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# COVID-19 and the brain regulation of the new proxemics

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COVID-19 is an infectious disease caused by an RNA virus with a crown-like appearance and grouped into the family Coronaviridae. Seven coronaviruses capable of infecting humans have been identified. The alpha (229E, NL63) and beta (OC43, HKU1) are associated with mild respiratory diseases. However, the other types (MERS-CoV, SARS-CoV, and SARS-CoV-2) can cause a severe acute respiratory syndrome. Most COVID-19 patients experience fever, fatigue, cough, and difficulty in breathing. Other symptoms have been observed as a loss of taste and/or smell, muscle aches, sore throat, headache, nausea, and diarrhea (CDC, 2020).

According to the World Health Organization (WHO), there are 29 million confirmed cases of COVID-19 worldwide, and more than 925,000 deaths are associated with this disease, and these numbers are increasing daily. The COVID-19 pandemic has been a global challenge and has come to change the population's daily life. Due to the pandemic potential, the WHO recommended the implementation of actions to prevent its spread. These precautions include: regular hand washing, social distancing keeping up to a 2-m distance between individuals and social isolation, avoiding going to crowded places, among others (WHO, 2020).

Although humans are sociable beings, when people interact, they usually maintain a certain interpersonal distance. The term proxemics (derived from the Latin proximus -near- and the suffix emics -relating to-) was established by the anthropologist Edward Hall. Hall proposed that proxemics describe "the interrelated observations and theories of man's use of space" (Hall, 1990). Currently, the proxemics has been defined as the study of personal space and the distance of separation that individuals preserve each other in social situations. Also, Hall described the existence of proxemic zones determined from observations and interviews with adult subjects residing in the United States. Therefore, proxemic zones were categorized as intimate, personal, social, or public. Intimate distance (0 to .46 m) is used for confidential communications between individuals with an intimate comfort level and often involves hugs, caresses, or whispers. Personal distance (.46 to 1.22 m) is usually considered as ideal for interactions among family and friends. This distance is where most communication with others occurs and is a relaxed space for talking, shaking hands, and gesticulating. Social distance (1.22 to 3.66 m) is observed in personal business and social gatherings. This distance can be considered as the zone of interaction between students, co-workers, or acquaintances. Public distance (more than 3.66) is observed when public figures or speakers address a lecture (Hall, 1990).

There are variables such as culture and gender that can influence individual proxemic behavior. Therefore, females interacting tend to get closer, almost invading the limit of intimate space, whereas males maintain greater distances between them (Willis, 1966). Some studies have concluded that people from different cultures have diverse perceptions about appropriate social distancing. Sorokowska et al. (2017) analyzed interpersonal distances in 42 countries and found a significant variability in the intimate, personal, and social distance across countries. Thus, it is considered that Latin American and Mediterranean societies interact at closer distances than Northern European and Northern America societies. Although these variations may be associated with environmental, sociopsychological, and neurobiological variables, the detailed mechanisms promoting different proxemic behaviors in societies are not yet fully described.

Human beings are extraordinarily sociable, and the brain has evolved to regulate the complex series of social behaviors, including proxemics. After decades of research, various brain regions such as the amygdala, superior temporal sulcus, temporal-parietal junction, and medial prefrontal cortex have been identified to activate during social interaction (Silston, Bassett, & Mobbs, 2018). The amygdala is a structure of the limbic system located in the inner part of the medial temporal lobe. This brain region is considered as an integrative center for emotional responses, including feelings like pleasure, fear, anxiety, and anger. Besides emotional responses, the amygdala is involved in a kind of primitive fear learning. This behavior is established when the amygdala receives external sensory information, integrates it through changes in the synaptic plasticity, and activates specific circuits to induce a coordinated fear response (Kochli, Thompson, Fricke, Postle, & Quinn, 2015). With this background, it could be plausible to hypothesize that during the COVID-19 pandemic, the amygdala is continuously stimulated by external sensory information. Going outside, observing people without adequate protection, such as face masks or listening to someone's cough, could be aversive stimuli that would commonly evoke an escape response in the individual. This coordinated fear response modifies the individual proxemic behavior avoiding the interaction in proxemic zones such as intimate and personal and increasing social isolation. Human studies have been carried out to identify brain structure changes under conditions of solitary confinement or social isolation. Hence, some reports have described a correlation between the amygdala volume and the social network size. It was determined with magnetic resonance imaging that individuals with minimal social contact had smaller amygdala volumes (Bickart, Wright, Dautoff, Dickerson, & Barrett, 2011). Furthermore, recently Düzel et al. (2019) examined brain tissue differences with voxel based-morphometry in more than 300 individuals with high loneliness scores and found smaller grey matter volumes in the amygdala, hippocampus, and cerebellum. Remarkably, the authors argue that significant atrophy of such regions could be associated with a lack of social interaction and loneliness-induced stress. Interestingly, it has been proposed that the amygdala also regulates personal space or proxemic behavior. This proposal arose from observations in monkeys and humans with bilateral lesions in the amygdala; these individuals lose any personal space dimension and prefer interactions within closer proximity (Kennedy, Gläscher, Tyszka, & Adolphs, 2009).

Due to the COVID-19 pandemic, we have had to establish new proxemics promoting distancing and social isolation. Probably, that will be our new everyday life soon. The pandemic can be stressful and is associated with significant levels of anxiety in the population. Some animal and human studies have suggested a crucial role for the amygdala in the generation of anxiety disorders (Ressler, 2010). Together, these findings suggest that the amygdala is continually responding to the different stimuli caused by the pandemic. Furthermore, it is well known that the brain has a fantastic ability to adapt to external factors. Thus, it is necessary to propose the following question: Will the COVID-19 pandemic induce an adaptive change that modifies the amygdala's structure and function? Future studies will be necessary to determine if the pandemic's pressure was enough to change our brain.

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### Conflict of interest

The authors declare they have no conflicts of interest.

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