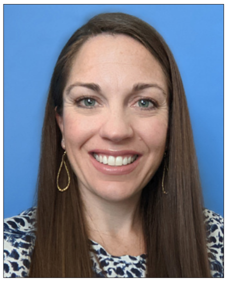

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Article

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Neuroscience and Self in Interdisciplinary Dialogue

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Within the framework of theological anthropology, a robust answer to the question "what is a human being?" *necessarily requires more than a detailed explication of physical, biological parts.*[1] *Yet, theological treatments should engage empirical evidence about these constituent parts to anchor models of persons around what is empirically observable.*[2] *To facilitate the necessary interdisciplinary dialogue for such a robust treatment of persons, this article provides a brief overview of select neuroscience literature on* self*. Specifically, I provide an initial introduction to measuring neural activity and the brain's default mode network (DMN), a region of the brain associated with internal, self-related thoughts dissociated from external input. Some researchers have suggested that the DMN is what makes the "self" special; rather than the self being a higher-order composite construct, it may be foundational to the brain's operations.*[3] *Although the role of the DMN in understanding self has not reached scientific consensus, a consideration of the DMN and the results of its dysfunction may stimulate interdisciplinary dialogue in at least two ways related to questions of selves. First, given the ongoing discussion about the proper interpretation of DMN data, this area may benefit from non-empirical, interdisciplinary contributions toward understanding selves. Second, the centrality of the DMN to selves suggests a healthy DMN is necessary (though not sufficient) for a healthy self. Practices for healthy DMN functioning can contribute to and be enriched by philosophical and theological perspectives about telos and Christian practice.*

Keywords: interdisciplinary, neuroscience, self, theological anthropology, default mode network, theory, scientific interpretation, *telos*, christian practice, contemplation and reflection, spiritual disciplines, multitasking

In framing his argument about the importance of habit, James K. A. Smith argues that "every approach to discipleship and Christian formation assumes an implicit model of what human beings are."[4] In fact, beliefs about who/what humans are guide all human action; different suppositions about human nature provide different guides for human activity toward some hoped-for outcome. Importantly, these beliefs do not always explicitly guide activity. In fact, operating *outside* conscious awareness may serve to make these beliefs a more significant influence as they go unquestioned, presumed a priori. Given the significance of these underlying beliefs about what *kind* of thing a person is, especially for the Christian developing toward Christlikeness, it is of tantamount importance to leverage all relevant tools in developing accurate models of what constitutes

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a person.[5] As discrete disciplines use increasingly specialized tools to address questions around personhood, studies in theological anthropology provide an important opportunity to integrate these disparate findings, using data to anchor proposals without being restricted to only empirical observations.[6]

Thus, the goal of this article is to explore neuroscience research relevant to theological discussions about selves. I start by introducing methods of neuroscience, highlighting how the problem of neurological baseline measures may provide insight into questions of selves. Specifically, questions about the nature of selves may be informed by research on the brain's baseline, intrinsic activity in the default mode network (DMN). Some neuroscientists argue that the DMN, essential for self-related processing, points to the self as special, a kind of fundamental, brute fact of being a self.[7] Moreover, questions about how to understand the proper functioning and purpose of selves may be informed by research highlighting how brain activity directed inward appears to be inversely related to brain activity directed outward. In discussing this research, I aim to delineate empirical anchors for conversations around personhood and to suggest pathways forward. The exploration of neuroscience, here, should not be understood as a statement that understanding humans' small, constituent parts is the key to understanding the whole of the person. However, the exploration of empirical findings across multiple disciplinary views, which includes neuroscience, promotes a more robust engagement with relevant empirical proposals to inform and enrich the integrative and generative processes involved in theological anthropology.

Measuring Brain Activity

Although an extensive introduction to the many and diverse methods of neuroscience is outside the scope of this review, one of the most important and influential tools in empirical investigations into the brain is *neuroimaging* or, as it is more commonly known, brain scanning.[8] Different brain scanning technologies exist, but the most prevalent is functional magnetic resonance imaging (fMRI).[9] fMRIs offer a window into the brain's activity by measuring changes in the blood-oxygen-level dependent (BOLD) signal. Neurons, the cells that are the basic building blocks of the nervous system, need energy in the form of glucose to function. During cognitive activity, neurons are active; neural activity, and the functioning it supports, is maintained via cerebral blood flow replenishing the necessary glucose for activity.[10] It is the change in blood flow and oxygenation of the blood that the fMRI machines measure with the BOLD signal.

The most significant limitation of the inference required to interpret the BOLD signal concerns its spatiotemporal resolution.[11] Even in a 1mm spatial measure, the BOLD signal is providing a summation of the response of millions of neurons, neurons that are measured over seconds, rather than the milliseconds of the underlying neural activity the BOLD signal seeks to measure.[12] Yet, even as there are limits in these measures, fMRI is demonstrated to be trustworthy as a representation of underlying brain activity. As new technologies emerge and become more accessible, the most pressing questions will concern the specificity of theories for empirical examination, the ecological validity of these empirical methods, and the ability to interpret across technologies.[13]

Measuring changes in brain activation has provided ample evidence for two related principles of brain activity: there is localization of function *and* distributed processing. As I discuss elsewhere, the brain consists of specific localized functions, particular activities produced/supported by discrete, localized areas of the brain (e.g., the specific areas in the brain detected in an fMRI where there is a change in the measured BOLD signal). These localized functions can be understood only in the context of the distributed nature of these functions across the cortex. For example, a function like "facial recognition" involves multiple components, each processed in specific areas distributed across different brain locations.[14]

Importantly, measuring brain activity via the BOLD signal is only meaningful as a *change* of activity. Because the brain is never "off," the brain at baseline in the fMRI machine has a particular pattern of neural activity. This baseline pattern, or control measurement, is used as a benchmark to detect subsequent changes in activation (i.e., during a particular cognitive or experimental task). Brain activity measured at baseline is subtracted from brain activity measured during the experimental task with the net differences in areas with increased blood flow interpreted as signaling the location of the brain regions that undergird that task. To say that area X of the brain is active during task A, then, requires that there is a clear indication that X is active during A at levels notably different than X's activity during comparative tasks (i.e., baseline).

Research is clear that when "task A" concerns the self, there are many different neural correlates (i.e., area Xs, area where there is brain activity different from baseline).[15] Reading this research gives two contradictory impressions. First, it gives the impression that neuroscience knows a lot about brain activity vis-à-vis the self.[16] The second impression, however, is the exact opposite. Like reading a list of ingredients on the back of a box of cereal will not be sufficient to recreate that cereal, the literature on the neural correlates of self seems to be able to say very little about the thing of interest: selves.

However, since a watershed paper by Raichle and colleagues, neuroscience has increasingly grappled with how to interpret and integrate these diffuse neural correlates into a coherent understanding of self.[17] Although there are many significant contributions within neuroscience to understanding self, I want to briefly explore how the implicit problem in fMRI measures tackled by Raichle and colleagues may also provide important insight into the person whose brain is being measured.[18] Specifically, the problem of "baseline" measurement begs the question as to whether there is a standard neural baseline by which change detected in an fMRI can be meaningfully understood or whether any baseline measure is simply a measure of another task-induced pattern of brain activation. The subsequent question is whether and how the answer to the baseline question influences what we understand about human persons. In the sections that follow, I discuss research on the brain's baseline with the goal of exploring implications of this research program for broader conversations concerning the contribution of neuroscience to the interdisciplinary questions of theological anthropology: what a person is and what a person is for.

The Brain's Baseline

The problem of a meaningful baseline of brain activity from which to compare and understand changes in neural activity (increases or decreases *from baseline*) led Raichle and colleagues to investigate the extent to which the control measurements, usually lying supine and still with eyes shut, may be significant.[19] That is, they asked whether there was a uniform, organized pattern of brain activation across people that could serve as a benchmark for an inherently meaningful (and quantifiable) baseline of activity. Their initial work, and the body of research that has followed, indicates that the brain has a *default mode network* (DMN) with a specific pattern of activation representing relaxed, non-goal-directed neural activity.[20]

Understanding any "default mode" requires first understanding the more general properties of networks. In neuroscience, networks can be understood either as *structural,* defined by anatomical similarities, connections, and the co-activation of physically connected neurons, or as *functional,* when distributed areas of the brain are temporally connected, producing cohesive, systematic, and patterned activity during a specific task.[21] Studies of the development of brain networks suggest that early in a human's lifespan, networks are organized primarily according to anatomical proximity, with the distribution of the functional networks resulting from developmental neurobiological processes and behavior.[22] What is/is not a network can be differentiated according to structural and functional connections, though these are not without methodological or theoretical influence.[23] That the brain would not be prepackaged with networks that are objectively and clearly distinguished belies the complexities inherent in the human brain, a model complex system.[24]

The observation that the baseline measure in an fMRI provides a consistent, predictable, temporally correlated pattern of activity, such as defines a functional network, reignited questions about the intrinsic activity of the brain. This interest, and the research that followed, has dramatically influenced current conceptions of brain activity and health by exploring questions about the functional and structural organization and operations of intrinsic activity.[25] Raichle et al. named this pattern of baseline activity as a *default mode* because it represents the intrinsic, internal, and coordinated (networked) activity of an awake but resting brain.[26] Activity in the DMN, then, can serve as the baseline of the brain (since "off" is not an option). Although some researchers question whether the DMN can qualify as a *network*, discussions of core brain networks typically include the DMN on the list, suggesting an overall acceptance of its status as a meaningful network of brain processes.[27] The discussions surrounding the DMN have spurred research to advance theory and understanding in a variety of important neurological and psychological constructs, such as memory replay and narrative, including stories for how we understand ourselves.[28] Research and theorizing about the DMN has also developed potential contributions of neuroscience to interdisciplinary dialogue that hopes to understand and define persons.[29]

The DMN includes symmetrical cortical regions in the left and the right hemispheres, focused in the middle regions of the prefrontal cortex (the brain region just behind human eyebrows) and the middle and side regions of the parietal lobe (roughly the top of the skull) and the temporal lobes (roughly behind the ears).[30] Research has demonstrated activation in this network when participants are at rest, activation that is similar to that during mind wandering (task-unrelated thought), self-referential mental activity, memory for personal life experiences (autobiographical memory), and during first-person perspectives and storytelling.[31] Moreover, the DMN is also active during certain "rudimentary" cognitive processes, including perception, action, and emotion.[32] The pattern of this activity has led to hypotheses about the role of the DMN in the integration and binding of experiences to produce consciousness.[33] Importantly, just like other networked neural activity, activity in this network should not be understood as all or nothing; some tasks (i.e., thinking about familiar others) activate one portion of the network, whereas other tasks (i.e., thinking about oneself) activate the network differently.[34] However, across studies that examine these differential patterns of activation, research generally converges on the conclusion that the regions labeled as the DMN are active when individuals engage in self-referential mental activities.

One important aspect of the DMN is that the increased activation in the DMN during internally directed self-reflections *decreases* when cognitive activity is oriented externally.[35] This is one of the distinguishing features of the DMN compared to other resting-state networks, the latter of which do not anticorrelate with externally oriented attentional networks.[36] For example, Fox and colleagues present data showing that when individuals engage in an attention-demanding task (i.e., actively listening or studying a visual array), the neural activation in the cortical areas associated with hearing and vision increases relative to baseline (which would be expected). This activation is *negatively* correlated, or anticorrelated, with activity in the DMN. As individuals dedicate more attention to the *external* world, increasing activity in those brain networks, activity in the DMN, responsible for monitoring the *internal* world, decreases.[37]

Research has demonstrated that the DMN undergoes development. The DMN of children is underdeveloped/differently connected compared to the healthy human adult DMN.[38] On its own, this finding should not be surprising considering general principles of brain growth, maturation, and experience-dependent plasticity.[39] Underlying brain development coincides with children's psychological development—for example, in their increasing capacity for self-recognition, narrative, first-person perspective memory, and theory of mind.[40] Brains, cognitive capacities, and behavior are deeply intertwined.[41] Given that the healthy functioning of the DMN includes a strong anticorrelation with external attention networks, research has increasingly started exploring the relationship between brain development, behavior, and attentional difficulties across development. For example, the disrupted distinction between the DMN and external attention networks associated with media multitasking may explain concerns about attention switching and emotion regulation among children and adolescents with problematic internet use.[42]

In typically developing adult humans, this inverse on/off relationship between DMN activation (internal attention, attention of self) and the activation of other, externally oriented attentional networks has been explored in research on the regulation of self. Consider, for example, the neural mechanisms undergirding media multitasking. When individuals' attention is persistently and pervasively orientated outward, such as in the replacement of internally reflective moments (e.g., the boredom of waiting in a line) with the scroll through social media while simultaneously listening to a podcast and checking for email or text notifications, the neural networks responsible for monitoring "out there" are strengthened. The net implication is a weakening, through disuse, of the intrinsic system that undergirds the capacity to filter out future external distractions.[43] Although the brain comes prepared with specific genetically scripted ways of developing, its great power is the capacity to be shaped according to its environmental input. Just as exercise strengthens the muscles that are worked according to how they are worked, a brain develops and strengthens networks according to their use.[44]

Given the research highlighting the consistent role of the DMN in self-processing, a reasonable question to follow concerns the extent to which disruptions to the DMN lead to significant disruptions to selves, such as in the case of excessive media multitasking or problematic internet use. Although the DMN and external task attention networks are anticorrelated in a healthy brain, research indicates a number of disorders marked by disturbances to the typical anticorrelations between the DMN and external attention networks or within the internal connectivity of the DMN. For example, disturbances in DMN connectivity have been implicated in autism spectrum disorder, major depressive disorder, and post-traumatic stress disorder.[45] Disturbances can also include hyperactivation of the DMN, which disturbs *when* this network activates, as is the case in bipolar disorder and psychosis.[46] These disturbances involve atypical patterns of activation, such as found among individuals with major depressive disorder. Specifically, those with major depressive disorder had patterns of increased and decreased activation within the DMN that were inverted compared to those without major depression.[47] This pattern of hyper/diminished activation points to the relationship between depression and increased self-focus and internally directed rumination.[48] Just as it is likely too simplistic to say that a "self is DMN," it is likely too simplistic to attribute disorders of self to disorders of the DMN. Yet, as researchers have pointed out, activity in the DMN is a primary contributor to consciousness and self-awareness, making disturbances to the DMN especially meaningful in understanding disorders related to self, even if the DMN cannot fully account for the production of the consciousness that yields self-awareness.[49]

On the other side of disorder, there is evidence that treatments for a variety of psychological problems have increased or decreased effectiveness as a function of individual DMN connectivity. For example, individuals with schizophrenia with lower levels of pretreatment DMN connectivity experience a diminished response to antipsychotic medications, thus experiencing the disorder more severely.[50] Likewise, recent review evidence suggests that the effectiveness of mindfulness interventions in alleviating psychological distress may be related to the extent of changes in DMN connectivity. Specifically, mindfulness interventions may engage the DMN in self-regulation around the direction of attention, especially away from the maladaptive, internal rumination associated with psychological problems such as anxiety and depression.[51]

This research converges on the conclusion that activity in the DMN is central to a coherent and healthy sense of self; disruptions in this network correspond with associated disruptions to selves. The next question concerns the extent to which the self is synonymous with the DMN. In the following section, I review one theory that begins to address this question.

The Baseline Self

Although the data presented in this body of research are compelling, the nature of their interpretation is relatively controversial, such that even papers arguing for a particular understanding for the DMN often start with a disclaimer that there is currently no scientific consensus about the DMN generally, nor whether it should be understood as a marker of a specialized system for self specifically.[52] This lack of scientific consensus has, in many ways, spurred additional theory and interpretations to guide research in the hopes of developing understanding and consensus. One of these theories concerning the DMN is offered by Georg Northoff, in which he argues for the foundational nature of self-as-object in brain processing. Self-as-object is in contrast to self-as-subject, which is a subjective, first person, conscious experience of "I." In his "basis model of self," Northoff suggests that rather than the self as a higher-order, emergent cognitive structure, self-as-object may be fundamental to all cognitive processes. Self-related processing, which is understood as nonpsychological, implicit neural activity for self-as-object, is differentiated from self-referential activity, which is driven by content and representation of self at a psychological level (i.e., self-as-subject, who I perceive myself to be). Northoff argues that self-related processing prioritizes self in neural activity such that other cognitive functions should be understood as emerging out of an inherent and baseline self-specificity; that there is not just overlap between the activity in the resting state DMN and self-related processes, but that self-specificity is encoded (contained) in the neural activities of the brain a priori to other, externally activated cognitive functions. In essence, rather than self-related processing emerging *from* other cognitive functions (e.g., perception, emotions), Northoff suggests that the data imply an interpretation in the *other* direction. Specifically, he interprets research on the brain's intrinsic activity—activity in the DMN—as a neural encoding of the self that undergirds these other functions.[53] Although Northoff's argument is primarily interested in neural activity (i.e., nonpsychological; not a subjective sense of "who I am" as self), subsequent work from this theoretical vantage suggests that self in this kind of model also has meaning as a *psychological* baseline that corresponds with a first-person, subjective experience that is meaningfully connected to the psychological experience of self (concerning self-related content and self-representations).[54]

Specifically, Scalabrini and colleagues interpret their data by stating that the self is "the default, reference, or psychological baseline for its own spectrum of thought."[55] Sui and Humphreys argued a similar conclusion in suggesting that self-reference activity involving DMN activation is what binds the distributed processing of neural activity together into an experienced, coherent whole. This binding is what provides a unified sense of self, others, world, and action despite the parsed and distributed nature of the brain's neural activity.[56] Sui argues that the significance of the self (and the DMN activation maintaining it) to conscious experience suggests that the self is not an epiphenomenal illusion.[57] Instead, consistent with Northoff's basis model of self, self-related processing may be foundational to all human neural activity, a necessary point of reference or baseline.

Northoff's argument points to an important feature of current scientific understanding related to the DMN. Although there is an impressive and growing list of activities that the DMN coordinates and undergirds, these activities require interpretation within a theoretical framework, making current theory-building a particularly important and dynamic activity. It is at this juncture that it is important to proceed cautiously; rather than accepting a theoretical explanation that may be underdetermined by the data or seizing onto simple but likely incomplete explanations, it is important to remember that data are interpreted.[58] Theoretical disagreements are important as they fuel scientific progress; they can also provide viable opportunities for interdisciplinary contributions.[59] In his paper, Northoff explicitly addresses the need for reconsideration of empirical models built on a set of philosophical assumptions.[60] It is in light of the possibility of fruitful interdisciplinary engagement at the nexus of scientific disagreement that I pursue this discussion.

Taken together, this body of research yields a tentative answer to a question raised above, concerning the potential for a neural baseline: there does appear to be a meaningful neural baseline of intrinsic brain activity, the activity of the DMN.[61] Moreover, though also more controversially, this DMN activity represents a fundamental and coherent neural network underpinning self-related processing and psychological concepts of self. This interpretation, even as it is debated, opens the possibility of asking the question concerning what such a neural network implies about human persons. I address two aspects of this question below: the first, examining how to think about scientific data and interpretation about selves; and the second, examining how research on the DMN may contribute to models of human telos.

Interdisciplinary Possibilities around Selves

In light of the previous discussion, my goal in what follows is not to offer definitive assessments of "self" based on the dynamic and varied theoretical interpretations of the default mode network (DMN). Instead, my goal is to engage this science as a Christian, asking whether and how theological commitments may influence an interpretation of the research on the DMN (see Selves and Scientific Interpretation below), and whether or how this research might inform ongoing Christian practice and formation (see Selves and Telos below). I aim to resist the allure of a simple "DMN is self" interpretation, which is a simplification of theories such as Northoff's *basis model of self* to the point of distortion. Instead, I hope that emerging data around the DMN may open possibilities for reflection and interdisciplinary dialogue. I am *not* arguing that selves *are* DMNs, an important assertion, as this claim would call into question the personhood of those with diminished DMNs (e.g., children, dementia patients) while implying that animals with DMN-like structures may be persons.[62] For scientific and for theological reasons, I do not think it is defensible to claim that a self/person is defined by and reducible to the DMN. Rather, I am suggesting that research aimed at understanding and interpreting the data concerning the DMN may benefit from philosophical and theological perspectives and, vice versa, may glean insights relevant to robust theological, philosophical, and historical debates about selves from the nascent and vibrant discussions about how to understand the DMN. Caveats notwithstanding, in what follows I suggest that research on the DMN has the potential to enliven interdisciplinary insight for the interpretation of DMN-related data and theory development and invite dialogue around what selves are *for.*

Selves and Scientific Interpretation

A primary controversy around the DMN concerns the appropriate interpretation for what function it serves and whether that function should be understood as a baseline for and central ingredient of a self. This controversy is directly related to the equally difficult question of the origin and nature of self-awareness and consciousness. Given this controversy, the emerging theory to interpret and explain DMN data may be especially well poised to benefit from non-empirical contributions. This includes thinking through how various philosophical commitments about the nature of self may yield different interpretations of the same data. Different data-consistent interpretations are possible because interpretation, explanation, and theory building involve assumptions that are not inherent in the data themselves.

Thus, a philosophical commitment that the self is epiphenomenal or that the self is meaningful will produce different inclinations for the interpretation of the DMN's function. Given the current debate, it is scientifically defensible to argue for self as more than an illusion, bearing in mind that this is an interpretation of data rather than self-evident in the data. It is important, however, that philosophical commitments and scientific progress be in dialogue. Commitments may change as data overwhelmingly point to specific conclusions in the same way that philosophical commitments can push science to ask different questions yielding new insights.[63] A clear recognition of the place of these kinds of philosophical commitments is important because, although science is without an explicit metaphysical framework, it is often wielded such as to assume metaphysical naturalism. This assumption prioritizes the findings of science as sufficient to explain (and explain away) the whole of human experience (including the perception of self).[64]

Earlier, I argued that a reduction of self to DMN was insufficient based on scientific *and* theological commitments. These commitments complicate an alluring but oversimplified story of self as DMN in a way that requires better theory development. For example, an investigation beyond what is possible in this review suggests that the self may be both fundamental (in the sense of DMN) *and* a higher-order, emergent property.[65] This entails two implications. One implication is that a simple "self-as-DMN" explanation of persons is insufficient. This is not, perhaps, surprising, given that some tasks, such as self-recognition or esteem-related thought, are not contained within DMN activity but are still related to self.[66] Rather than reducing the self to a single brain network, there should be sufficient caution to maintain an appropriate balance of skepticism alongside the possibilities offered in the theory and interpretation of the function of the DMN. Though the data clearly inform the articulated perspectives, it is possible that this disagreement is less about these data and more about the (implicit) philosophical assumptions undergirding their interpretation.

A second implication of these competing models, then, is that even within the brain there are different levels at which the self can be reduced to: the default baseline and an emergent, higher-order construct. Together, this research suggests that both levels of understanding may be correct. The self is, in some sense, reducible to the most fundamental circuit of the brain and it is, at the same time, more than this reduction as an integrative output of the brain. This should not be surprising, given that the brain is a complex system in which multiple interacting and competing systems produce and are shaped by cognition and behavior.[67] At minimum, the self, when examined with the language of neuroscience, requires the kind of robust analysis that includes fundamental and emergent aspects. If these levels of explanation are required *within* the brain, why would they not be required in thinking about the self *beyond* the brain? The multiple layers by which the self can be understood may echo the Hebrew understanding of self as *nephesh*. Even though English translations use words like "soul" and "spirit" (connotating something separate from body), there is a consensus among biblical scholars that these terms refer to the wholeness of a human person.[68] Perhaps a view of self as both fundamental and as an emergent whole might provide a new language for theological arguments around mind/soul/bodies. The multiple layers of self from a neuroscientific perspective may enliven equivalent analyses in theological thought about selves.

Selves and Telos

A second interdisciplinary opportunity emerging from DMN research is related to thinking about what selves are *for:* the purpose, direction, and telos of selves. In a theological view of developmental psychology, Balswick, King, and Reimer introduce the concept of the *developmental dilemma.*[69] The dilemma is that developmental psychology, though intended to describe, explain, and optimize human behavior, is unable to provide a robust and compelling vision for telos. Data (though not scientists) are agnostic on the issue of whether one set of life outcomes is optimal relative to another set of outcomes. For example, although data can (and does) reveal that spending money for the benefit of others increases happiness relative to spending money on oneself, data cannot defend the assertion that this increase in happiness is something to be desired.[70] Although researchers may point to the associations between happiness and other outcomes such as longevity or relationship quality, this simply moves the target as these other outcomes cannot be defended as good or bad by the data alone. In this sense, data require a framework that is robust *beyond* empirical observations in order to contextualize the meaningfulness of the data. It is in this vein that I believe research on the DMN can produce an enriching dialogue with Christian theology and tradition, both of which can provide a context beyond the empirical observations within which one can ask how an understanding of healthy DMN development may adjudicate between competing interpretations of and visions for Christian practice.

An examination of when and how the DMN functions properly, can yield insight into the purpose of self, insight that may produce meaning within a Christian framework. Consider the analogy of a tool. Although a tool has a purpose, it may be used outside of its intended design. However, consistent misuse against its intended purpose may cause significant and long-term damage to the tool. By examining the pattern of damage to the tool, it is possible to better understand what the tool is *not* for, leaving fewer options available for considering its intended telos. It is this kind of understanding that patterns of DMN activity and disruption might provide—an understanding that has implications for personal and corporate Christian practice. Although brain networks may initially have primary functions, they are constantly co-opted to serve additional purposes.[71] When such a co-opting yields significant damage or distress—for example, to self in the case of the disorders described above—this suggests that the network is no longer operating within its normal, intended function. The implication is that the current function is beyond the sustainable scope of the network's purpose.

The DMN is a neural network active during internal, reflective, and nondirected thought linked to selves. In a healthy brain, its activity *necessarily precludes* the kind of externally directed attention that is required to think about others. That is, the DMN works antagonistically with externally oriented attention networks; activating the DMN attenuates activity in outward focused attention networks and vice versa. Mary Helen Immordino-Yang and colleagues reviewed evidence for the importance of this kind of internal reflective activity supported by the DMN for healthy socioemotional development. They concluded that individuals with stronger within-DMN coordination and with more differentiated "on/off" switches (i.e., stronger anticorrelation) between DMN activity and externally oriented attention network activity score higher on a number of measures of cognitive and social abilities compared to those with less coordinated and less differentiated networks. Thus, they promote educational activities that engage *constructive internal reflection,* as means to develop stronger intranetwork coordination and internetwork decoupling.[72] The suggestion that internal reflective behaviors can change brain connectivity is supported by research demonstrating how mindfulness interventions change the functional connectivity of the DMN. More generally, this suggestion is consistent with principles of brain plasticity, that changes in behavior can shape (and reshape) patterns of neural activity and networking.[73]

Broadly, recommendations for healthy DMN development are similar to general recommendations for health, including consistently getting enough sleep, exercise, and eating a healthy diet.[74] More specifically, however, the scope of activities supported by the DMN suggests at least three particular relational and behavioral patterns that reinforce healthy functioning of the DMN: (1) cultivating interpersonal relationships that develop empathy and emotional intelligence; (2) practicing contemplation and reflection; and (3) the regular exercise of self-regulation, especially as related to media multitasking and the impulse to fill moments of bored mind-wandering with entertainment and externally oriented engagement.[75] Given the relationship between behavior and brain development, the development of healthy DMNs requires behaving and interacting in a way that supports the neural developments of these capacities in the first place.

These three suggestions to engage in healthy interpersonal relationships, quiet contemplation, and measured self-regulation reflect values embedded within Christian communities. Todd and Liz Hall, for example, provide an exceptional review of the role and importance of the local church as more than a building to be visited, but an interpersonal means for formation. Formation involves transformation of self and behavior that can be understood as reflective of changes in brain connectivity and processing. The first interpersonal relationship between parent and child has particular importance in shaping future relationships via neural and psychological mechanisms.[76] Specific to DMN development, consider the recent research indicating that the strength of parental religious belief influenced the connectivity of their adolescent children's DMN; one possible interpretation is that the nature of parents' religious beliefs influenced how adolescents viewed themselves as reflected in stronger activation within particular locations of the DMN.[77] Moreover, interpersonal relationships within the church can be a critical source of healing and transformation. Consider research demonstrating the importance of church ministry for children's ability to cultivate loving, supportive relationships, and the role of these ministries in promoting healing among children who have experienced trauma.[78] Importantly, one of the best predictors of church communities that support children's relational development and resilience in the face of trauma is the children's ministry's use of contemplative-reflective practices, practices which are likely to engage the DMN given the similarity to mindfulness practices known to engage the DMN.[79]

Regarding quiet contemplation, there is considerable overlap between constructs such as mindfulness and constructive internal reflection (both of which support healthy DMN activation), on the one hand, and Christian spiritual disciplines, on the other. Voices such as Richard Foster and Dallas Willard point to the importance of spiritual disciplines such as solitude, meditation, simplicity, and service in Christian formation, disciplines that date back to the early church.[80] More recently, Christian psychologists have worked to reclaim these practices as a theistic and theologically grounded replacement for contemporary mindfulness rooted in Buddhism.[81] It seems that mindfulness or constructive internal reflection is good for individuals' psychological experience and their DMN. More importantly, it also seems that these practices are rooted in the formative experiences well known to the early church, experiences to which individuals such as Willard and Foster call the church to return.

The third and final suggestion to develop a healthy DMN is perhaps the most familiar to Christians, to practice measured self-regulation. In fact, at this point one might think that the goal of these activities is merely to "look inward" more, to exercise self-control, to meditate and ponder Christ. This conclusion, however, is premature. Many cases of disorder linked to disruption in the DMN is connected to *hyper*activation of this network.[82] It seems that healthy brains, with respect to the DMN, have a specific balance in the networks that support inwardly directed attention (attention to self) and outwardly direction attention (attention to others). Mark McMinn, for example, understands virtue as the telos of Christian formation, entailing the proper orientation to and balance of self and other focus in light of God's love.[83] Formation toward Christlikeness involves both solitude *and* service; it involves both inward reflection *and* external attention, each at its proper time. That means self-regulation serves to enable the development of "proper time" capacity. This capacity entails reflection, meditation, and the internal disciplines of preparing and prompting individuals for external attention and service, which then call individuals to return to reflection and meditation. This cycle is contrary to the multitask mentality of modern culture where individuals neither attend internally nor externally with intention and control: this is a behavioral practice with neurological and psychological ramifications.[84] Just as a tool might break if used incorrectly, when human behavior is inconsistent with intended purpose—by either looking too much inward or being too distracted by the outward—there are measurable changes in brain and behavior, changes associated with dysfunction.

Conclusion

In this article, I presented neuroscience theory that suggests selves may be fundamental to the brain in the default mode network (DMN). In this interpretation, selves also serve as a psychological baseline by which we make sense of and engage everything else. Importantly, when the DMN is active (e.g., during quiet self-reflection), brain systems engaging the external world are not; when attention is directed externally (e.g., in talking with others), activity in the DMN is diminished. This pattern of activity is the marker of a healthy brain and a robust self, including the more emergent, higher-order functions of self.

This line of research seems well positioned to contribute to and benefit from the interdisciplinary dialogue in theological anthropology in at least two ways. First, this body of research provides an opportunity to explicitly work through how philosophical commitments influence the interpretation of data. This exercise is good for science, but it can also positively influence the more general science-religion dialogue by identifying the range of possible beliefs within the scope of orthodox Christianity. This kind of "Christian identity expansion" is an important feature of bridging the perceived gaps between science and Christianity.[85] One of the possibilities of this exercise is the conclusion that, neurologically, the self may be a meaningful construct. Although brains are best understood as competing and distributed networks of activity, the self may undergird all this activation in a significant and fundamental manner. The current scientific debates around this theoretical interpretation can benefit from philosophical assessment and also contribute new framework and language within the scope of theological anthropology.

Second, the necessary toggle between contemplative, internal reflection and externally oriented attention/goal-directed tasks offers a significant point of engagement for Christian practice which, as Smith indicates, is grounded in one's theological anthropology.[86] Neuroscience, devoid of an explicit metaphysical narrative structure, cannot make claims about telos; yet drawing from these data about the proper functionality of these internal and external systems may prove useful within a Christian theological framework. Because our understanding of what *kind* of beings we are determines purpose—how we approach discipleship, formation, and goals related to meaningful living—theological considerations of how the DMN works and when it does not may contribute to clarity on a Christian's telos, pastoral decisions around ministry practice, and personal practices for Christian disciplines, among others. Although a lofty goal, it is my hope that such an understanding may highlight the deep need to reinvigorate old Christian practices in worship and contemplation, even amidst the flashy chaos of modern culture. ☼

Notes

[1]Marc Cortez, *Theological Anthropology: A Guide for the Perplexed* (London, UK: T&T Clark, 2010).

[2]Erin I. Smith, "A Tale of Two Perspectives: How Psychology and Neuroscience Contribute to Understanding Personhood," *Scientia et Fides* 9, no. 2 (2021): article 2, https://doi.org/10.12775/SetF.2021.017.

[3]Georg Northoff, "Is the Self a Higher-Order or Fundamental Function of the Brain? The 'Basis Model of Self-Specificity' and Its Encoding by the Brain's Spontaneous Activity," *Cognitive Neuroscience* 7 (2016): 203–22, https://doi.org/10.1080/17588928.2015.1111868.

[4]James K. A. Smith, *You Are What You Love: The Spiritual Power of Habit* (Grand Rapids, MI: Brazos Press, 2016), 2. See also James K. A. Smith, *Desiring the Kingdom: Worship, Worldview, and Cultural Formation* (Grand Rapids, MI: Baker Academic, 2009) for a more technical treatment of the subject.

[5]Cortez, *Theological Anthropology*, 6.

[6]Erin Smith, "A Tale of Two Perspectives."

[7]Northoff, "Basis Model of Self-Specificity."

[8]John T. Cacioppo, Gary G. Berntson, and Howard C. Nusbaum, "Neuroimaging as a New Tool in the Toolbox of Psychological Science," *Current Directions in Psychological Science* 17, no. 2 (2008): 62–67, https://doi.org/10.1111/j.1467-8721.2008.00550.x.

[9]Uri Hasson and Christopher J. Honey, "Future Trends in Neuroimaging: Neural Processes as Expressed within Real-Life Contexts," *NeuroImage* 62, no. 2 (2012): 1272–78, https://doi.org/10.1016/j.neuroimage.2012.02.004.

[10]Philipp Mergenthaler et al., "Sugar for the Brain: The Role of Glucose in Physiological and Pathological Brain Function," *Trends in Neurosciences* 36, no. 10 (2013): 587–97, https://doi.org/10.1016/j.tins.2013.07.001; and Marcus E. Raichle et al., "A Default Mode of Brain Function," *Proceedings of the National Academy of Sciences of the United States of America* 98, no. 2 (2001): 676–82, https://doi.org/10.1073/pnas.98.2.676.

[11]Hasson and Honey, "Future Trends"; Zilu Ma and Nanyin Zheng, "Brain-Wide Connectivity Architecture: Developmental Aspects," in *Factors Affecting Neurodevelopment: Genetics, Neurology, Behavior, and Diet*, ed. Colin R. Martin, Victor R. Preedy, and Rajkumar Rajendram (London, UK: Elsevier, 2021), 247–57, https://doi.org/10.1016/B978-0-12-817986-4.00022-5.

[12]Consider the adjective employed by Northoff, "Basis Model of Self-Specificity," 208, in describing the BOLD signal: *sluggish*.

[13]Ed Bullmore and Olaf Sporns, "Complex Brain Networks: Graph Theoretical Analysis of Structural and Functional Systems," *Nature Reviews Neuroscience* 10, no. 3 (2009): 186–98, https://doi.org/10.1038/nrn2575; and Hasson and Honey, "Future Trends."

[14]Erin Smith, "A Tale of Two Perspectives."

[15]Helder F. Araujo et al., "Neural Correlates of Different Self Domains," *Brain and Behavior* 5, no. 12 (2015): 1–15, https://doi.org/10.1002/brb3.409.

[16]See, for example, the long lists of brain regions associated with different components of self in Seth J. Gillihan and Martha J. Farah, "Is Self Special? A Critical Review of Evidence from Experimental Psychology and Cognitive Neuroscience," *Psychological Bulletin* 131, no. 1 (2005): 81–83, https://doi.org/10.1037/0033-2909.131.1.76; and Brick Johnstone, Daniel Cohen, and Andrew Dennison, "The Integration of Sensations and Mental Experiences into a Unified Experience: A Neuropsychological Model for the 'Sense of Self,'" *Neuropsychologia* 159 (2021): 3, https://doi.org/10.1016/j.neuropsychologia.2021.107939.

[17]Raichle et al., "A Default Mode of Brain Function."

[18]Two notable contributions within neuroscience to understanding selves include Johnstone et al., "Neuropsychological Model"; and Julius Kuhl, Markus Quirin, and Sander L. Koole, "Being Someone: The Integrated Self as a Neuropsychological System," *Social and Personality Psychology Compass* 9, no. 3 (2015): 115–32, https://doi.org/10.1111/spc3.12162.

[19]Raichle et al., "A Default Mode of Brain Function."

[20]Marcus E. Raichle, "The Brain's Default Mode Network," *Annual Review of Neuroscience,* 38, no. 1 (2015): 433–47, https://doi.org/10.1146/annurev-neuro-071013-014030.

[21]Structural networks are described by Yong He, Zhang J. Chen, and Alan C. Evans, "Small-World Anatomical Networks in the Human Brain Revealed by Cortical Thickness from MRI," *Cerebral Cortex* 17, no. 10 (2007): 2407–19, https://doi.org/10.1093/cercor/bhl149. Functional networks are described by Karola Kaefer et al., "Replay, the Default Mode Network and the Cascaded Memory Systems Model," *Nature Reviews Neuroscience* 23 (2022): 628–40, https://doi.org/10.1038/s41583-022-00620-6; Vinod Menon, "Large-Scale Brain Networks in Cognition: Emerging Principles," in *Analysis and Function of Large-Scale Brain Networks,* ed. Olaf Sporns (Washington, DC: Society for Neuroscience, 2010): 45–53.

[22]Ma and Zheng, in "Brain-Wide Connectivity," discuss developmental neurobiological processes; and behavior is addressed by Fengji Geng, Morgan Botdorf, and Tracy Riggins, "How Behavior Shapes the Brain and the Brain Shapes Behavior: Insights from Memory Development," *Journal of Neuroscience* 41, no. 5 (2021): 981–90, https://doi.org/10.1523/JNEUROSCI.2611-19.2020.

[23]The influence of theoretical and methodological choices can be seen in a number of ways, such as in defining brain modules, Danielle S. Bassett and Michael S. Gazzaniga, "Understanding Complexity in the Human Brain," *Trends in Cognitive Sciences* 15, no. 5 (2011): 200–9, https://doi.org/10.1016/j.tics.2011.03.006; and in defining structures or networks, Bullmore and Sporns, "Complex Brain Networks"; Xuhong Liao, Athanasios V. Vasilakos, and Yong He, "Small-World Human Brain Networks: Perspectives and Challenges," *Neuroscience & Biobehavioral Reviews* 77 (2017): 286–300, https://doi.org/10.1016/j.neubiorev.2017.03.018; and Menon, "Large-Scale Brain Networks."

[24]Bullmore and Sporns, "Complex Brain Networks."

[25]Raichle, "Brain's Default Mode Network" provides an overview of the significance of the discovery of the DMN. Michael D. Greicius et al., "Functional Connectivity in the Resting Brain: A Network Analysis of the Default Mode Hypothesis," *Proceedings of the National Academy of Sciences of the United States of America* 100, no. 1 (2003): 253–58, https://www.jstor.org/stable/3074142, explore the functional connectivity of the DMN. Tan Tao et al., "The Structural Connectivity Pattern of the Default Mode Network and Its Association with Memory and Anxiety," *Frontiers in Neuroanatomy* 9 (2015), https://doi.org/10.3389/fnana.2015.00152, explore structural aspects of the DMN.

[26]Raichle et al., "A Default Mode of Brain Function."

[27]Alexa M. Morcom and Paul C. Fletcher dispute the merits of understanding the DMN as a network, "Does the Brain Have a Baseline? Why We Should Resist a Rest," *NeuroImage* 37, no. 4 (2007): 1073–82, https://doi.org/10.1016/j.neuroimage.2006.08.013. However, it is common to have the DMN listed in discussions that provide an overview of the brain's large-scale networks: e.g., Menon, "Large-Scale Brain Networks."

[28]Kaefer et al., "Replay"; and Lewis Mehl-Madrona and Barbara Mainguy, "Neuroscience and Narrative," *Anthropology of Consciousness* 33, no. 1 (2022): 79–95, https://doi.org/10.1111/anoc.12144.

[29]Northoff, "Basis Model of Self-Specificity"; and Pengmin Qin, Niall W. Duncan, and Georg Northoff, "Why and How Is the Self Related to the Brain Midline Regions?," *Frontiers in Human Neuroscience* 7 (2013): 6–7, article 909, https://doi.org/10.3389/fnhum.2013.00909.

[30]Raichle, "Brain's Default Mode Network."

[31]Activity at rest, Raichle et al., "A Default Mode of Brain Function"; during mind-wandering, Georg Northoff, "How Does the Brain's Spontaneous Activity Generate Our Thoughts? The Spatiotemporal Theory of Task-Unrelated Thought (STTT)" in *The Oxford Handbook of Spontaneous Thought: Mind-Wandering, Creativity, and Dreaming,* ed. Kieran C. R. Fox and Kalina Christoff (New York: Oxford University Press, 2018), 55–70, https://doi.org/10.1093/oxfordhb/9780190464745.013.9; during self-referential mental activity, Christopher G. Davey, Jesus Pujol, and Ben J. Harrison, "Mapping the Self in the Brain's Default Mode Network," *NeuroImage* 132 (2016): 390–97, https://doi.org/10.1016/j.neuroimage.2016.02.022; Georg Northoff et al., "Self-Referential Processing in Our Brain: A Meta-Analysis of Imaging Studies on the Self," *NeuroImage* 31, no. 1 (2006): 440–57, https://doi.org/10.1016/j.neuroimage.2005.12.002; Pengmin Qin and Georg Northoff, "How Is Our Self Related to Midline Regions and the Default-Mode Network?," *NeuroImage* 57, no. 3 (2011): 1221–33, https://doi.org/10.1016/j.neuroimage.2011.05.028; during memory for personal life experiences, Kaefer et al., "Replay"; and during first-person perspectives and storytelling, Andrew A. Fingelkurts and Alexander A. Fingelkurts, "Persistent Operational Synchrony within Brain Default-Mode Network and Self-Processing Operations in Healthy Subjects," *Brain and Cognition* 75, no. 2 (2011): 79–90, https://doi.org/10.1016/j.bandc.2010.11.015; and Mehl-Madrona and Mainguy, "Neuroscience and Narrative."

[32]Northoff, "Basis Model of Self-Specificity"; and Jie Sui and Glyn W. Humphreys, "The Integrative Self: How Self-Reference Integrates Perception and Memory," *Trends in*

Cognitive Sciences 19, no. 12 (2015): 719–28, https://doi.org/10.1016/j.tics.2015.08.015.

[33]Mehl-Madrona and Mainguy, "Neuroscience and Narrative"; Jie Sui, "Self-Reference Acts as a Golden Thread in Binding," *Trends in Cognitive Sciences* 20, no. 7 (2016): 482–83, https://doi.org/10.1016/j.tics.2016.04.005; Edward Vessel, G. Gabrielle Starr, and Nava Rubin, "The Brain on Art: Intense Aesthetic Experience Activates the Default Mode Network," *Frontiers in Human Neuroscience* 6 (2012): article 66, https://doi.org/10.3389/fnhum.2012.00066; Jun Zhang et al., "Abnormal Default Mode Network Could be a Potential Prognostic Marker in Patients with Disorders of Consciousness," *Clinical Neurology and Neurosurgery* 218 (2022): 107294, https://doi.org/10.1016/j.clineuro.2022.107294.

[34]Araujo et al., "Neural Correlates"; Qin and Northoff, "Is Our Self Related to Midline Regions?"

[35]Michael D. Fox et al., "The Human Brain Is Intrinsically Organized into Dynamic, Anticorrelated Functional Networks," *Proceedings of the National Academy of Sciences of the United States of America* 102, no. 27 (2005): 9673–78, https://doi.org/10.1073/pnas.0504136102; and Raichle, "Brain's Default Mode Network."

[36]Kaefer et al., "Replay."

[37]Fox et al., "Human Brain."

[38]J. Cui et al., "Microstructure of the Default Mode Network in Preterm Infants," *American Journal of Neuroradiology* 38, no. 2 (2017): 343–48, http://dx.doi.org/10.3174/ajnr.A4997; and Kaustubh Supekar et al., "Development of Functional and Structural Connectivity within the Default Mode Network in Young Children," *NeuroImage* 52, no. 1 (2010): 290–301, https://doi.org/10.1016/j.neuroimage.2010.04.009.

[39]Uma R. Karmarkar and Yang Dan, "Experience-Dependent Plasticity in Adult Visual Cortex," *Neuron* 52, no. 4 (2006): 577–85, https://doi.org/10.1016/j.neuron.2006.11.001; and Patrice Voss et al., "Dynamic Brains and the Changing Rules of Neuroplasticity: Implications for Learning and Recovery," *Frontiers in Psychology* 8 (2017): 1657, https://doi.org/10.3389/fpsyg.2017.01657.

[40]Concerning self-recognition: Kristin Hansen Lagattuta and Ross A. Thompson, "The Development of Self-Conscious Emotions: Cognitive Processes and Social Influences," in *The Self-Conscious Emotions: Theory and Research,* ed. Jessica L. Tracy, Richard W. Robins, and June Price Tangney (New York: The Guilford Press, 2007), 91–113; and Michael Lewis and Jeanne Brooks-Gunn, "Chapter 8: The Development of Self Recognition," in *Social Cognition and the Acquisition of Self* (New York: Plenum Press, 1979): 198–221. Concerning narrative and first-person perspective memory: Patricia J. Bauer, Marina Larkina, and Joanne Deocampo, "Chapter 6: Early Memory Development," in *The Wiley-Blackwell Handbook of Childhood Cognitive Development,* second edition, ed. Usha Goswami (West Sussex, UK: Wiley-Blackwell, 2011), 153–79; and Geng et al., "Behavior Shapes the Brain." Concerning theory of mind: Rogier Mars et al., "On the Relationship between the 'Default Mode Network' and the 'Social Brain,'" *Frontiers in Human Neuroscience* 6 (2012): 189, https://doi.org/10.3389/fnhum.2012.00189; and Henry M. Wellman, David Cross, and Julanne Watson, "Meta-Analysis of Theory-of-Mind Development: The Truth about False Belief, *Child Development* 72, no. 3 (2001): 655–84, http://www.jstor.org/stable/1132444.

[41]John W. Krakauer et al., "Neuroscience Needs Behavior: Correcting a Reductionist Bias," *Neuron* 93, no. 3 (2017): 480–90, https://doi.org/10.1016/j.neuron.2016.12.041; and Voss et al., "Dynamic Brains."

[42]William M. Kelley, Dylan D. Wagner, and Todd F. Heatherton, "In Search of a Human Self-Regulation System," *Annual Review of Neuroscience* 38, no. 1 (2015): 389–411, https://doi.org/10.1146/annurev-neuro-071013-014243; and Kristiana Siste et al., "Altered Resting-State Network in Adolescents with Problematic Internet Use," *Journal of Clinical Medicine* 11, no. 19 (2022): 5838, https://doi.org/10.3390/jcm11195838.

[43]Kelley et al., "Self-Regulation System."

[44]Voss et al., "Dynamic Brains."

[45]Weijie Bao et al., "Alterations in Large-Scale Functional Networks in Adult Posttraumatic Stress Disorder: A Systematic Review and Meta-Analysis of Resting-State Functional Connectivity Studies," *Neuroscience and Biobehavioral Reviews* 131 (2021): 1027–36, https://doi.org/10.1016/j.neubiorev.2021.10.017; Jianxiu Li et al., "Abnormal Core Functional Connectivity on the Pathology of MDD and Antidepressant Treatment: A Systematic Review," *Journal of Affective Disorders* 296 (2022): 622–34, https://doi.org/10.1016/j.jad.2021.09.074; and Aarthi Padmanabhan et al., "The Default Mode Network in Autism," *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging* 2, no. 6 (2017): 476–86, https://doi.org/10.1016/j.bpsc.2017.04.004.

[46]Randy L. Buckner, "The Brain's Default Network: Origins and Implications for the Study of Psychosis," *Dialogues in Clinical Neuroscience* 15, no. 3 (2013): 351–58, https://doi.org/10.31887/DCNS.2013.15.3/rbuckner; and Tina Chou et al., "Restoration of Default Mode Network and Task Positive Network Anti-Correlation Associated with Mindfulness-Based Cognitive Therapy for Bipolar Disorder," *Psychiatry Research: Neuroimaging* 319 (2022): 111419, https://doi.org/10.1016/j.pscychresns.2021.111419.

[47]Georg Northoff and E. Sibille, "Why are Cortical GABA Neurons Relevant to Internal Focus in Depression? A Cross-Level Model Linking Cellular, Biochemical, and Neural Network Findings," *Molecular Psychiatry* 19 (2014): 966–77, https://doi.org/10.1038/mp.2014.68.

[48]Northoff, "Basis Model of Self-Specificity."

[49]Jian Li et al., "Mapping the Subcortical Connectivity of the Human Default Mode Network," *NeuroImage* 245 (2021): 118758, https://doi.org/10.1016/j.neuroimage.2021.118758.

[50]Urvakhsh Meherwan Mehta et al., "Resting-State Functional Connectivity Predictors of Treatment Response in Schizophrenia—A Systematic Review and Meta-Analysis," *Schizophrenia Research* 237 (2021): 153–65, https://doi.org/10.1016/j.schres.2021.09.004.

[51]Michelle Melis et al., "The Impact of Mindfulness-Based Interventions on Brain Functional Connectivity: A Systematic Review," *Mindfulness* 13, no. 8 (2022): 1857–75; and Hadley Rahrig et al., "Meta-Analytic Evidence That Mindfulness Training Alters Resting State Default Mode Network Connectivity," *Scientific Reports* 12 (2022): 12260, https://doi.org/10.1038/s41598-022-15195-6.

[52]Gillihan and Farah, for example, in "Is Self Special?," argue that there is not sufficient evidence that a self-system is *special*, something that is anatomically distinct, processed differently than other kinds of systems, independent of other systems, and specific to humans. Moran, Kelley, and Heatherton likewise argue that the

self-system should be understood as any other cognitive system, just more powerful in directing activities, in Joseph Moran, William Kelley, and Todd Heatherton, "What Can the Organization of the Brain's Default Mode Network Tell Us about Self-Knowledge?," *Frontiers in Human Neuroscience* 7 (2013): 391, https://doi.org/10.3389/fnhum.2013.00391. Northoff, on the other hand, in "Basis Model of Self-Specificity," presents evidence that self-related processing is the foundation of other cognitive processes and is contained within the intrinsic activity of the brain. Scalabrini et al. have found a psychological correspondence for this containment regarding self, in Andrea Scalabrini et al., "The Self and Its Internal Thought: In Search for a Psychological Baseline," *Consciousness and Cognition* 97 (2022): 103244, https://doi.org/10.1016/j.concog.2021.103244. Kaefer, in "Replay," provides an example of the utility of investigating the networked activity of the DMN in understanding broader cognitive processes, such as memory, even while the specific function and interpretation of the DMN is debated.

[53]Northoff, "Basis Model of Self-Specificity."

[54]Scalabrini, "Psychological Baseline."

[55]Ibid., 2.

[56]Sui and Humphreys, "Integrative Self."

[57]Sui, "Self-Reference."

[58]This warning is fueled, in part, by a retrospective reflection on the scientific and public craze around mirror neurons which were used to try to explain nearly everything having to do with social cognition in the 2000s. Many of these claims were overstated and oversimplified. Cecilia Heyes, "Mesmerising Mirror Neurons," *NeuroImage* 51, no. 2 (2010): 789–91, https://doi.org/10.1016/j.neuroimage.2010.02.034; and Cecilia Heyes and Caroline Catmur, "What Happened to Mirror Neurons?," *Perspectives on Psychological Science* 17, no. 1 (2022): 153–68, https://doi.org/10.1177/1745691621990638.

[59]For an example of disagreements promoting understanding in specific scientific contexts, see Daniel Kahneman and Gary Klein, "Conditions for Intuitive Expertise: A Failure to Disagree," *American Psychologist* 64, no. 6 (2009): 515–26, https://doi.org/10.1037/a0016755. For an analysis of the nature of disagreement in science, see Wout S. Lamers et al., "Meta-Research: Investigating Disagreement in the Scientific Literature," *eLife* 10 (2021): e72737, https://doi.org/10.7554/eLife.72737. See Erin Smith, "A Tale of Two Perspectives," for suggestions for interdisciplinary contributions.

[60]Northoff, "Basis Model of Self-Specificity."

[61]However, as mentioned previously, there is a seemingly minority interpretation that intrinsic activity should not be understood as a functional network: see Morcom and Fletcher, "Resist a Rest." More recently, evidence has also suggested that the DMN may be better understood as multiple, interconnected networks rather than as a single network: see Randy L. Buckner and Lauren M. DiNicola, "The Brain's Default Network: Updated Anatomy, Physiology, and Evolving Insights," *Nature Reviews Neuroscience* 20, no. 10 (2019): 593–608, https://doi.org/10.1038/s41583-019-0212-7.

[62]For the development of DMN in pre-term infants and children, see Damien A. Fair et al., "The Maturing Architecture of the Brain's Default Network," *Proceedings of the National Academy of Sciences of the United States of America* 105, no. 10 (2008): 4028–32, https://doi.org/10.1073/pnas.0800376105; Huiqing Hu, Rhodri Cusack, and Lorina Naci, "Typical and Disrupted Brain Circuitry for Conscious Awareness in Full-Term and Preterm Infants," *Brain Communications* 4, no. 2 (2022): fcac071, https://doi.org/10.1093/braincomms/fcac071; and Supekar et al., "Development." For DMN changes in Alzheimer's patients, see Anne Hafkemeijer, Jeroen van der Grond, and Serge A. R. B. Rombouts, "Imaging the Default Mode Network in Aging and Dementia," *Biochimica et Biophysica Acta (BBA) – Molecular Basis of Disease* 1822, no. 3 (2012): 431–41, https://doi.org/10.1016/j.bbadis.2011.07.008. For a discussion of differences in human and primate DMNs, see Clément M. Garin et al., "An Evolutionary Gap in Primate Default Mode Network Organization," *Cell Reports* 39, no. 2 (2022): 110669, https://doi.org/10.1016/j.celrep.2022.110669. For a discussion on rat DMNs, see Hanbing Lu et al., "Rat Brains Also Have a Default Mode Network," *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 10 (2012): 3979, https://doi.org/10.1073/pnas.1200506109. For a general discussion of the DMN that briefly addresses many of these individual items, see Ma and Zheng, "Brain-Wide Connectivity."

[63]See, for example, the description of the role of philosophy vis-à-vis science in Alex Rosenberg, *Philosophy of Science: A Contemporary Introduction,* third edition (New York: Routledge, 2012), 1–18.

[64]Erin Smith, "A Tale of Two Perspectives."

[65]Kuhl et al., "Being Someone."

[66]Moran et al., "Self-Knowledge."

[67]Bullmore and Sporns, "Complex Brain Networks"; Geng et al., "Behavior Shapes the Brain"; and Voss et al., "Dynamic Brains."

[68]Cortez, *Theological Anthropology*, 70. This consensus does not imply that there is agreement about the particularities of the composition of these wholes: most scholars agree that scripture authors were interested in the whole of an embodied person, not just specific components housed within a person.

[69]Jack O. Balswick, Pamela Ebstyne King, and Kevin S. Reimer, *The Reciprocating Self: Human Development in Theological Perspective,* second edition (Downers Grove, IL: IVP Academic, 2016), 19–27.

[70]Elizabeth W. Dunn, Lara B. Aknin, and Michael I. Norton, "Spending Money on Others Promotes Happiness," *Science* 319, no. 5870 (2008): 1687–88, https://www.science.org/doi/10.1126/science.1150952.

[71]Michael L. Anderson, "Neural Reuse: A Fundamental Organizational Principle of the Brain," *Behavioral and Brain Sciences* 33, no. 4 (2010): 245–66, https://doi.org/10.1017/S0140525X10000853.

[72]Mary Helen Immordino-Yang, Joanna A. Christodoulou, and Vanessa Singh, "Rest Is Not Idleness: Implications of the Brain's Default Mode for Human Development and Education," *Perspectives on Psychological Science* 7, no. 4 (2012): 352–64, https://doi.org/10.1177/1745691612447308.

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