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Default Mode Network as the Neurophysiological Groundwork of Collectivity

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Abstract

All newborns are born with a collective self that carries the traces of the selves of all humans who lived before them, and then form their individual self over the collective self in the light of the experience and information they gathered by themselves. This library of knowledge in question can be reached for a short time during sleep and mind-wandering. Easy access to this great source of knowledge requires that the archive in question is recorded in a neural network that has widespread projections in the brain. In our opinion, the best candidate for this is default mode network due to its neurophysiological and neuroanatomical characteristics. In this article, default mode network is discussed as a dynamic neural archive, which carries all the knowledge of humanity and the concept of collectivity is discussed with a philosophical point of view on the basis of neuroscience.

Key Words: default mode network; collectivity; collective-self; neurophilosophy

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Introduction

The basis of life is “collectivity” with other living beings. Collectivity was described in previous papers (Ceylan *et al.*, 2022; Ünsalver *et al.*, 2021) as the formation and maintenance of social bonds/partnerships that become parts of collective societal units that cooperate at various levels, situations and times in life that results in possible collective

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survival and reproduction of the members of the unit. Collectivity is a dynamic collaboration that the members of the *collectome* establish together in the collective system in such a way to complement each other and understand a common objective (Ceylan *et al.*, 2022). It was suggested that this vitality of collectivity for the survival of humankind might make collectivity to be considered as an instinct that all human beings are born with and probably encoded in the DNA (Ünsalver *et al.*, 2021).

Human beings are born dependent on a caregiver. The biological attachment system described by Bowlby (1978), entails the baby and the caregiver as partners are the primer of collectivity for the baby. As theory of mind, sense of agency, and various motor skills develop, the child starts separating from the caregiver developing the potential to become an independent or autonomous being by the end of adolescence. However, most humans keep, form, or need social bonds throughout their lives that is facilitated and supported with social emotions and cognitions.

With the effect of collectivity, the interactions established among people must have paved the way for formation of a "collective self". That is, every newborn's formation of representations of other people's selves in its mind by imitating them must have led to the formation of a collective self which consists of overlapped selves through thousands of years. This collective self, just like collectivity, must have constituted a basis for each individual to form their own self by being transferred from generation to generation, while on the other hand, being enriched by each new individual self.

Thus, both collectivity instinct and collective self, or in summary, collectivity, should have a biological correspondence in the brain and these two concepts should be the activity of a widespread and powerful neural network which has been active since the day a person is born (maybe even since the prenatal period). We think that the neurophysiological representation of collectivity is within a network which is evolution-wise old and contains multiple structures, probably the Default Mode Network (DMN). DMN is the widespread spontaneous and simultaneous activity of the networks in different parts of the brain while the person is not engaged with any task (Raichle *et al.*, 2001). DMN, which is a very low-level activity, diminishes when the brain starts to engage a task or an object, and it is replaced by the activity related to the task in question. Reduction of DMN activity when the person is busy with a task, makes one think DMN is separate from the external world, far from daily events, tasks and thoughts that the person encounters, an activity of another world. This is because the interaction between the brain and the external world creates higher-frequency brain waves like alpha and beta waves. As DMN is a low-frequency basal activity of neural structures (Neuner *et al.*, 2014), and as it is out of question for the brain to form an object relationship with the external world, perform an objective task or form a thought

related to this relationship or task through a basal activity, DMN should not be an activity of the person's resting state within their present life, but on the contrary, it should be an activity of a neural record system that belongs to previously experienced worlds for getting away from the daily world completely. In our opinion, this is an activity that belongs to the cult of collective knowledge that humanity has accumulated in the world and refined from the part to the present through evolution. This crucial knowledge, for example, instincts and urges, has reached from the past to the present as records in DMN and by being transferred from generation to generation. Some basic pieces of information that had much greater importance for humans in the past and therefore still take a lot of space in DMN records, are still influencing our present thoughts, emotions and behaviors more than needed. One of the most important among these instincts, "collectivity instinct", is recorded in DMN, because it is indispensable as one of the most important strengths of living for humankind.

These pieces of information recorded in DMN which has been formed by overlapping through evolution show more or less the same characteristics in the individuals of the same species, for example, in all *Homo sapiens* individuals. Therefore, the issue is that it carries a common root information which connects us and resembles the archetypes of Jung, and through this root information, the information coming from sensory systems is processed and categorized. So, this is a significant finding that shows that it codes a common culture of knowledge for humanity. On the other hand, considering human evolution, in the information records of humans, there should be information records of other species as residues. Therefore, what is recorded in the human DMN contains information belonging to reptiles in trace amounts, mammalians in some amount, primates to a greater extent and humans the most. DMN shows similar characteristics in non-human primates and humans (Mars *et al.*, 2012).

DMN activity is primarily a social activity, it is an activity of collectivity, and it is the activity that is common in all humans. It is the language commonly spoken by humans as if they are a part of a superorganism which establishes a common ground for agreement for these pieces in question. It was reported that some brain regions related to DMN are active during tasks that involve social cognition (Mars *et al.*, 2012). That is, brain regions that are activated in relation to social tasks are overlapped with regions that show DMN activation. Therefore, DMN is the best candidate that may form the neural basis in the background of this highly social human behavior that we describe as collectivity instinct, and this article discusses the foundations of this argument.

Neuroanatomical Groundwork of Collectivity

DMN is the activity of a multiregional system where the brain regions belonging to earlier periods in terms of evolution are at the center. The brain regions in the network include various temporal and parietal regions and hippocampal structures, mainly the medial prefrontal cortex (mPFC) and the anterior/posterior cingulate cortices (ACC/PCC) (Raichle, 2015). DMN's mPFC, PCC and medial temporal lobes are structures of the medial cortical line, and they are evolutionarily old cortical structures of the brain (Northoff *et al.*, 2006). It was argued that DMN mainly consisted of the dorsomedial prefrontal cortex (dmPFC) subsystem and the medial temporal lobe subsystem (Andrews-Hanna *et al.*, 2010). While the first system contains the temporoparietal junction, the lateral temporal cortex and the temporal pole in addition to dmPFC, the second system includes the ventral mPFC, the posterior inferior parietal lobule, the retrosplenial cortex, the parahippocampal cortex, and hippocampal formation. It was reported that these two subsystems connect each other through PCC and anterior mPFC which are structures located in the medial line, and these two central structures have strong anatomical and functional relationships with other DMN structures (Andrews-Hanna *et al.*, 2010).

It is likely that DMN activity is spread through the thalamus, because when the cortex receives a stimulus (for example, a task stimulus), the thalamus becomes silent and DMN is deactivated. While the thalamus is an important and central relay station that distributes information in the brain, it is in communication with several brain regions. While it transmits almost all incoming information to the cortex via thalamo-cortical connections, it also provides integration of information among cortical regions and coordinates several neural networks (Di & Biswal, 2014; Hwang *et al.*, 2017). It was shown that it has a strong, both structural and functional connectivity with the DMN regions of the thalamus (Cunningham *et al.*, 2017; Fernandez-Espejo *et al.*, 2012). By this, it was thought that it modulates the transition between the internal and external awareness of DMN to include the thalamus (Cunningham *et al.*, 2017).

On the other hand, it was reported that thalamus lesions cause DMN dysfunction (Jones *et al.*, 2011), so, the thalamus should have an important role in DMN activity. The thalamus was probably serving as a primitive cortex before the neocortex was formed, while now it is working as the "hub" for the information coming from all sensory systems and transmits the information to the cortex after processing it to some extent. In this case, the thalamus has processed the information coming from the external world for tens of thousands of years and it is in a position that is accustomed to the character of the knowledge of everything past, so, it should be the most suitable candidate that will reflect the common knowledge of humanity to DMN regions.

It was shown that DMN centers joined some memory processes (Shapira-Lichter *et al.*, 2013). It was argued that, among these, especially posterior DMN centers have a role in episodic memory retrieval due to their connections with temporal lobe structures including the hippocampus (Andrews-Hanna *et al.*, 2010). It was reported that parietal nodes of DMN are activated along with temporal systems during episodic memory retrieval, and while episodic memory retrieval and posterior DMN nodes (angular gyrus and PCC/precuneus) are activated, mPFC node is deactivated (Sestieri *et al.*, 2011). It was also shown that the semantic memory system and DMN converged spatially and functionally (Wirth *et al.*, 2011). So, it appears highly possible that DMN centers carry the common archive of humanity in coordination with medial temporal lobe structures. Past objective and social information should be being transferred from generation to generation in abstract and concrete structures, and each individual should be enriching the information coming to themselves in their medial temporal lobe structures. Medial temporal lobe structures may be coding the entirety of existing information by creating different ignition combinations for objective and social information by working just like an operating system, and DMN regions may be receiving information from this storage and keeping it alive under a constant DMN ignition. A common self emerges as a meta-cognition of this collective knowledge based on the past. Medial temporal lobe structures pass the archive in DMN through some algorithms and combinations to reveal them as ready memory and turn it into a DMN region that is useful for the world of today. The thalamus probably cuts off the connection with the external world during sleep and processes the object information received from the external world by comparing it to the common information of the past in medial temporal lobe structures.

Sleep, Mind-wandering and Collectivity

When we look at the clarified functions of the brain regions that form DMN, we see that they are related to emotion and cognition. These regions are repositories that belong to emotional patterns that are evolutionarily gained, and they perform emotion-cognition connections. We believe that the knowledge that has been accumulated since the earliest humans has been recorded in the mentioned brain regions and reached our time this way.

So, how does this record process work? It was shown that DMN is in a dynamic structure at the same time and both its nodal and global topologies change in time in different states of the brain, and this situation occurs as a result of obtaining new information (Lin *et al.*, 2017). So, DMN is not constantly fixed or stable, it is reorganized and its configuration changes with the procedure of information processing. While DMN has the highest activity in a resting state, it is

deactivated during a task. In addition to this, the DMN after a given task is topologically different in comparison to the DMN before the task. This suggests that DMN is constantly modulated as a response to cognitive tasks. Thus, DMN is a system that is open to change and development, and it is updated by the person's experiences. These changes that are reflected in the genetic code through epigenetic mechanisms are probably transferred to the next generation, and this way, each newborn is born with DMN that is inherited from its ancestors with the latest updates. Hence, the DMN of 100 years ago should be at least slightly different from the DMN of today.

We believe that the updating process takes place through two important processes as sleep and mind-wandering. For the information obtained from objects through the day via sensory systems to be placed into the DMN library, it should first be compared to the existing library content and then the necessary and suitable pieces of information should be embedded into the information that has been brought through evolution. So, there is a need for a normal one-night sleeping process. It was shown the DMN changes patterns during sleep (Tagliazucchi *et al.*, 2013). That is, DMN shows activity variation within itself in situations where sensory systems are relatively closed to the external world. While DMN activity in the NREM stage which is the first stage of sleep resembles that in an awake state, the connection between the frontal (mPFC, ACC) and posterior (PCC and inferior parietal cortex/angular gyrus) regions of DMN is severed, the activities of anterior areas within themselves are reduced, and the correlation among the posterior areas gets stronger (Horovitz *et al.*, 2009). Another study investigated DMN activity in mild/deep NREM and REM stages. Accordingly, it was reported that the connectivity among the core DMN regions (ACC, PCC, IPL/AG) is protected, the connectivity among the subsystems of DMN showed some changes, and the functional connectivity between PCC and dmPFC was weaker in REM sleep than in NREM (Koike *et al.*, 2011). The first of the common findings of these two studies was that there was no noticeable change in the activities of DMN regions during sleep. It was shown that, as in during sleep, DMN activity continued in coma patients (Boly *et al.*, 2008) and people under anesthesia (Greicius *et al.*, 2008). This suggests that DMN is awake when there are no object relationships, it is active even in sleep and in cases where brain functions are slowed down to a great extent, and it is a highly effective and essential neural network.

Another common finding of the neuroimaging studies mentioned above is that the connectivity between the anterior and posterior core DMN structures is weakened or severed as the sleep gets deeper. What could be the function of this connectivity disruption in DMN during sleep? Here, one should look at the role of dmPFC. While it is known that dmPFC has roles of mentalizing and self/other-related judgments, that is, it plays a very important role in social cognition, there is an opinion that it is activated more by highly abstract stimuli

as making decisions about other people involves abstract thinking, social and affective processes (Baetens *et al.*, 2017). This region is considered one of the most associative centers in the frontal lobe (Eickhoff *et al.*, 2016). As dmPFC has the role of combining information among different brain regions, it was suggested that dmPFC is separated from the information transmission in DMN by disruption of the connectivity between dmPFC and PCC, and therefore, logical transmission of the stored information is affected negatively, and the loss of logical thinking during REM sleep may be related to this (Koike *et al.*, 2011). REM is a sleep stage in which the brain shows a physiological activity similar to that of an awake state. Dreams are usually processes where there are no logical rules and primary process thought is dominant. In dreams, people can do things that they cannot do / that cannot be done in real life, see people/places/objects that they do not know at all, go to the past or the future by isolation from the concept of time, and try to solve conflicts and issues in daily events. Such an intense and rich mental activity belongs to a process where the archaic library of knowledge that we mention is provided for the person's experience with all its clarity. Transmission of pieces of information that are obtained through the day takes place while DMN is active with all its centers in the initial stages of sleep, and in the REM stage, the functional connection with dmPFC is severed in the REM stage and the library of knowledge recorded in the DMN centers in the posterior are activated. Therefore, new pieces of information obtained through the day are compared to the archaic information recorded in DMN where the relationship with the present world is mostly and temporarily disrupted, they are confirmed, and they are recorded if found to be useful. As a result of a healthy sleep, sometimes, a person may change their mind about a part of the decisions they took in the light of new information obtained during the day. The decision that has been taken is probably placed in the DMN deposit containing the information that is the common heritage of thousands of years of humanity's history during sleep, its agreement is tested, and in case it is not found to agree, the person changes their mind about the decision. It was reported that people who have REM sleep show high levels of success in integrating unconnected pieces of information for solving a problem (Cai *et al.*, 2009). This study provides data which suggest that sleep processes are a way to access the archaic databank recorded in DMN, and answers to present problems are found with the help of the information obtained from it.

Therefore, a sufficient and high-quality sleeping pattern is required for DMN to function healthily. While sleep strengthens the connection between DMN and task-related activity, lack of sleep severs this connection. In cases where sleep processes are disrupted such as sleep deprivation, the relationship between the old-world record and the new-world record is disturbed, and thus, the person's decision-making mechanisms and rational thinking processes are also affected negatively. It is known that, in long periods without sleep, cognition,

memory and attention are disrupted, and in serious cases, psychotic signs emerge by disruption of assessment of reality. In our opinion, the reason for this is that DMN activity, which validates reality, is affected negatively due to insufficient amount of sleep.

Updates in DMN may sometimes be achieved without the need for sleep, when the person is resting by getting away from the external world or is in a mind-wandering state. DMN activity takes place also in this mental state where the person closes themselves to the external world -though not as much as in sleep- relatively, and old and new information can be compared. Mind-wandering is an experience in which a person ignores external stimuli and focuses on internal information and stimuli (Smallwood & Schooler, 2015). In this form, it is considered to be the opposite of the concept of mindfulness which is defined as focusing on experiences at the present and being aware of them (Brown & Ryan, 2003). While it has been argued that mind-wandering is associated with negative emotions (Carriere *et al.*, 2008), and it is very different to mindfulness which has been reported to be correlated with mental and physical health, there are also those who reported that mind-wandering is associated with creativity (Baird *et al.*, 2012; Smallwood & Schooler, 2015). Nevertheless, it has been known for centuries that instead of solving a problem by focusing on it, stepping back for a certain time and focusing on something else works in problem-solving.

We also think that mind-wandering provides access to thousands of years of human knowledge by getting away from the daily life objects in a person's life via DMN activity, and with this aspect, it is an important and useful experience for the person. Likewise, DMN activity was reported to be related to mind-wandering (Mason *et al.*, 2007). At this point, the thalamus should have an important role, because it was argued that the thalamus, which is believed to create the alpha rhythm, modulates DMN connectivity during mind-wandering (Ros *et al.*, 2013), and for this reason, the thalamic alpha rhythm that is spread around DMN regions is the neuronal source of the thalamic alpha rhythm (Wang *et al.*, 2014). In contrast, it was shown that the functional connectivity between DMN regions and the thalamus decreases during the experience of mindfulness (Wang *et al.*, 2014). It seems reasonable that the functional connectivity between DMN regions and the thalamus decreases in such a case, because during mindfulness experience, the person focuses on the external world, thus, the thalamus should be activated and DMN should be deactivated. So, it is possible that the functional connectivity between the thalamus and DMN is increasing during mind-wandering where the focus is withdrawn from the external world and directed towards inside. In summary, it seems possible that DMN, which is taken as a source of collectivity instinct carries the past human knowledge to the present by a neural activity involving the thalamus and it makes this knowledge accessible by the means of mind-wandering.

Output of DMN Activity

DMN activity is basically the cult knowledge belonging to humanity, and collectivity instinct, intuition and common sense are rooted in this knowledge. These may be considered as an output of DMN activity along with collective self. While collective self is discussed under another title, the other concepts are mentioned both here and within the text in general.

After the agreement between newly-obtained information and the information in DMN is tested, if this new information will be permanent, DMN's topology, and accordingly, its emotional and cognitive processes also change. Updates in DMN are transferred to next generations, and therefore, each generation filters the information, skills and experiences that it obtains in its own period through DMN, and records those that it finds necessary and valuable in the neurophysiological deposit of DMN. This is why people mostly make similar decisions on similar issues or change their mind about their decisions in similar ways, because confirming or not confirming a taken decision for almost every person is related to having almost the same DMN activities. Of course, it may be claimed that this is a situation related to cultural collectivity, but we believe that the cultural knowledge accumulated through generations is also recorded in DMN and represented there. The person is constantly in contact with this knowledge, because DMN activity is related to the integration of introspection, self-referential thought and cognitive and emotional processes (Greicius *et al.*, 2003). DMN activity is the biological and cultural depository belonging to humanity by evolution, a sort of common library that contains all knowledge. Just like a person tries to reach the most accurate result by visiting a library to reach correct information and providing a deep perspective for the problem that they encounter at the present over the biological, sociological, psychological and historical material in the library, they also refer to DMN with processes of introspection, self-referential thought, integrative cognitive and emotional processes, derive the decision that is the most suitable for themselves and the past of humanity from there, and implement it.

The point where introspection, self-referential thought and integration of cognitive and emotional processes want to reach is "prudence" which is present in everyone. Prudence is usually defined as common sense and moral sense. According to Einstein, it is a set of prejudices gained until a person is eighteen years old. In our opinion, prejudices consist of abstract information humans brought about evolutionarily. Our prejudices are mostly for our protection, they are pieces of evolutional information coming from our ancestors through cultures and even other living being in the past rather than those obtained from the person's own experiences, and they are kept active through DMN to be reached on demand. If the nature has a mind of its own, it is expected to transfer the knowledge of life obtained

by billions of living beings from generation to generation by collection without destruction. So, how will this common experience be introduced for the usage of the person? Firstly, it is required for this knowledge to be kept ready for usage on demand for putting into use in daily life, so that the newly obtained information gathered from individual experiences can be validated over it.

Another output of DMN activity is intuition, that is, direct comprehension of reality through instinct. The instinctive comprehension mentioned here is actually a derivative of the sum of knowledge coming from memories that belong to all humanity. Considering that DMN is a basic brain activity and the baseline brain-activity fluctuations may profoundly modify our conscious perception of the external world (Boly *et al.*, 2007), it may be thought that DMN activity codes out approach to life, judgments, way of existence in life, tendencies, character traits, and monotonic responses that we provide for all events in general. These codes are a version of the knowledge that has accumulated through generations and its relevant parts are opened for new information for it to express its own tendency in behavioral manifestation. Files in DMN are opened with every piece of new information, and contact is made with as much previous information as the number of opened files. DMN also makes changes in its physiological structure in the light of new information coming from the external world and transfers these changes to next generations (Lin *et al.*, 2017).

Neurophysiological Groundwork of Collectivity

An EEG pattern which was correlated with DMN's intrinsic functional connectivity and composed of delta/beta waves was shown, and a neurophysiological correlate that suggested DMN connectivity was reported (Hlinka *et al.*, 2010). In our opinion, this result indicates the correlation between the external world where the person is living at the present and the knowledge of the old world recorded in DMN, and the neurophysiological basis of the existence of constant exchange/validation of information between the two. In an fMRI/DTI study which investigated the correlations of structural-functional connectomes, it was reported that the structures constituting DMN showed a high structural-functional connectome agreement (Horn *et al.*, 2014). In addition to DMN structures showing high functionality, their direct presence in the structural connection also shows how important DMN is for the brain. When data obtained from such neuroimaging studies allow complete description of the neurophysiological traits of DMN, we think, we will be able to state that a person is not born as a tabula rasa, they code the biological/cultural past of their ancestors over DMN, all individuals who are biologically related and have grown up in the same cultural

setting have very similar DMN structures, and they comprehend an area of life together via this common structure.

In an intracerebral study, it was shown that gamma suppression took place in the most important elements of DMN, PCC and mPFC, during a task, and this suppression probably started at a region and moved to the other DMN region (Jerbi *et al.*, 2010). In these two DMN regions, gamma suppression took place 250-500 ms following the start of task-related activity, and it ended at 1000 ms. While the temporal dynamics of the gamma suppression in DMN regions are not completely known, we may say that different DMN regions work in collaboration with each other. That is, DMN regions and the task-related regions that interact with objects work in a continuity, and the common and basic information recorded in DMN modulates task-related behavior.

Monto *et al.* (2008) used infra-slow EEG to provide some evidence for very slow EEG fluctuations. These fluctuations were correlated with slow perceptual performance. This revealed that the slow perceptual performance of the person is correlated with very slow EEG waves and indicated that physiological and behavioral patterns are similar to each other. In the light of this, we may say that there is an uninterrupted continuity starting from DMN and passing through task-related records and behavior, and this wholeness covers the temporal dimension not only on a physiological behavioral level, but also by progressing from past towards the future.

On the other hand, it is very likely that DMN is not only an archive that stores the common self and all the other human-related information, but also a bridge that provides synchronization between body and mind. It has been suggested that DMN is a source of slow oscillations, which are the basis of neuronal activity, together with cardiorespiratory oscillations, on which limbic and cortical activity are found, respectively (Jerath & Crawford, 2015). In another study, respiratory oscillations based on nasal respiration have been shown to synchronize electrical activity in the human olfactory cortex and limbic brain areas, including amygdala and hippocampus (Zelano *et al.*, 2016). Accordingly, there should be a neuronal activity in the brain that begins with respiration, continues with cardiopulmonary rhythm and DMN rhythm, extends to the cortex and, in this way, triggers each other from bottom to top. Here, DMN probably acts as an amplifier, perhaps like a built-in interface between the physical arrangement and the cerebral arrangement, at the brain side. Oscillations originating from the most basic biological activities of human being, such as respiration and circulation, are reflected to the whole brain by being amplified by the DMN interface. This should also be forming the basis of the body-mind synchronization. DMN is probably not only a network that belongs to the brain, but also a network that perceives and reflects the biological rhythm of human beings holistically, in a way to modulate the mental processes.

Collective-self and DMN

It was reported that DMN activity is related to mental activities such as self-referential thoughts, navigation, autobiographic memory, mentalizing, introspection and mind-wandering (Davey *et al.*, 2016; Mason *et al.*, 2007; Spreng *et al.*, 2009). The species *Homo sapiens* was probably less involved with objects in its initial years and spent most of its day by self-referential thought and introspection or group-referential thoughts related to its community. As the limits of self were not as advanced as today, group-referential thought had characteristics that could replace self-referential thoughts. Belonging to a group had essential importance before or in addition to identification with a "self". Thus, individual self was not clearly distinguished from collective self. As in mini ice ages that were experienced through different eras, people's struggle to live by living cramped in some caves provided a basis for development of collectivity instinct. People's obligation to share limited resources and collective habitation to ensure their safety have become the initial factors in the development of collective self today. Thus, today's self-referential thought may have started as group-referential or collectivity-referential thoughts of that day, and these collective self-thoughts may be responsible for DMN activity. So, we may say that DMN activity is the activity of the collective existence of humanity in cases where definite object relationships are not formed. Again, when there is a case of task-related thinking related to an object or in a more general sense, DMN is deactivated as it is needed to get outside of this collective existence and establish an individual relationship with the object, and object-oriented cortical activity starts.

A person does not recognize their self by themselves. According to German philosopher Edmund Husserl, "we are someone else's self." So, we learn to call ourselves "myself" because others call us "yourself" in a collective structure. Indeed, before calling themselves "I", children refer to themselves as "you" as expressed by their parents and relatives, and then they convert it to "I". Therefore, when a person is in a collective self, they gain their individual self in a way that the collective self describes them. Individual self always emerges out of collective self. Through time, a person converts the diversity in the external collective structure into internal diversity with their individual self.

Another important factor that forces people to develop individual self over a collective self was the usage of tools. This is because while people were overcoming various tasks by collaboration before starting to use tools, human-tool collaboration may have prevented human-human cooperation, and this situation may have forced the development of individual self by causing diversification of the experiences of each individual regarding objects. Tool usage may have suppressed collective self by increasing cognitive activity on DMN regions and causing DMN to diminish.

Inferior frontal gyrus, premotor cortex, anterior insula, primer motor cortex, sensorial cortex and superior temporal sulcus "mirror neuron" fields, and they are either overlapped or in close connection with DMN regions (Molnar-Szakacs & Uddin, 2013). Mirror neuron fields were considered as fields of physical self over motor movements (Molnar-Szakacs & Uddin, 2013), while DMN fields were considered as fields that belong to both individual self and the selves of others (Lombardo *et al.*, 2010). It appears that mirror neurons and DMN interact with each other in a way that constitutes the physical and psychological neuronal components of individual self.

Moreover, it was stated that the ventral part of mPFC which represents collective self has representations of "I", while the dorsal part has representations of "others" (Molnar-Szakacs & Uddin, 2013). Therefore, as a whole mPFC codes collective self and individual self together, and this is evidence that collective self gives rise to individual self. The anatomic connections of mPFC with the motor cortex that were shown in rats (Hoover & Vertes, 2007) could probably make it easier to distinguish individual and collective self. As known, it is believed that babies comprehend the person that provide care for them as a part and extension of one being until their individual self develops. In time, when the baby notices that it can perform different motor movements than the person providing care for it, it perceives that its own body, its physiological self is separate, and notices its psychological self. It becomes possible to understand the movements of the person standing across, and therefore, their intensions, with the mediation of the ventral and dorsal mPFC connections of the motor cortex. This is because when a person performs motor movements that are similar to those of others, their mPFC is activated through this movements defined in the associative motor cortex, and they match the intention of the other's movement and that of their own. They then carry this link to dmPFC and read the intention of the person in this movement. So, the person projects their own intention during their own movements as the intention of the other during similar movements. Therefore, the person reads the other over themselves. For example, the information on what it means for someone to raise their hand is understood via dorsal-ventral mPFC connections.

Interestingly, perception of time and space is disrupted in schizophrenia patients and lonely people who show weakness in collectivity. The reason for this is that, to a great extent, a person learns about both time and space through their collectivity with other people. A person walking from afar towards the individual or one that is walking away provides the individual with the perception of space. A person's connection to the past via the death of a loved one teaches them about perception of time. For a person to learn about these two perceptions that are highly difficult to learn, a part of their self should stay in the past in terms of time and stay at a distance in terms of space. A person can experience these two feelings only if they are both there and here, both in the past and the present. This is because time

is expansion from the present to the future and the past, and space is expansion from here to there and beyond. A person gains perception of time and space if they spread themselves towards there and beyond and the future and the past. Only in the case that this expansion is made forward and backward, to the past and to the future despite that the person themselves is “here and at the present” they experience spatial and temporal extension. Hence, perceptions of time and space are formed thanks to both the connections between the ventral and dorsal mPFC regions, and their connections with the temporal lobe.

Conclusion

The nature must have established a strong neural network, probably DMN, to store thousands of years of knowledge, experience, accumulation and the collective self which belongs to the entire humanity safely and permanently. DMN is a highly basic and powerful structure with continues its basal activity under anesthesia, during sleep and even in a coma as long as the person is still alive. It continuously maintains its activity as the information it carries is indispensable and its absence is not in accordance with life, and it only steps back for short time intervals in cases of new information and interactions about the world and provides a basis for creation of new records. Furthermore, DMN also keeps records of the information of collective self, which is the common self of humanity, and thus, provides a basis for creation of individual self.

This article discussed collectivity and related concepts, as well the possible biological correspondence of these concepts in the brain from a neurophilosophical standpoint. We believe that this article has the quality to inspire future neuroscience studies in terms of shedding light on the biological correlates of the described abstract concepts in the brain.

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