Perspectives on affective computing for the early diagnosis of neurodegenerative diseases

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Abstract

There are differences between healthy subjects that present a normal aging and subjects that even without showing symptoms of neurodegenerative diseases are already in the previous stages of the disease, when it comes to process emotions. In this way, it would be possible to use the recognition of emotions as a method of aid for the diagnosis of neurodegenerative diseases in early stages. However, apathy, mobility difficulties, and changes in emotional regulation associated with normal aging make it difficult to detect emotional disturbances. Therefore, in this article we propose the development of experimentation protocols that allow the evaluation of the emotional state of subjects through based-home affective computing technologies.

Keywords: Emotions · Aging · Neurodegenerative diseases · Affective computing

Emotions in Normal Aging

Emotional experience and its regulation changes with age during the lifespan. Based on socioemotional selectivity theory, with chronological age, present-oriented goals are prioritized over future-oriented goals, this motivational change therefore influences emotion regulation and cognitive processing [1]. Older adults, as opposed to young adults, give more importance or prioritize emotional strategies than reasoning, learning or memory [2]; and consequently, highly arousing emotional cause alterations in the performance of cognitive tasks [3]. Lifespan developmental theories suggest that as individuals grow older, they become increasingly motivated and able to regulate their emotions, which could result in reduced negativity and enhanced positivity [4]. In general, older adults report lower levels of distress, depressive symptoms and lower frequencies of negative emotions in daily life than middle-age and young

adults [5] [6]. However, no differences exist in the intensity with respect to age when experiencing both positive and negative emotions [7] [8]. This could be explained by the fact that contrary to what happens with the majority of biological processes and cerebral functions, emotion regulation is not impaired by aging. The reported decrease of negative affect has not been linked to explicit physiological changes but with the ability of a better regulation and control of self-emotions associated with maturity [9]. Moreover, the negative affect that may take place at older ages is related with the physical impairment that is suffered [2].

In terms of brain functional disability with age, the regions implicated in the emotional processing as the limbic system and the prefrontal cortex present different levels of impairment or patterns of decline depending on the individual. But, in general over the age of 60 the limbic system, in charge of perceiving, encoding and recalling emotional stimuli, is fairly well maintained; however, the prefrontal cortex that in normal conditions responds more slowly to the emotional event than the limbic system and is in charge of higher-order reasoning and behavior related with the emotional experience, is associate with pronounced decline. At the peripheral nervous system, although the response in front of arousing stimuli has no age-related difference, reactivity is reduced among older adults due to also biologically decline. Older adults display reduced cardiovascular activity in response to both positive and negative emotions [2]. On the other hand, at the neuroendocrine level, cortisol reactivity in response to stressors is prolonged with age, leading to a longer baseline recovery after arousal stimuli [10]. Nevertheless, despite normal-neurophysiological decline related with age, no impairments are found in the processing of emotions in daily life. Older adults present a better control and regulation of their emotions showing slower and reduced reactions to both valence and arousal stimuli. The fact that with normal ageing the processing/regulation of emotions becomes more mature, reducing the consequences of negative emotions, is a priori a protective factor as it avoids serious consequences in the face of stressful stimuli since the body could not respond to them in a non-harmful way given the deteriorations associated with age.

Emotions in Neurodegenerative Diseases

When neurodegenerative diseases occur during aging, most patients have deficiencies in the regulation of emotions not only once the symptoms of the neurodegenerative disease are present, but also in previous or early stages of the development of the disease. Therefore, suggesting that regulation and emotional response could be a biomarker for early differential diagnosis [11]. Deficiencies in the recognition of emotional facial expressions have been observed during initial stages of both Alzheimer's disease and frontotemporal dementia [11]. Non-demented Parkinson's disease patients have also shown deficits in emotional recognition abilities when discerning between discrete emotions presented both with visual and auditory stimuli [12]. Moreover, recognition of all negative emotions, particularly in the facial domain [13], and ability to recognize emotional states in others [14], tend to be impaired in the onset and progression of Huntington's disease [9]. The recognition and distinction between different types of emotions is deficient among these patients, especially when it comes to recognizing emotional stimuli in facial expressions, although at different levels or degrees of severity [15], but all of them reflecting a damage or deterioration of the cerebral structures responsible for the processing of emotions or the connections between them [12]. These deficits in emotional regulation may partially explain the social difficulties and some behavioral problems observed in neurodegenerative disease patients.

On the other hand, the fact that deficits in emotional regulation due to damage to the brain structure may already be detectable in stages prior to the appearance of symptoms of neurodegenerative diseases, motivates the study of emotions in the elderly population range in order to specify the possible underlying anatomofunctional substrates and therefore propose suitable treatments. However, it is known that self-care and the search for medical help are reduced if the symptoms are not severe and that many times the symptoms that may be indicating a disease are interpreted as age-associated impairments by the patients themselves [16]. For this reason, the detection of early stages of disease through deterioration in the regulation of emotions may go unnoticed.

Affective Computing and Aging

The advances that are taking place in the last years in the area of affective neuroscience, focus on the study of the neurophysiology of emotion, have led to progressions in affective computing. Affective computing is in charge of the development and implementation of applications able to recognize emotions from physiological signals based on affective neuroscience advances, in order to ensure a proper human computer interaction [17]. The implementation of affective computing in the home for the care of elderly and relieve of loneliness and social isolation of this part of the population has begun to be tested through voice interaction systems, that have shown high levels of acceptance and satisfaction in improving the situation from loneliness to old age [18]. Moreover, due to an increasing aging population and the medical costs that this entails, the home health care industry is growing and advancing more and more in the development of tele-home health systems as vital sign monitoring devices, video conferencing, medication reminder systems and web-based systems [19]. However, little has been done in the emotional aging affective computing domain in terms of early diagnose of neurodegenerative diseases.

So far, most of the emotional studies in older adults have been based on the study of event-related potentials during the stimulation through emotional pictures [20], emotional short sounds [21] or snapshots of different facial expressions reflecting several discrete emotions [22]. However, nowadays it is still not possible to perform electroencephalographic recordings outside of the clinical or laboratory environment, due to technology still cannot ensure non-supervised recordings. Moreover, these type of stimulation paradigms require a high trial repetition which is not ecological in terms of daily life situations. For this reason, dynamic stimuli, i.e. audiovisual stimuli, would be more feasible for home-based emotion evaluation. Furthermore, although the brain electrical activity signal is more accurate, cardiac activity, skin galvanic response and skin temperature signals have proven to be able to discriminate between emotions in both valence and arousal scales [23]. The advantage of using this type of signals is that there are bracelets that record them, so that result comfortable for the subject leading to their fully mobility and do not require restricted recording conditions [24].

Conclusion

Based on the fact that emotion recognition process in older adults could be used as a biomarker for neurodegenerative disorders [25] [26] [27]; the knowledge regarding the emotional pathways and mechanisms of action provided by affective neuroscience and the advances in affective computing technologies, we believed that it would be possible to develop a system

capable of aid in the early diagnose of certain neurodegenerative diseases. However, more efforts are needed to find the physiological patterns that may discern between healthy subjects and subjects at risk of neurodegenerative diseases; as well as to elaborate the experimentation protocols that may allow to unmask alterations in the regulation of emotions from the home environment; in this way facilitating and reducing the cost of medical work and reaching a wider range of population.

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