Neuroscience and Self in Interdisciplinary Dialogue

Erin I. Smith

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. Yet, theological treatments should engage empirical evidence about these constituent parts to anchor models of persons around what is empirically observable. 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. 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.

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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.” 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. 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.

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. 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. Different brain scanning technologies exist, but the most prevalent is functional magnetic resonance imaging (fMRI). 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. 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. 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. 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.

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.

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 com-
parative 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). Reading this research gives two
contradictory impressions. First, it gives the impres-
sion that neuroscience knows a lot about brain activity vis-à-vis the self. 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
the self. Although there are many significant contrib-
utions 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 per-
son whose brain is being measured. 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 ques-
tion is whether and how the answer to the baseline question influences what we understand about
human persons. In the sections that follow, I dis-
cuss 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 activ-
ity 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. 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.

Understanding any “default mode” requires first
understanding the more general properties of net-
works. In neuroscience, networks can be understood
either as structural, defined by anatomical similari-
ties, connections, and the co-activation of physically
connected neurons, or as functional, when distributed
areas of the brain are temporally connected, pro-
ducing cohesive, systematic, and patterned activity
during a specific task. Studies of the development
of brain networks suggest that early in a human’s
lifespan, networks are organized primarily accord-
ing to anatomical proximity, with the distribution of
the functional networks resulting from developmen-
tal neurobiological processes and behavior. What
is/is not a network can be differentiated according
to structural and functional connections, though
these are not without methodological or theoretical
influence. That the brain would not be prepack-
aged with networks that are objectively and clearly
distinguished belies the complexities inherent in
the human brain, a model complex system.

The observation that the baseline measure in an fMRI
provides a consistent, predictable, temporally corre-
lated 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 explor-
ing questions about the functional and structural
organization and operations of intrinsic activity. 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. 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, discus-
sions of core brain networks typically include the
DMN on the list, suggesting an overall acceptance
of its status as a meaningful network of brain pro-
cesses.
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. Research and theorizing about the DMN has also developed potential contributions of neuroscience to interdisciplinary dialogue that hopes to understand and define persons.

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). 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. Moreover, the DMN is also active during certain “rudimentary” cognitive processes, including perception, action, and emotion. 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. 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. 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-reflection decreases when cognitive activity is oriented externally. 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. 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.

Research has demonstrated that the DMN undergoes development. The DMN of children is underdeveloped/differently connected compared to the healthy human adult DMN. On its own, this finding should not be surprising considering general principles of brain growth, maturation, and experience-dependent plasticity. 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. Brains, cognitive capacities, and behavior are deeply intertwined. 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.

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. 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.\textsuperscript{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.\textsuperscript{45} Disturbances can also include hyperactivation of the DMN, which disturbs \textit{when} this network activates, as is the case in bipolar disorder and psychosis.\textsuperscript{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.\textsuperscript{47} This pattern of hyper/diminished activation points to the relationship between depression and increased self-focus and internally directed rumination.\textsuperscript{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 disruptions 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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. Although Northoff’s argument is primarily interested in neural activity (i.e., non-psychological; 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). 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.” 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. 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. 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. Theoretical disagreements are important as they fuel scientific progress; they can also provide viable opportunities for interdisciplinary contributions. In his paper, Northoff explicitly addresses the need for reconsideration of empirical models built on a set of philosophical assumptions. 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. 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. 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. 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. 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. 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. 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. 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. 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. 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. 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. 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.

Broadly, recommendations for healthy DMN development are similar to general recommendations for health, including consistently getting enough sleep, exercise, and eating a healthy diet. 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
and Christian spiritual disciplines, on the other.

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. 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. 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.

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.

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. More recently, Christian psychologists have worked to reclaim these practices as a theistic and theologically grounded replacement for contemporary mindfulness rooted in Buddhism.

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 hyperactivation of this network. 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 directed 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 in light of God’s love.

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. 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.65 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.66 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

5Cortez, Theological Anthropology, 6.
6Erin Smith, “A Tale of Two Perspectives.”
7Northoff, “Basis Model of Self-Specificity.”
12Consider the adjective employed by Northoff, “Basis Model of Self-Specificity,” 208, in describing the BOLD signal: sluggish.
Perspectives on Science and Christian Faith


Erin Smith, “A Tale of Two Perspectives.”


Ma and Zheng, in “Brain-Wide Connectivity,” discuss


Raichle et al., “A Default Mode of Brain Function.”


Raichle et al., “A Default Mode of Brain Function.”


Bullmore and Sporns, “Complex Brain Networks.”


Raichle et al., “A Default Mode of Brain Function.”

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 57, 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.”


Raichle, “Brain’s Default Mode Network.”


Araujo et al., “Neural Correlates”; Qin and Northoff, “Brain’s Default Mode Network.”

Kelley et al., “Self-Regulation System.”

Voss et al., “Dynamic Brains.”


Northoff, “Basis Model of Self-Specificity.”


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...


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. D’Innocenzo, “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.


Buckner, “The Brain’s Default.”


James Smith, You Are What You Love; and James Smith, Desiring.

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