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When examining brain activation, many researchers question what areas are activated during a specific task or a given stimulus. However, this approach may lead one to believe that when there is no task or stimulus, that no brain regions should be activated. The default mode network is a state of brain activation, where the individual is not attending to any external cues in the environment, but certain regions are still activated. It has been found that the default mode network regions of the brain are negatively correlated with regions that are activated during tasks and stimuli presentation, known as task-positive regions. Thus, it was found that the default mode network and task-positive region could not be co-active because they appeared oppositely activated. However, previous studies show that there is a shared region between both networks: the dorsolateral prefrontal cortex (DLPFC). This article discusses the implications of DLPFC being a part of both networks, how the model of the two networks could be revised, and how it is adaptive and beneficial for the two networks to work in tandem.

Attentional processing has been examined throughout psychological literature. The ability to attend to an object in one's environment is an important attribute for everyone, whether it be while driving (i.e. where attention is paramount to ensure safety) or following lecture slides during class. Attention is necessary in countless scenarios, and attending to various aspects of our environment may occur automatically or with top-down attentional control (Hopfinger, Buonocore, & Mangun, 2000). However, what happens when someone is attending to nothing?

This process is often referred to as daydreaming or mind wandering, and occurs when a person is not attending to any cues in the environment. Researchers have long questioned what people think about and what processes occur while not attending to cues in the environment. Previous studies have shown that there is a link between daydreaming and a phenomenon known as mental time travel, in which a person recalls episodic events from their past and starts to plan for future events (Mason et al., 2006). When this occurs, attentional networks in the brain are not active; instead a network known as the default mode network becomes activated (Mason et al., 2006). The default network includes aspects of the medial temporal lobe, medial prefrontal cortex, the posterior cingulate cortex, ventral precuneus, and medial, lateral and inferior parietal cortex; this network appears to be active when the mind is at rest and when the individual is not focusing or attending to any stimulus in the environment (Mason et al., 2006).

Interestingly, the default network appears to have an antagonistic relationship with several brain areas that increase in activity during attention-demanding tasks (Fox et al., 2005); however, recent research has shown that this dichotomy does not always hold true (Gerlach et al., 2011). This paper will review both perspectives, as well as the cognitive functions of the default network and areas activated by attention-demanding tasks by examining goal-directed, problem-solving behaviour.

An experiment performed by Fox et al. (2005) focused on exploring the organization and activation of the default network, and of an

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attentional network. Fox et al. (2005) examined extant research and found that cognitive tasks, which demand attention, have two predominant effects on the activation of brain regions. First, the areas involved in task execution (i.e., frontal cortex and parietal cortex) were shown to increase in activation during cognitive tasks that required attention (Fox et al., 2005). Second, the areas involved in the default network decreased in activation during cognitive tasks that required attention (Fox et al., 2005). Moreover, as the difficulty of the cognitive tasks increased, activity in task execution regions became further increased and default network activation became further decreased. Fox et al. (2005) called the areas that were activated during attention-demanding cognitive tasks, "task-positive regions" and referred to the default network areas as "task-negative regions". For the rest of this paper, the network of areas involved in attention-demanding tasks will be referred to as task-positive regions, while task-negative regions will be referred to as the default network.

The experimenters (Fox et al., 2005) sought to determine the dichotomy of the areas associated with task-positive activation and task-negative activation by examining the correlations in blood-oxygen-level dependent (BOLD) fluctuations, measured with functional magnetic resonance imaging (fMRI). Fox et al. (2005) did not present a task, but instead measured the resting brain by studying spontaneous changes in the BOLD fluctuations. They examined six seeded regions that were associated with task-positive or task-negative responses. Specifically, they looked at the intraparietal sulcus (IPS), the frontal eye field (FEF), and the middle temporal region (MT+) for task-positive responses, while looking at the medial prefrontal cortex (MPC), posterior cingulate/precuneus (PCC), and lateral parietal cortex (LP) for default network responses (Fox et al., 2005).

The experimenters recruited 10 participants who were scanned in three different conditions. Although there was no overt task for the participant to complete, each scan was a different condition. One condition was with their eyes open, with a crosshair presented on the screen, which the participant was asked to fixate on. The second condition was with eyes closed, and the third condition was with eyes open, but in low illumination so no fixation occurred. The absence of an overt task coupled with a five minutes and thirty seconds duration in the fMRI scanner ensured an accurate representation of the resting brain. The scans were performed in an fMRI scanner and the experimenters averaged the correlation coefficients of the six seeded regions, associated with either task-positive or default network activation, across participants.

The results showed that the default network responses were significantly activated in three of the seeded regions discussed earlier: the PCC, MPF, and LP (i.e., the regions composing the default network). As well, they found that the default network regions were strongly negatively correlated with the IPS, FEF, and MT+ (i.e., the task-positive network). Fox et al. (2005) suggested that the default network and the task-positive network are highly *intracorrelated*, but the two networks are negatively *intercorrelated*.

These results suggested that the activation and deactivation dichotomy could be observed in the resting brain in response to attention-demanding tasks, without any overt task being presented. The negative correlation found between the two networks suggests that both the task-positive network and the default network act in opposition. In other words, as one network increases in activation, the other network decreases in activation. Specifically, as attentional demands arise, the task-positive network increases in activation and the default network decreases in activation. Conversely, when there is no attentional stimuli present, or the brain is in a resting state (e.g., during sleep or daydreaming), the default network increases in activation and the task-positive network decreases in activation. In other words, there should not be a resting state of mind where the default network and task-positive network are maximally activated at the same time. The Fox et al. (2005) experiment shed light onto the differential organization of the brain in terms of these two attentional streams.

Importantly, the two attentional streams appear to operate on a spectrum (Fox et al., 2005). As Fox at al. (2005) reviewed from previous studies, an increase in difficulty of the cognitive task leads to an increase in the task-positive network's activation. Integrating that with the findings from this study, the more attention-demanding a cognitive task is, the greater the decrease in default network activation. This leads to an interesting question: can there be an attention-demanding stimulus that is prominent enough to activate the task-positive network, but not so prominent as to greatly decrease the default network?

In a recent study by Gerlach, Spreng, Gilmore and Schacter (2011), the co-activation of the task-positive network and the default network was examined. Through extant literature, Gerlach et al. (2011) determined that a prominent area associated with the task-positive network is the dorsolateral prefrontal cortex (DLPFC). In fact, findings in the Fox et al. (2005) study showed that the DLPFC was also found to be positively correlated with the task-positive network and negatively correlated with the default network. The mid-DLPFC is an important area for problem-solving, as it is an integral component of executive functioning (Gerlach et al., 2011). Specifically, it has been shown to be important for encoding action sequences, rendering sequenced plans of movement, and relating actions to internal goals; this suggests that may be an active component of the default network (Gerlach et al., 2011). As well, the DLPFC has been active during attention demanding tasks that decrease the default network activation; this suggests it is a necessary component of the task-positive network (Gerlach et al. 2011). These findings led to Gerlach et al. (2011) hypothesizing that the DLPFC was important to both the default network and the task-positive network and could be simultaneously activated when problem-solving. The interesting point about Gerlach et al.'s hypothesis (2011) was not only that it proposed the activation of two negatively correlated networks, but suggested that these two networks are coupled during goal-directed simulation.

Goal-directed simulation was part of the methodology of the Gerlach et al. (2011) experiment. Goal-directed simulation is defined as a situation in which an individual plans to solve a problem in reference to their own self, while integrating multiple types of information (i.e., how the problem has been solved in the past, things that may obstruct their solution to the problem, and how effective or long-term their solution will be; Gerlach et al., 2011). Gerlach and colleagues employed this mental process and used it as the basis for their experiment. Participants were first presented with a scenario that posed a problem (e.g., being left alone in a friend's dorm room) and were then given a word that may act as a solution to that problem. The participant was instructed to imagine, or simulate, themselves acting to solve the problem via the solution they were prompted with. For example, the experimenters gave the example of the scenario being in a dorm room and the problem being the participant had tried on their friend's ring and it would not come off their finger (Gerlach et al., 2011). The prompt word was *soap*, which acted as a possible solution to the problem, and the participant would subsequently imagine the problem-solving process (i.e., using the soap to remove the ring).

This method was used because it would activate the default network while the mentation is occurring, but also activate the task-positive network while thinking about performing the action. The results showed that this simulation task was associated with PCC, the right middle temporal gyrus, right MPF cortex, the right temporo-parietal junction and the left inferior parietal lobule; all of these regions are associated with the default network (Gerlach et al., 2011). There was additional activation during the simulation in the bilateral DLPFC, which is associated with executive functioning (i.e., problem-solving; Gerlach et al., 2011).

Gerlach et al. (2011) suggested that there is a coupling of the two networks during goal-directed problem-solving. The default network was significantly activated during the task, and the DLPFC was significantly activated, which is an important component of the task-positive network (Gerlach et al., 2011). The experimenters explained this finding by using previous literature that shows the PCC is associated with spatial processing, something that would be required when imagining a scenario, like being in a dorm room (Gerlach et al., 2011). As well, they argue the PCC is often co-active with parahippocampal cortex, which has been associated with familiar contexts (Gerlach et al., 2011). The parahippocampal cortex is important in constructing an imaginary scenario by utilizing past contexts when they are prompted to place themselves in a scenario (Gerlach et al., 2011). Gerlach et al. (2011) also reiterated the finding that the DLPFC plays a role in action sequence planning, action coordination, and sequencing the movement of actions, which should be strongly associated with problem-solving. They concluded by suggesting that simulating the solution to a problem activated a part of the task-positive network that can be co-active with the default network, without either network being repressed (Gerlach et al., 2011). Importantly, this finding does not support previous assertions that both networks can be co-activated (Fox et al., 2005), which leads to new questions regarding the organization and activation of these two networks.

Fox and colleagues (2005) made important contributions to the organization and negative correlation between the task-positive network and the default network. However, based on the findings in Gerlach et al.'s experiment (2011), it is possible for components of both networks to be simultaneously activated and even coupled in order to problem solve. This suggests that the dichotomous view of task-positive network versus default network does not always hold true, though it does appear to be valid during attentional demands in the external environment.

These results (Fox et al., 2005; Gerlach et al., 2011) in combination helps form an explanation of the functionality of the default network. In the extant literature, the default network was often referred to as an area that is activated when nothing is happening in the environment, when the individual is daydreaming or their mind is wandering (Mason et al., 2006). Perhaps unintentionally, this made the default network appear to be unimportant because its activation is not associated with an overt task or simulation. However, the results of the Gerlach et al. (2011) experiment suggested that the mental time travel mentioned earlier has a functional purpose as it relates to problem-solving. Specifically, when an individual is not attending to anything in the external environment, the default network is active and can be co-active with an executive functioning region, the DLPFC. Together, the co-activation of the two networks can lead to problem-solving simulation and planning the steps necessary to solve problems. This shows an adaptive function to not attending to external stimuli, and shows that daydreaming may help solve future problems by planning the steps required in a solution.

Andrews-Hanna (2012) elaborated on the adaptive functions of the default network by synthesizing the structural and anatomical findings with the behavioural and psychological components of the default network. Andrews-Hanna (2012) proposed that the network is a necessary component of "internal mentation" which is required for our everyday functioning. When one thinks of daydreaming, they may think that it is useless or a distraction between tasks requiring focus. However, Andrews-Hanna (2012) suggested that not only is the default network adaptive, it is also necessary; it acts as a way to solve problems by accessing past memories and simulating future actions. Daydreaming and mind-wandering are conducive to everyday living because they allow one to learn from the past in order to plan the future.

Conversely, attending to external stimuli and tasks should decrease the activation of the default network (Fox et al., 2005). What effect would this have on goal-directed problem-solving simulations? The results suggested that, because there is a co-activation of the default network and the DLPFC for problem-solving, if the default network activation is decreased, then problem-solving cannot occur with the use of the default network (Gerlach et al., 2011). This suggests that as attention to external stimuli increases, the default network activation decreases and thus, problem-solving mental simulations decreases. It may be beneficial for future research to focus on disentangling the task-positive network and the default network in relation to problem-solving mental simulations, to see if both are absolutely required for problem-solving.

In conclusion, the previous assertion that the task-positive network and default network are negatively correlated and oppositely activated (Fox et al., 2005) does not hold true in every instance, (e.g., when mental simulations of problem-solving are occurring; Gerlach et al., 2011). This suggests that there may be other cognitive processes that can be co-active with the default network, and the function of the default network may be elucidated by determining these other processes. It may be beneficial for future research to propose a model that examines what cognitive processes suppress the default network and which processes can be co-active with the default network.

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