation targets transdiagnostic symptoms implicated in stress-related disorders: Understanding relationships between changes in mindfulness, sleep quality, and physical symptoms. *Evidence-Based Complementary and Alternative Medicine* 2018.

Griffith, G. M., Bartley, T., & Crane, R. S. (2019). The inside out group model: Teaching groups in mindfulness-based programs. *Mindfulness*, *10*(7), 1315–1327.

Gusnard, D. A., Akbudak, E., Shulman, G. L., & Raichle, M. E. (2001). Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain function. *Proceedings of the National Academy of Sciences of the United States of America*, *98*, 4259–4264.

Hasenkamp, W., & Barsalou, L. W. (2012). Effects of meditation experience on functional connectivity of distributed brain networks. *Frontiers in Human Neuroscience*, *6*, 1–14. doi:10.3389/fnhum.2012.00038.

Hayes, S. C., Hofmann, S. G., & Ciarrochi, J. (2020). A process-based approach to psychological diagnosis and treatment: The conceptual and treatment utility of an extended evolutionary meta model. *Clinical Psychology Review*, *82*, 101908.

Hernández, S. E., Barros-Loscertales, A., Xiao, Y., González-Mora, J. L., & Rubia, K. (2018). Gray matter and functional connectivity in anterior cingulate cortex are associated with the state of mental silence during Sahaja yoga meditation. *Neuroscience*, *371*, 395–406. doi:10.1016/j.neuroscience.2017.12.017.

Hölzel, B. K., Hoge, E. A., Greve, D. N., Gard, T., Creswell, J. D., Brown, K. W., Barrett, L. F., Schwartz, C., Vaitl, D., & Lazar, S. W. (2013). Neural mechanisms of symptom improvements in generalized anxiety disorder following mindfulness training. *NeuroImage: Clinical*, *2*, 448–458. doi:10.1016/j.nicl.2013.03.011.

Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, *6*(6), 537–559.

Hutto, D. D., & Myin, E. (2017). *Evolving enactivism: Basic minds meet content*. MIT Press.

Jang, J. H., Jung, W. H., Kang, D. H., Byun, M. S., Kwon, S. J., Choi, C. H., & Kwon, J. S. (2011). Increased default mode network connectivity associated with meditation. *Neuroscience Letters*, *487*, 358–362.

Josipovic, Z., Dinstein, I., Weber, J., & Heeger, D. J. (2012). Influence of meditation on anti-correlated networks in the brain. *Frontiers in Human Neuroscience*, *5*, 183.

Kajimura, S., Masuda, N., Lau, J. K. L., & Murayama, K. (2020). Focused attention meditation changes the boundary and configuration of functional networks in the brain. *Scientific Reports*, *10*(1), 18426. doi:10.1038/s41598-020-75396-9.

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review*, *30*(7), 865–878.

Kilpatrick, L. A., Suyenobu, B. Y., Smith, S. R., Bueller, J. A., Goodman, T., Creswell, J. D., Tillisch, K., Mayer, E. A., & Naliboff, B. D. (2011). Impact of mindfulness-based stress reduction training on intrinsic brain connectivity. *NeuroImage*, *56*(1), 290–298.

Kirmayer, L. J. (2019). Toward an ecosocial psychiatry. *World Social Psychiatry*, *1*(1), 30.

Koch, I., Gade, M., Schuch, S., & Philipp, A. M. (2010). The role of inhibition in task switching: A review. *Psychonomic Bulletin & Review*, *17*(1), 1–14.

Kreplin, U., Farias, M., & Brazil, I. A. (2018). The limited prosocial effects of meditation: A systematic review and meta-analysis. *Scientific Reports*, *8*(1), 1–10.

Lamm, C., Decety, J., & Singer, T. (2011). Meta-analytic evidence for common and distinct neural networks associated with directly experienced pain and empathy for pain. *NeuroImage*, *54*(3), 2492–2502.

Laukkonen, R. E., & Slagter, H. A. (2021). From many to (n) one: Meditation and the plasticity of the predictive mind. *Neuroscience & Biobehavioral Reviews*, *128*, 199–217.

Legrand, D., & Ruby, P. (2009). What is self-specific? Theoretical investigation and critical review of neuroimaging results. *Psychological Review*, *116*(1), 252–282.

Levitt, J. T., Brown, T. A., Orsillo, S. M., & Barlow, D. H. (2004). The effects of acceptance versus suppression of emotion on subjective and psychophysiological response to carbon dioxide challenge in patients with panic disorder. *Behavior Therapy*, *35*(4), 747–766.

Li, W., Garland, E. L., McGovern, P., O'brien, J. E., Tronnier, C., & Howard, M. O. (2017). Mindfulness-oriented recovery enhancement for internet gaming disorder in US adults: A stage I randomized controlled trial. *Psychology of Addictive Behaviors*, *31*(4), 393.

Lin, Y., Callahan, C. P., & Moser, J. S. (2018). A mind full of self: Self-referential processing as a mechanism underlying the therapeutic effects of mindfulness training on internalizing disorders. *Neuroscience & Biobehavioral Reviews*, *92*, 172–186.

Lindsay, E. K., Young, S., Brown, K. W., Smyth, J. M., & Creswell, J. D. (2019). Mindfulness training reduces loneliness and increases social contact in a randomized controlled trial. *Proceedings of the National Academy of Sciences*, *116*(9), 3488–3493.

McLaughlin, K. A., Colich, N. L., Rodman, A. M., & Weissman, D. G. (2020). Mechanisms linking childhood trauma exposure and psychopathology: A transdiagnostic model of risk and resilience. *BMC Medicine*, *18*(1), 1–11.

Miller, M. L., & Hormes, J. M. (2022). Cognitive and behavioral inflexibility as a transdiagnostic process underpinning exercise dependence. *International Journal of Mental Health and Addiction*, 1–12.

Millière, R., Carhart-Harris, R. L., Roseman, L., Trautwein, F.-M., & Berkovich-Ohana, A. (2018). Psychedelics, meditation, and self-consciousness. *Frontiers in Psychology*, *9*. doi:10.3389/fpsyg.2018.01475.

Morris, L., & Mansell, W. (2018). A systematic review of the relationship between rigidity/flexibility and transdiagnostic cognitive and behavioral processes that maintain psychopathology. *Journal of Experimental Psychopathology*, *9*(3).

Ñāṇananda, B. (1997). Concept and reality in the buddhist thought.

Nijenhuis, E. R., & Van der Hart, O. (2011). Dissociation in trauma: A new definition and comparison with previous formulations. *Journal of Trauma & Dissociation*, *12*(4), 416–445.

Nolen-Hoeksema, S., & Watkins, E. R. (2011). A heuristic for developing transdiagnostic models of psychopathology: Explaining multifinality and divergent trajectories. *Perspectives on Psychological Science*, *6*(6), 589–609.

Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain—A meta-analysis of imaging studies on the self. *NeuroImage*, *31*, 440–457.

Nyklíček, I., Hoogwegt, F., & Westgeest, T. (2015). Psychological distress across twelve months in patients with rheumatoid arthritis: The role of disease activity, disability, and mindfulness. *Journal of Psychosomatic Research*, *78*(2), 162–167.

Ostafin, B. D., Bauer, C., & Myxter, P. (2012). Mindfulness decouples the relation between automatic alcohol motivation and heavy drinking. *Journal of Social and Clinical Psychology*, *31*(7), 729–745.

Papies, E. K., Barsalou, L. W., & Custers, R. (2012). Mindful attention prevents mindless impulses. *Social Psychological and Personality Science*, *3*(3), 291–299.

Qin, P., & Northoff, G. (2011). How is our self related to midline regions and the default-mode network? *NeuroImage*, *57*, 1221–1233.

Rainville, P., Duncan, G. H., Price, D. D., Carrier, B., & Bushnell, M. C. (1997). Pain affect encoded in human anterior cingulate but not somatosensory cortex. *Science*, *277*(5328), 968–971.

Roefs, A., Fried, E. I., Kindt, M., Martijn, C., Elzinga, B., Evers, A. W., … Jansen, A. (2022). A new science of mental disorders: Using personalised, transdiagnostic, dynamical systems to understand, model, diagnose and treat psychopathology. *Behaviour Research and Therapy*, *153*, 104096.

Sass, L., Borda, J. P., Madeira, L., Pienkos, E., & Nelson, B. (2018). Varieties of self disorder: A bio-pheno-social model of schizophrenia. *Schizophrenia Bulletin*, *44*(4), 720–727.

Schultz, P. W., & Searleman, A. (2002). Rigidity of thought and behavior: 100 years of research. *Genetic, Social, and General Psychology Monographs*, *128*(2), 165.

Segal, Z., Williams, M., & Teasdale, J. (2018). *Mindfulness-based cognitive therapy for depression*. Guilford Publications.

Seth, A. K. (2013). Interoceptive inference, emotion, and the embodied self. *Trends in Cognitive Sciences*, *17*(11), 565–573.

Shapiro, S. L., Brown, K. W., Thoresen, C., & Plante, T. G. (2011). The moderation of mindfulness-based stress reduction effects by trait mindfulness: Results from a randomized controlled trial. *Journal of Clinical Psychology*, *67*(3), 267–277.

Sridharan, D., Levitin, D. J., & Menon, V. (2008). A critical role for the right fronto-insular cortex in switching between central-executive and default-mode networks. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(34), 12569–12574. doi:10.1073/pnas.0800005105.

Stalnaker, T. A., Takahashi, Y., Roesch, M. R., & Schoenbaum, G. (2009). Neural substrates of cognitive inflexibility after chronic cocaine exposure. *Neuropharmacology*, *56*, 63–72.

Sui, J., & Gu, X. (2017). Self as object: Emerging trends in self research. *Trends in Neurosciences*, *40*(11), 643–653.

Sui, J., & Humphreys, G. W. (2015). The integrative self: How self-reference integrates perception and memory. *Trends in Cognitive Sciences*, *19*(12), 719–728.

Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*(4), 213–225.

Taylor, V. A., Daneault, V., Grant, J., Scavone, G., Breton, E., Roffe-Vidal, S., Courtemanche, J., Lavarenne, A. S., Marrelec, G., & Benali, H. (2013). Impact of meditation training on the default mode network during a restful state. *Social Cognitive and Affective Neuroscience*, *8*, 4–14.

Tognoli, E., Zhang, M., Fuchs, A., Beetle, C., & Kelso, J. S. (2020). Coordination dynamics: A foundation for understanding social behavior. *Frontiers in Human Neuroscience*, *14*, 317.

Tomasino, B., Fregona, S., Skrap, M., & Fabbro, F. (2012). Meditation-related activations are modulated by the practices needed to obtain it and by the expertise: An ALE meta-analysis study. *Frontiers in Human Neuroscience*, *6*(346), 1–14. doi:10.3389/fnhum.2012.00346.

Turgon, R., Ruffault, A., Juneau, C., Blatier, C., & Shankland, R. (2019). Eating disorder treatment: A systematic review and meta-analysis of the efficacy of mindfulness-based programs. *Mindfulness*, *10*(11), 2225–2244.

Uddin, L. Q. (2021). Cognitive and behavioural flexibility: Neural mechanisms and clinical considerations. *Nature Reviews Neuroscience*, *22*(3), 167–179.

Uddin, L. Q., Yeo, B. T. T., & Spreng, R. N. (2019). Towards a universal taxonomy of macro-scale functional human brain networks. *Brain Topography*, *32*(6), 926–942. doi:10.1007/s10548-019-00744-6.

Vago, D. R., Farb, N., & Spreng, R. N. (2022). Clarifying Internally-Directed Cognition: A Commentary on the Attention to Thoughts Model. *Psychological Inquiry*, *33*(4), 261–272.

Vago, D. R., & Silbersweig, D. A. (2012). Self-awareness, self-regulation, and self-transcendence (S-ART): A framework for understanding the neurobiological mechanisms of mindfulness. *Frontiers in Human Neuroscience*, *6*. doi:10.3389/fnhum.2012.00296.

Varela, F. J., Thompson, E., & Rosch, E. (2017). *The embodied mind, revised edition: Cognitive science and human experience*. MIT press.

Wampold, B. E. (2015). How important are the common factors in psychotherapy? An update. *World Psychiatry*, *14*(3), 270–277.

Wampold, B. E., & Ulvenes, P. G. (2019). Integration of common factors and specific ingredients. In J. C. Norcross, & M. R. Goldfried (Eds.), *Handbook of psychotherapy integration* (pp. 69–87). Oxford University Press.

Wielgosz, J., Goldberg, S. B., Kral, T. R., Dunne, J. D., & Davidson, R. J. (2019). Mindfulness meditation and psychopathology. *Annual review of clinical psychology*, *15*, 285–316.

Yang, C.-C., Barrós-Loscertales, A., Pinazo, D., Ventura-Campos, N., Borchardt, V., Bustamante, J.-C., Rodríguez-Pujadas, A., Fuentes-Claramonte, P., Balaguer, R., Ávila, C., & Walter, M. (2016). State and training effects of mindfulness meditation on brain networks reflect neuronal mechanisms of its antidepressant effect. *Neural Plasticity*, *2016*, 1–14. doi:10.1155/2016/9504642.

Young, K. S., van der Velden, A. M., Craske, M. G., Pallesen, K. J., Fjorback, L., Roepstorff, A., & Parsons, C. E. (2018). The impact of mindfulness-based interventions on brain activity: A systematic review of functional magnetic resonance imaging studies. *Neuroscience & Biobehavioral Reviews*, *84*, 424–433. doi:10.1016/j.neubiorev.2017.08.003.

Zgierska, A. E., Burzinski, C. A., Mundt, M. P., McClintock, A. S., Cox, J., Coe, C. L., … Fleming, M. F. (2019). Mindfulness-based relapse prevention for alcohol dependence: Findings from a randomized controlled trial. *Journal of Substance Abuse Treatment*, *100*, 8–17.