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Rest Is Not Idleness: Implications of the Brain's Default Mode for Human Development and Education

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Abstract

When people wakefully rest in the functional MRI scanner, their minds wander, and they engage a so-called default mode (DM) of neural processing that is relatively suppressed when attention is focused on the outside world. Accruing evidence suggests that DM brain systems activated during rest are also important for active, internally focused psychosocial mental processing, for example, when recalling personal memories, imagining the future, and feeling social emotions with moral connotations. Here the authors review evidence for the DM and relations to psychological functioning, including associations with mental health and cognitive abilities like reading comprehension and divergent thinking. This article calls for research into the dimensions of internally focused thought, ranging from free-form daydreaming and off-line consolidation to intensive, effortful abstract thinking, especially with socioemotional relevance. It is argued that the development of some socioemotional skills may be vulnerable to disruption by environmental distraction, for example, from certain educational practices or overuse of social media. The authors hypothesize that high environmental attention demands may bias youngsters to focus on the concrete, physical, and immediate aspects of social situations and self, which may be more compatible with external attention. They coin the term *constructive internal reflection* and advocate educational practices that promote effective balance between external attention and internal reflection.

Keywords

reflection, memory, prosocial emotion

"Rest is not idleness."

John Lubbock, *The Use of Life* (1894)

Clinicians and teachers often discuss the benefits of "down time" and reflection for making sense of one's experiences and decisions about future behavior. For example, many experiential education programs emphasize the importance of time for introspection, and interventions and therapies that teach skills for quiet reflection and mindfulness produce benefits especially for social and emotional functioning (Cohen, 2006; Collaborative for Academic, Social, and Emotional Learning Briefs, 2007; Semple, Lee, Rosa, & Miller, 2010) but also for academic achievement (Brackett, Rivers, Reyes, & Salovey, 2010). Why should this be, and how can developmental, clinical, and educational psychologists better conceptualize the role of off-line and reflective processing for human development? Conversely, how might researchers think in new ways about the impacts of high environmental attentional demands on learning and socioemotional development, including, for example, demands from entertainment media, from the challenges associated with urban settings, or in the classroom?

Emerging conceptions of brain functioning reveal that neural networks responsible for maintaining and focusing attention into the environment appear to toggle with a so-called default mode (DM) of brain function that is spontaneously induced during rest, daydreaming, and other nonattentive but awake mental states (Smallwood, Obonsawin, & Heim, 2003). Further evidence from social and affective neuroscience suggests the importance of brain systems implicated in the DM for active, internally focused psychosocial mental processing, for example, in tasks involving self-awareness and reflection,

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recalling personal memories, imagining the future, feeling emotions about the psychological impact of social situations on other people, and constructing moral judgments (Buckner, Andrews-Hanna, & Schacter, 2008; Gilbert & Wilson, 2007; Spreng & Grady, 2010; Spreng, Mar, & Kim, 2009). Studies examining individual differences in the brain's DM connectivity, essentially measures of how coherently the areas of the network coordinate during rest and decouple during outward attention, find that people with stronger DM connectivity at rest score higher on measures of cognitive abilities like divergent thinking, reading comprehension, and memory (Li et al., 2009; Song et al., 2009; van den Heuvel, Stam, Kahn, & Hulshoff Pol, 2009; Wig et al., 2008). Taken together, these findings lead to a new neuroscientific conception of the brain's functioning "at rest," namely, that neural processing during lapses in outward attention may be related to self and social processing and to thought that transcends concrete, semantic representations and that the brain's efficient monitoring and control of task-directed and non-task-directed states (or of outwardly and inwardly directed attention) may underlie important dimensions of psychological functioning. These findings also suggest the possibility that inadequate opportunity for children to play and for adolescents to quietly reflect and to daydream may have negative consequences—both for social-emotional well-being and for their ability to attend well to tasks.

Despite the potential implications, however, psychological scientists are largely unaware of or have underappreciated the relevance of this actively growing body of neural findings, and cognitive neuroscientists interested in development and education have largely focused on the immediate, negative effects of attention lapses on task-directed performance (e.g., Kane et al., 2007; McVay & Kane, 2010; Smallwood, Beach, Schooler, & Handy, 2008; Smallwood, Fishman, & Schooler, 2007). Therefore, our goals in this article are (a) to introduce psychological scientists to recent advances in understanding the functioning of the brain and mind during lapses in outward attention; (b) to generate an early hypothesis from the neuroscience findings concerning the effects of consistently high external attention demands in schools and leisure environments on socioemotional development in children and adolescents; (c) to propose preliminary examples of productive connections between this hypothesis and current educational and developmental psychological research findings, in order to demonstrate the utility of the neural findings for psychologists; and (d) to advocate educational practices that promote more effective balance between children's needs for external attention and internal reflection. The overarching premise of the article is that although daydreaming and other lapses in outward attention lead to poor performance on concentration-requiring tasks in the moment, skills for reflecting during lapses in outward attention and time for safely indulging mind wandering may be critical for healthy development and learning in the longer term.

Looking out and Looking in: The Discovery of Complementary Brain Networks

Neuroscience studies over the past several decades have revealed that contrary to early theories, attention is not a general property of the whole brain but the product of specific networks that contribute to various aspects of processing. Decades of study have differentiated three systems responsible for monitoring and responding to the environment around us and for focusing our mental processing on incoming stimuli: alerting, orienting, and executive control (see Corbetta & Shulman, 2002; Fan, McCandliss, Sommer, Raz, & Posner, 2002; Posner & Petersen, 1990). These functions, which rely heavily on lateral frontal and parietal regions, are important for cognitive development, and interventions that support children in strengthening skills related to these aspects of attention improve cognitive and academic performance in a variety of domains (Posner & Rothbart, 2005; Smallwood et al., 2007; Stevens, Lauinger, & Neville, 2009).

But what does the brain do when not engaged in a focused, goal-directed task? Newly emerging theories of the brain's functional architecture reveal that the attention networks described above are part of a broader complement of brain networks that can roughly be conceptualized as supporting two alternating systems. One of these networks is "task positive"; its recruitment is associated with active engagement in goal-directed tasks involving attention to the world and evaluating the salience of external stimuli (Seeley et al., 2007). This network supports what we will call the "looking out" system. Another network, known variously as the "task negative" or "resting" network, has been found to be associated with the brain's default mode of operation (Buckner & Vincent, 2007; Raichle et al., 2001). This network comprises mainly regions along the midline of the brain, in both the parietal and the frontal lobes, along with more lateral regions in the inferior part of the parietal lobe and the medial part of the temporal lobe (see Fig. 1). During neuroimaging experiments, the activity in these regions is heightened most reliably during passive rest (Greicius, Krasnow, Reiss, & Menon, 2003), induced by paradigms such as asking participants to stare for several minutes at a plus sign shown in the center of their field of vision or to relax with their eyes open or closed. We will call this the "looking in" system. (Note our nomenclature: We use the term *network* to describe sets of brain regions whose activity is functionally coordinated. We use the term *system* to describe the psychologically relevant capacities that are supported by the brain *network*.)

The past decade of neuroscience research has revealed that as one network is increasingly engaged, the other is decreasingly engaged (Esposito et al., 2006; Fox et al., 2005). It is thought that the toggling of these networks reflects a shift from a state of external monitoring and focus on goal-directed activity ("looking out") into a more free-form, internally directed, stimulus-independent mental state ("looking in"; see

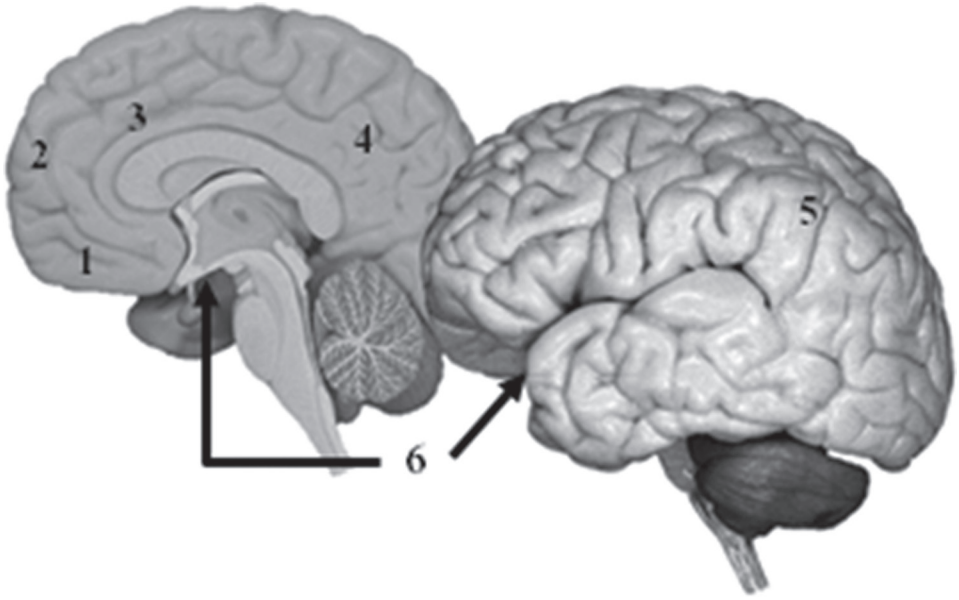

Fig. 1. Overview of the main brain regions comprising the default mode (DM) network, with brief descriptions of associated socioemotional functions. The DM regions listed are relatively more active and show coordinated activity during wakeful "rest." The regions depicted are also involved in many other functions, including various cognitive association functions and aspects of homeostatic regulation and somatosensation, especially for the milieu of the internal body (i.e., the "guts"). The left side of the image shows the front of the brain; the right and left hemispheres are split apart to show the medial surface. Note that these brain areas cannot be said to "do" the functions listed. Instead, they are especially "associated" with these functions and as such are thought to play important roles within the complex networks of regions underlying the functions. 1. Ventromedial prefrontal cortex (vmPFC): Induction of social emotions; nonconscious induction of somatic responses, such as skin sweating associated with a sense of risk; modulation of the parasympathetic branch of the autonomic nervous system (important for calming of heart rate). 2. Dorsomedial prefrontal cortex (dmPFC): Representation of self in relation to others; predicting emotional outcomes of social interactions for self and close others; judging psychological and emotional qualities and traits; feeling emotions about others' mental situations. 3. Anterior middle cingulate cortex (ACC): A centrally connected "hub" of the cortex, also heavily interconnected with somatosensory regions that feel the guts and viscera; error monitoring, emotion, and empathy; feeling physical and social pain; modulation of the sympathetic branch of the autonomic nervous system (important for activation of heart rate, arousal). 4. Posteromedial cortices (PMC): The most centrally connected "hub" of the cortex; high-level integrative representation of the physiological condition of the visceral "gut" body; construction of a subjective sense of self-awareness; activated in social emotions, moral decision making, and episodic memory retrieval; contains dorsal posterior cingulate cortex (dPCC), involved in attention monitoring or switching and integration of information. 5. Inferior parietal lobule (IPL): involved in successful episodic memory retrieval; empathically simulating others' perspectives and the goals of others' actions. 6. Hippocampus: Formation and recall of long-term memories (not visible in these views).

Smallwood, Brown, Baird, & Schooler, 2011, for a related argument). Recent research suggests that these networks' efficiency and co-regulation improve as the brain matures through childhood (Fair et al., 2008) but that the rudiments of this functional organization are present in childhood (Supekar et al., 2010; Thomason et al., 2008), infancy, and possibly even prenatally (Doria et al., 2010; Fransson et al., 2007; but see Fransson, Åden, Blennow, & Lagercrantz, 2011).

In addition, it is likely that the networks that support systems for "looking in" and "looking out" are codependent and co-regulate one another—the functioning of one, both in the moment and over the longer term, has been found to predict the functioning of the other. There is a growing body of neuroscience studies showing that the quality of DM brain activity during rest is related to the quality of subsequent neural and behavioral responses to environmental stimuli and that momentary and longer lasting complementary fluctuations in these networks are important for perception, attention, and goal-directed cognition (see Northoff, Duncan, & Hayes, 2010, for a review; Spreng, Stevens, Chamberlain, Gilmore, & Schacter, 2010). For example, in a neuroimaging experiment in which participants alternated blocks of resting with looking at images and listening to sounds, the more effectively the DM regions were activated during rest and deactivated while attending to the images and sounds, the more brain activation there was in sensory cortices during the image and sound

presentations (Greicius & Menon, 2004). Longitudinal studies also suggest that there is considerable variability in the strength of DM connectivity among adults and that although patterns of activity during rest are relatively stable in adulthood (Beason-Held, Kraut, & Resnick, 2009), training introspection (e.g., through meditation) can alter the functioning of DM networks as well as improve skills for sustained attention on a task (e.g., Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007; Brewer et al., 2012; Chiesa, Calati, & Serretti, 2010; Hölzel et al., 2007; Jha, Krompinger, & Baime, 2007; Tang et al., 2007).

Relations to individual differences in socioemotional functioning

The efficiency with which a brain toggles between activity associated with DM and outward attention as well as the strength of functional connectivity between DM regions during "rest" seem also to be associated with neural and psychological health, especially around social and emotional functioning. Atypicalities in DM functioning have been found to be related to social-emotional symptoms in schizophrenia (Whitfield-Gabrieli et al., 2009), autism (Cherkassky, Kana, Keller, & Just, 2006; Kennedy, Redcay, & Courchesne, 2006), attention deficit disorder (ADD; Castellanos et al., 2008; Tomasi & Volkow, 2012; Uddin et al., 2008), anxiety disorders (Etkin, Prater, Schatzberg, Menon, & Greicius, 2009; Zhao et al., 2007), depression (Greicius et al., 2007), and other conditions. The differences in DM functioning among these populations seem to relate consistently to the hallmark symptoms of the disorder. For instance, autism is associated with atypically low levels of functional connectivity between DM regions during rest; these findings are thought to reflect a paucity of social and psychological thought and emotion (Kennedy & Courchesne, 2008). People with schizophrenia, by contrast, show heightened activation and hyperconnectivity in the DM network that are insufficiently attenuated during outward attention (Bluhm et al., 2007; Garrity et al., 2007; Zhou et al., 2007); this pattern is thought to produce a heightened propensity toward mentalizing and a blurring of boundaries between one's own and others' minds that contributes to disordered thought when coupled with schizophrenics' excessive alertness to the external environment (Whitfield-Gabrieli et al., 2009).

Relations to individual differences in cognitive functioning

Tantalizing new evidence suggests that certain aspects of DM functioning during "rest" and during tasks are related to intelligence in adults as indexed by standardized IQ scores, to reading and memory abilities, and to performance ability on attention-demanding cognitive tasks. For example, studies have found that when people with higher IQ scores "rest" in the functional MRI (fMRI) scanner, the DM connectivity in their brains, especially for long-range connections, is stronger than that measured in the brains of people with average IQs (Li et al., 2009; Song et al., 2009). The main finding concerns not the amount of activation in DM regions but the functional coordination or extent of "cross-talk" between DM regions. In participants with higher IQs, there is more efficient communication and coordination between frontal and parietal DM regions during "rest," which is thought to underlie better cognitive abilities for making connections between disparate pieces of information (van den Heuvel et al., 2009).

With regard to reading and memory ability, findings are related to efficient toggling between the complementary networks. In reading studies, clearer functional segregation during "rest" between DM regions and a key brain region specialized for reading (the left fusiform gyrus, not part of the DM) is associated with reading skill among adults; this clear segregation is not yet mature in children ages 8–14 (Koyama et al., 2011). In memory studies, better long-term recall is associated with greater deactivation of DM regions involved in encoding and recall, specifically the hippocampus and its neighboring parahippocampal gyrus, during simple cognitive tasks compared with during "rest" (Wig et al., 2008). Failure to adequately deactivate another DM region, the posteromedial cortices, during a task requiring outwardly focused attention is also associated with memory declines in older adults (Miller et al., 2008).

Finally, measures of efficient down regulation of DM network activity during external attention-demanding tasks have been found to predict cognitive performance on these tasks in real time. For example, in an experiment using deep-brain electrode recording during simpler and more complex visual search tasks, magnitude of moment-to-moment suppression in DM networks increased with the complexity of processing required and predicted subjects' performance (Ossandon et al., 2011).

To summarize, although the main focus in attention research relevant to development and education to date has been on "looking out" into the environment, for example, the facility with which a child filters out distractions and maintains focus on a task (Posner & Rothbart, 2005; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005), the neuroscience findings reviewed here suggest that (a) the quality of neural processing that supports the system for "looking out" is tied to the quality of neural processing that supports the system for "looking in" and to individuals' abilities to move between these two modes efficiently; (b) the quality of neural processing during "looking in" is related to socioemotional functioning as well as to other dimensions of thought that transcend the "here and now." Yet the implications of these neural findings for psychological development in naturalistic environments like schools have not been studied. The next section provides an overview of the psychological operations that have been related to activity in DM brain regions in adults, in order to begin a conversation among psychological scientists about the dimensions of thought associated with lapses in outward attention and developmental implications. We focus on socioemotional functioning to highlight

the interdependence of the neural networks that support attentive mental states and states that may promote meaning making and socioemotional well-being.

What Does the Mind Do When the Brain Is "at Rest"? Memories, Prospections, Emotions, and the Mental "Self"

As almost any human being can attest, when a person disengages from externally oriented goal-directed behavior, his or her mind is not idle—instead, it can become absorbed in a dynamic stream of free-form thought that is associated with mind wandering, spontaneous recollection of previous memories, production of hypothetical scenarios and future plans, and other personal and social thoughts and imaginings (Andreasen et al., 1995; Smallwood & Schooler, 2006). When considered this way, it is no wonder that some sectors of the brain are highly active during neuroimaging paradigms meant to induce "rest." The mind is not idle in the absence of externally focused, goal-directed tasks—instead, the relative lapse in perceptual vigilance provides an opportunity to mentally wander far from the current physical context, maintaining just enough attention to engage automatic behaviors and to monitor the environment for interruptions, while indulging thoughts, fantasies, and memories about the social world and the psychological self.

It is interesting to note that in addition to studies reporting signature DM activations during non-goal-directed activities such as "rest" in the fMRI scanner, there is now a growing list of neuroimaging studies that report activations in DM regions during goal-directed tasks involving introspective, socioemotional, and self-referential processing or simulation. For instance, activation in DM regions has been found when individuals engage in such activities as feeling compassion for a young mother with cancer or feeling inspired by her determination (Immordino-Yang, McColl, Damasio, & Damasio, 2009); imagining how their opinions would change if they awoke one day as a member of the opposite sex (Tamir & Mitchell, 2011); evaluating moral scenarios, for example, scenarios depicting treatment of wartime prisoners (Harrison et al., 2008); and recalling memories for personal experiences (see Wagner, Shannon, Kahn, & Buckner, 2005, for a review).

Notably, processing related to cognitive perspective taking or traditional theory of mind functions or to evaluating the more concrete and immediate physical and cognitive aspects of social situations is not especially associated with DM regions (see Waytz & Mitchell, 2011, for a related argument). Instead, DM regions seem to be recruited for processing that pertains less to factual knowledge from one's memory or deduction about another's knowledge state and more to simulation and evaluation of abstract social, emotional, and moral implications of one's own or others' knowledge states. For example, several studies have implicated the dorsomedial prefrontal cortex in judgments about psychological traits and emotional qualities of the self and close others (Blakemore & Frith, 2004; Jenkins & Mitchell, 2011; Kelley et al., 2002; Kitayama & Park, 2010; Mitchell, Banaji, & Macrae, 2005; Northoff et al., 2006), an effect that can be modulated by in-group/out-group racial comparisons (Mathur, Harada, & Chiao, 2011) and by cultural conceptions of interdependent versus independent self (Harada, Li, & Chiao, 2010; Markus & Kitayama, 1991). Involvement of the inferior–posterior sector of the posteromedial cortices, the most centrally connected "hub" of the DM network (Hagmann et al., 2008), has been found to be related to self-awareness (Buckner et al., 2008) and autobiographical self (Damasio & Meyer, 2009) and has been consistently implicated in episodic and personal memory retrieval (Immordino-Yang & Singh, 2011; Wagner et al., 2005), daydreaming (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009), moral judgment tasks (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001), and social emotions about others' mental qualities and circumstances, such as admiring another's virtuous commitment to those less fortunate or feeling compassion for someone who has lost a loved one (Immordino-Yang et al., 2009). By contrast, tasks that require simply recognizing and labeling an emotional facial expression from a picture or emotionally reacting to a person's skillful performance or physical injury do not recruit this network (and in fact may suppress its activation because such tasks require outward attention; Immordino-Yang et al., 2009; Sreenivas, Boehm, & Linden, 2012).

Taking this evidence together, we find that brain regions involved in the DM appear to be specifically recruited and specialized for processing abstract information relevant to the psychological, affective, and subjective aspects of the self and other people, both in everyday contexts and for more complex moral, socioemotional, prospective, and retrospective functions (Buckner & Carroll, 2007). This description is necessarily broad—after all, DM activation could be said to underlie half of what the mind does. Our aim in providing this description is to give psychological scientists a sense of the dimensions of thought associated with lapses in outward attention, for comparison with those associated with heightened outward attention (e.g., sensory perception and vigilance to the physical context, cognitive processing of situationally relevant tasks, motor control and coordination of actions, perception of social and emotional stimuli [but not deep reflection on their meaning], and recalling semantic or factual information). This comparison is important because, judging from what is being learned of brain functioning, activating the neural platform that supports mental processes associated with DM regions may be relatively incompatible with externally focused attention or vigilance into the environment, especially while control systems for monitoring and alternately engaging inward focus and outward attention are immature. Our hope is that in distilling the neural findings, we have provided a starting point for appreciating the breadth of their applicability. The next section grounds these ideas with a naturalistic example, in order to narrow the focus onto a new hypothesis for development.

An Example of Spontaneous "Looking in" During Social Learning

Consider the reaction of one college-age participant, "John," during a one-on-one social emotion-induction interview in which he was told a true story meant to induce compassion. The story is about a young boy who grew up in a small industrial city in China during an economic depression that often left him hungry. The boy's father had died just after the boy's birth, leaving his mother to work long hours as a laborer. John was shown a video clip in which the boy's mother describes how, one winter afternoon, she found a coin on the ground and used it to buy warm cakes for her son, who had been all day at school with nothing to eat. The mother recounts how her son had been so hungry, yet he had offered her the last cake, which she declined by lying that she had eaten already. After the video, the experimenter asked John how this situation made him feel, to which John responded:

> This is the one [true story from the experiment] that's hit me the most, I suppose. And I'm not very good at verbalizing emotions. But . . . um . . . I can almost feel the physical sensations. It's like there's a balloon or something just under my sternum, inflating and moving up and out. Which, I don't know, is my sign of something really touching. . . . [pause] And, so, the selflessness of the mother . . . and then also of the little boy. You know, having these wonderful cakes that he never gets to have, and still offering them to her . . . and then her turning them down, is . . . uh . . . [long pause] It makes me think about my parents, because they provide me with so much and I don't thank them enough, I don't think. . . . I *know* I don't. So, I should do that. (adapted from Immordino-Yang, 2011)

In answering the straightforward question of how this story made him feel, John revealed a common pattern in which deliberations leading to a complex reaction to a social situation begin with a general report of feeling emotionally touched or moved ("hit"), which is sometimes accompanied by visceral sensations ("a balloon . . . under my sternum"). Even though John did not seem to really know yet what emotion he was having ("I'm not very good at verbalizing"), he noticed the emotional power of the story based on the physiological "signs" he felt. But he did not stop there. Instead, after briefly reviewing the relevant actions from the story (who gave whom what to eat) and their meaning based on what he knew about the situation (there is a shortage of food, so sharing food implies "selflessness"), John paused. He appeared to briefly withdraw from the interaction with the experimenter and blankly gazed into his lap. Then he emerged with a report of having spontaneously evaluated his own relationship with his parents. By evaluating the emotional implications of another boy's situation, John learned to better appreciate his own.

How does this example pertain to the argument at hand? John's reaction to the compassion-inducing story nicely demonstrates how new insights and understandings are actively, dynamically constructed (Fischer & Bidell, 2006; Fischer & Immordino-Yang, 2002)—learners build from prior knowledge and work to actively accommodate new information to make sense of the current situation. It also demonstrates the value of a reflective pause in moving from considering the concrete, action-oriented, context-specific details of *this* situation (knowing what happened and why) to constructing an understanding of the broader and longer term emotional implications for one's own or *any* situation (in John's case, what the actions mean for the protagonists' psychological qualities and how recognizing these qualities leads him to express greater appreciation of his own parents' sacrifices for him). What is interesting is that our neural data support the interpretation that John's pauses are a behavioral manifestation of DM neural activity. Our current analyses reveal that the more a participant reflectively pauses in the social emotions interview, the more cognitively abstract and complex his or her answers (i.e., the higher the construal level; Pavarini, Schnall, & Immordino-Yang, 2012), the more DM activity the participant will later show when feeling emotions with moral connotations in the MRI scanner, and the stronger the participant's DM connectivity during rest (Immordino-Yang, Pavarini, Schnall, & Yang, 2012).

In the next section, we focus on two developmental implications of the findings: (a) that time and skills for constructive internal reflection are beneficial for emotional learning and well-being; and (b) that inordinately biasing children's and adolescents' attention to the external world may undermine the development of abilities to think about the abstract, moral, and social-emotional aspects of situations, information, memories, and self. Put another way, we hypothesize that consistently imposing high attention demands on children, either in school, through entertainment, or through living conditions, may rob them of opportunities to advance from thinking about "what happened" or "how to do this" to constructing knowledge about "what this means for the world and for the way I live my life." For instance, it could lead teenagers to admire a skillful sports player but not the mental fortitude of, say, a courageous civil rights leader.

What Does This Mean for Children? Toward the Hypothesis That Healthy Psychological Development Requires Opportunities and Skills for "Looking in"

One implication of the DM findings is that the brain seems to honor a distinction between the processing of information about concrete, physical, and immediate circumstances, facts and procedures, and abstract information about mental, hypothetical, and longer term circumstances and implications. Given that deliberating on abstract social-emotional and

hypothetical circumstances seems to be associated with the "looking in" system, we hypothesize that these kinds of thinking may be particularly vulnerable to disruption by external distraction, especially while attentional monitoring and control are immature. Had the experimenter above interrupted John during his reflective pause, would he have made the conceptual leap from considering the story to evaluating his own relationship with his parents? If John had grown up under conditions that did not support time for safe internal reflection, would he have failed to fully develop this skill? We do not know the answers to these questions. But given the accumulating neural evidence, it seems reasonable to conjecture that important skills for reflection and for building personal meaning may depend heavily on psychological functions associated with activity in DM brain networks and may therefore be curtailed if environmental attention demands and distractions are consistently overly high.

Preliminary connections to education

Although education research on learning and achievement have not been framed to highlight transitions to internally focused attention, there are hints that teaching skills for productive internal, self-directed processing in schools may be beneficial both for socioemotional well-being and for academic skills (see also Immordino-Yang & Sylvan, 2010; Yeager & Walton, 2011). For example, high school students encouraged before a test to write in a journal about their beliefs about the implications of their test performance for their life more broadly overcame anxiety and performed better (Ramirez & Beilock, 2011). Similarly, envisioning advantageous possibilities for one's future identity and connecting these possibilities to current behavioral choices have been found to powerfully improve school performance and motivation (Oyserman, Terry, & Bybee, 2002), but the efficacy of these activities is heavily dependent on students' subjective interpretation of their experiences (Destin & Oyserman, 2009; Hatcher & Bringle, 1997). In elementary school-age children, emotional well-being, self-confidence, and academic achievement are bolstered for students taught to take a "meta-moment" in which they remove themselves from distracting circumstances, reflectively evaluate their memories and feelings, envision an ideal "self," and then make an appropriate plan (Brackett et al., 2010).

Together, these interventions may improve academic performance, compared with various control interventions without a socioemotional focus, in part because they set up neuropsychological circumstances optimally conducive to extracting the emotional meaning of situations, to connecting this meaning to personal memories, and to imagining a better future course of action. Of course, students should not be encouraged to waste time or to dwell on inconsequential or irrelevant private musings during work time. Doing so clearly decreases productivity (Smallwood et al., 2007). Still, the DM research reviewed here suggests that for students to optimally engage attentively to tasks, they may also require skills and opportunities for high-quality knowledge consolidation. Considering the neural and psychological evidence together suggests that adequate developmental opportunity for appropriate lapses in outwardly directed attention, and potentially even for high-quality introspective states, may be important for well-being and for optimal performance on focused tasks, as the quality of thought during "looking in" and "looking out" may be interdependent. Because of this, it may be that educational experiences and settings crafted to promote balance between "looking out" and "looking in," in which children are guided to navigate between and leverage the brain's complementary networks skillfully and in which teachers work to distinguish between loss of attentive focus and engaging a mindful, reflective focus, will prove optimal for development. Put another way, leaving room for self-relevant processing in school may help students to own their learning, both the process and the outcomes.

Emerging evidence on the effects of heavy social media use

The prevalence of digitally mediated communication and entertainment among youths has dramatically increased in recent years, and texting is reputedly superseding all other forms of friendship interaction among teens in developed nations (Pew Research Center, 2010, 2011). This shift in technology use has caused widespread concern about how heavy reliance on digitally mediated communication may affect development. Are children losing skills for face-to-face social interaction, and how would this loss of skill manifest psychologically?

Although there is very little published research to date addressing these questions, cumulative evidence on DM functioning would suggest a relatively straightforward implication. If youths overuse social media, if they spend very little waking time free from the possibility that a text will interrupt them, we would expect that these conditions might predispose youths toward focusing on the concrete, physical, and immediate aspects of situations and self, with less inclination toward considering the abstract, longer term, moral, and emotional implications of their and others' actions. One recent study of more than 2,300 young adults (Canadian college students ages 18–22) tested related hypotheses and found results that accord remarkably with these predictions (Trapnell & Sinclair, 2012). The study found that higher levels of social texting among research participants were weakly but consistently positively associated with out-group prejudice and materialism, for example, with reporting lower positivity toward indigenous Canadians, and with believing that physical attractiveness is an important personal value. Conversely, higher levels of texting were consistently negatively associated with measures of moral reflectiveness, for example, with motivation to promote social equality or justice in the community, and with perceived importance of living with integrity.

Although it is not clear in this study whether texting caused the moral changes or whether youths with particular social

dispositions gravitate toward heavy use of texting, there are hints that the effects might be causal. Trapnell and Sinclair (2012) also found that an increase in texting over the 5 years of the study (2007–2011) paralleled a decrease in reported reflectivity. A separate experimental manipulation study by Abraham, Pocheptsova, and Ferraro (2012) found that after being asked to draw and describe their cell phone, participants showed temporary decreases in prosocial behavior (as measured by willingness to donate time or resources to a charity for the homeless) but increases in perceived social connectedness. Another small-scale study reported that among youths, higher texting frequency was associated with finding friendships less "fulfilling" (Angstermichael & Lester, 2010). The somewhat alarming implication, still not directly tested, is that if youths are habitually pulled into the outside world by distracting media snippets, or if their primary mode of socially interacting is via brief, digitally transmitted communications, they may be systematically undermining opportunities to reflect on the moral, social, emotional, and longer term implications of social situations and personal values. This situation could potentially alter the perceived quality of their social relationships and over time might bias identity development toward focusing on concrete or physical abilities, traits, and accomplishments.

Of note, in our opinion, the preliminary findings described here should not be taken as de facto evidence that access to technology is necessarily bad for development or weakens morality. After all, texting is another (digital) tool that is only as good as the user's purposes or goals. If texting is used to change momentary, context-specific behavior, for example, to remind individuals with health problems to engage in particular health-related behaviors, evidence suggests that it can be remarkably effective (Cole-Lewis & Kershaw, 2010). Instead, these data should be taken as an early warning of the possibility that overusing technologies that reduce social communication to short snippets that continually interrupt the receiver, and that restrict communication to less reflective content, could be harmful. "High texting" youths in the Trapnell and Sinclair (2012) study sometimes reported receiving or sending upward of 300 non-work-related texts per day, which is more than twice the average reported by the Pew Research Center (2011).

Of course, the flip side of the coin might also be true: If used well, access to these same technologies could promote social reflectiveness and moral responsibility by facilitating communication between people who are far from each other and who would not otherwise have opportunities to interact, in order to foster empathic understanding of world situations and cross-cultural perspectives. For example, in the Iranian election protests of 2009–2010, rapid-fire social media are thought to have been instrumental both for the organization of the political movement and for garnering international empathy for protesters (Kamalipour, 2010). As another example, primary schools with a global curricular focus by necessity use digital media to connect classrooms oceans apart, so that students can share experiences and beliefs with students from different cultural backgrounds (Süssmuth, 2007; see also http://www.iearn.org). In the end, the question will not be as much about what the technology does to people as it will be about how best to use the technology in a responsible, beneficial way that promotes rather than hinders social development.

Meaning Making and the Brain: Forging an Interdisciplinary Research Focus on Constructive Internal Reflection

Taken together, the neurobiological research suggests a need to conceptualize and study processes of knowledge building that may be supported during internally focused thought and vulnerable to disruption by external input. The findings suggest that these processes may span from relaxed mind wandering and daydreaming to intense and effortful internal focus. Relaxed daydreaming is potentially important for deriving and sifting through the social and emotional implications of everyday situations and relationships and connecting them to personal experiences and future goals (see also Baird, Smallwood, & Schooler, 2011); effortful internal focus is potentially important for making meaning of new information and for distilling creative, emotionally relevant connections between complex ideas. We use the term *constructive internal reflection* to describe this range of skills and behaviors in the hope that future research will flesh out and validate the dimensions of internally focused thought and their relation to psychological constructs such as attention, memory, abstract concepts, identity formation, critical thinking, and socioemotional development.

Future research could also address the possibility of individual differences in thinking during "rest" in the scanner, to explore the naturalistic thought patterns that individuals call up as they daydream idly or reflect purposefully, and relations to social behavior and other developmental outcomes. For a classic example, work by Mischel and others on self-control in children demonstrates the beneficial effects of strategic abstraction on the ability to delay immediate gratification (Mischel, Ebbesen, & Zeiss, 1972; Mischel, Shoda, & Rodriguez, 1989). Famously, 4-year-old children who were able to distract themselves from eating a marshmallow when left alone with it, in order to successfully wait 15 min to obtain a promised additional marshmallow (or other treat), later grew into more academically and socioemotionally competent adolescents and more successful adults than children who were unable to delay their gratification for a later reward (Mischel, Shoda, & Peake, 1988; Moffitt et al., 2011). It is interesting to note, though, that differences in the thought strategies preschool children used to avoid eating the treat were associated with how long they were able to wait: Children who distracted themselves and avoided looking at the marshmallow did relatively well. But children who instead imagined future and hypothetical possibilities, for example, focusing on how delicious the second marshmallow would taste or imagining that

the marshmallow in front of them was a cloud, delayed the longest (for reviews, see Mischel et al., 2011; Mischel et al., 1989).

Drawing on these findings, in launching a research focus on constructive internal reflection, our recommendation is that the new research build from work on the primacy of meaning making for human development—beginning with classic work by Bruner (1990); Frankl (1946/2006); Kegan (1982); Mezirow (2000), and others and continuing with more modern work (see Park, 2010, for a review). This work collectively recognizes the importance of revisiting and reorganizing one's memories to reconcile them with current experiences, in order to purposefully move forward with a productive, fulfilling life. These researchers' theories also universally recognize the role of internal reflection in this reconciliation process. But we would contend that neuroscientific studies hold the potential to offer a new view of this psychological landscape as well as new tools to probe it—suggesting explanations and mechanisms for why meaning making requires reflection as well as an early hypothesis about how development may be reshaped under conditions of systematically high environmental attention demands.

In conclusion, a new research focus is needed to formulate and explore the implications of the brain's DM functioning for psychological development. This research would more deeply probe the conditions under which both internally and externally focused attention become active as well as how the development of mechanisms for monitoring and shifting between these modes is shaped by experience, context, and biological predispositions. As therapists, teachers, and parents who discuss the benefits of "down time" well know, as does anyone who has had a creative insight in the shower, rest is indeed not idleness, nor is it a wasted opportunity for productivity. Rather, constructive internal reflection is potentially critical for learning from one's past experiences and appreciating their value for future choices and for understanding and managing ourselves in the social world.

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