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Review

Could Self-Consciousness Be Enhanced in Alzheimer's Disease? An Approach from Emotional Sensorial Stimulation

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Abstract. Alzheimer's disease (AD) provides a valuable field of research into impairment of self-consciousness (SC), because AD patients have a reduced capacity to understand their mental world, to experience and relive previous personal events, as well as to interpret thoughts, feelings, and beliefs about themselves. Several studies observed that AD patients had an altered SC, but not a complete abolition of it. Emotions are an integral part of the construction of personal identity, therefore of Self. In general, most studies on emotion in AD patients have observed that emotion is not completely abolished and it lets them better remember autobiographical events with greater emotional charge. The positive effect of autobiographical memories rich in emotional content, evoked directly/automatically by sensorial stimuli such as familiar odors or music, could be used to reestablish/reinforce the permanence and coherence of the Self in AD. We studied the research of empirical evidence supporting the power of the sensorial cues associated with emotion, which could be capable of enhancing the SC in AD. We presented the studies about "Emotional stimulations" using odor, music, or taste cues in AD. All studies have shown to have a positive impact on SC in AD patients such as odor-evoked autobiographical memories, taste/odor-evoked autobiographical memories, emotional sensorial stimulation using musical cues, and multi-sensorial stimulations using healing gardens. We found research supporting the notion that emotional sensorial stimulations can even temporarily exalt memory, affective state, and personal identity, that is, the SC in AD. The emotional sensory stimulations could be used as a tool to activate the SC in AD and hence improve the quality of life of patients and caregivers.

Keywords: Alzheimer's disease, dementia, emotion, healing garden, music, neurodegenerative disease, non-pharmacological therapy, odor, self-consciousness, sensorial stimulation, smell, taste

INTRODUCTION

Consciousness is a mental biological phenomenon, which allows us to build a sense of our life and of the personal identity of others and thus, it is inexorably linked to the concept of subjectivity [1]. José Ortega y Gasset [2] provided the differentiation between two kinds of "being conscious" states: the "being aware" and the "conscious being". The "being aware" refers to those states of being awake and the "conscious being" refers to being able to perceive oneself objectively, without losing the private interpretation of oneself at the same time. This paradox of consciousness implies the integration of cognition and emotion.

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The most important historical antecedent of the neurobiological bases of SC is probably Luria [7], who assigned consciousness to the third functional unit, in particular to the frontal lobes [8–10]. Later, Dr. Damasio [4] argued that the critical neural system for SC is the participation of the prefrontal cortex, because it is a highly convergent zone. This neural zone receives signals from all the sensorial regions where the conscious experiences are formed, as well as from bio-regulatory sectors of the brain and represents categorizations of previously lived situations with their corresponding specific emotional valence. For Dr. Damasio, SC is a process of coordinated activation of personal identity memories, located in a ubiquitous network, more localized in the convergence zones, situated in the temporal and frontal superior cortex, as well as in the subcortical nuclei (such as those of the amygdala). In addition, Gil et al. [11] also described the crucial participation of the frontal supramodal associative cortex in SC, related to the heteromodal associative frontal cortex where information arrives from areas involved in memory, language, and visual-perceptual functions to finally synthesize them.

In a broad way, recent studies have observed that the default mode network (DMN) seems to assure the coherence of Self [12, 13], and it works at rest states, when the subject is focused on himself (mediation, daydreaming, etc.). The DMN is a broad neural network with components that converge with key associative areas, defined essentially by the ventral mid-temporal zone, the posterior zone of the cingulum, A39, and the fronto-orbital and fronto-ventral cortex [14]. We will present below the study results supporting the power of the sensorial cues associated with emotion which could be capable of enhancing the SC in AD patients.

SELF-CONSCIOUSNESS IN ALZHEIMER'S DISEASE

SC is considered a multifaceted concept [15]. It includes consciousness of its body [16], of the perceptions [17], of mood state [18], of the projects [19], or the future [20]. It also includes a moral consciousness that allows human beings to make judgments about their thoughts and actions [21, 22] and to act in a complex social world with knowledge of themselves and others [23]. Finally, it is the awareness of each one's own history, of his autobiography [1] and, consequently, is inseparable from memory [24], thanks to which the identity of each human is building.

In 1892, William James [25] proposed three Selfs: physical, social, and psychological. Later, Dr. Neisser [26] suggested a model of five factors of the Self cohesion: 1) ecological self or the self as it is directly perceived with respect to the physical environment, 2) interpersonal self or the self engaged in personal interactions, 3) extended self or the self as it was in the past and what it will be in the future, 4) private self of personal experiences, and 5) conceptual self or self concept about oneself. In addition, Dr. Gallagher [27] argued that the aspects of Self are organized in certain patterns that can vary in weight and value in a dynamic constitution of a self.

There are several tools assessing SC such as the Self-Consciousness Scale (SCS) [28], Self-Absorption Scale (SAS) [29], Self-Reflection and Insight Scale (SRIS) [30], Philadelphia Mindfulness Scale (PHILMS) [31] and Rumination-Reflection Questionnaire (RRQ) [32], Double Mirror Paradigm [33], Self questionnaire (SQ) [34], and Self-Consciousness Questionnaire (SCQ) [22]. The first six scales are self-report measures which are more appropriate for evaluating a healthy population and they focus on few components/factors of SC such as self-image, self-attention, and insight. The last two questionnaires are adapted to the dementia population and they assess the most SC factors. Besides, the SCQ was validated for various clinical populations, though the major limitation is the ceiling effect in healthy individuals.

The SCQ [22] in AD involves a clinical evaluation by a structured interview with the patient. The SCQ is a tool to assess the SC as ecologically as possible, in a manner that is as close as possible to the everyday life of the subjects (Table 1). SC is considered the object of scientific study, looking for the state (preserved or impaired) of SC factors. The SCQ allows the evaluation of the following seven SC factors [22]: 1) Personal identity, 2) Metacognition, 3) Affective state, 4) Body representation, 5) Prospective memory, 6) Introspection, and 7) Moral judgements. The SCQ is composed of SC factors referring verbal self-referential processing/"self-feelings" (V-SRP; e.g., Personal identity) and non-verbally self-referential processing/"self-feelings" (NV-SRP; e.g., Body representation), in terms from Araujo et al. [35] and Siddharthan et al. [36]. The SCQ showed a high inter-observer validity (Kendall's correlation: 0.96, $p < 0.0001$), as well as a high reliability evaluated by test-retest (Spearman correlation: 0.73, $p < 0.0001$).

AD is a neurodegenerative disease essentially characterized by a progressive cognitive deterioration

Table 1
Self-Consciousness Questionnaire: the questions assessing the seven factors (F) of Self-consciousness

F1- Personal identity
– What is your name (surname and first name)?
– Have you had a job? What was it?
– What is the first name of your spouse (or partner)?
– What is your mother's first name?
F2- Anosognosia
– Why have you come to see me?
– Do you have any health problems that prevent you from leading a normal life?
– Have you got any problem with your memory?
F3- Affective state
– Do you feel happy or unhappy? Why?
F4- Body representation
– Would you say that you are fair- or dark-haired?
– Are you now sitting, standing or lying down?
F5- Prospective memory
– What are you planning to do shortly or tomorrow?
F6- Introspection
– If you had to live your life over again, is there anything you would like to change? What?
F7- Moral judgments
– Is it a good thing or a bad thing to tell a lie? Why?
– Is it a good thing or a bad thing to give some money or some food to someone who is starving? Why?

with a progressive loss of autonomy of daily life activities and quality of life, as well as social interactions. AD provides a valuable field of research into impairment of the Self, contributing to a progressive deterioration of SC, because AD patients have a reduced capacity to understand their mental world, to experience and relive previous personal events, as well as to interpret thoughts, feelings, and beliefs about themselves [37, 38]. Many studies have assessed anosognosia in dementia populations [39–45], but we found few works studying SC in patients with AD. Besides, various studies observed structural and metabolic alterations in the anterior cingulate region associated with a diminution of awareness in early AD [41, 43, 45].

All studies using the SCQ observed that AD patients had an impaired SC, but not a complete abolition of it [22, 34, 46, 47]. They found a similar pattern of impairment or integrity of the different factors of SC in AD. Thus, they revealed that the most altered aspects were Anosognosia, Moral Judgments, and Prospective Memory, and the less impaired ones were Personal Identity, Affective State, and Body Representation. Several studies have observed that AD patients appropriately maintained body representation [34, 48, 49], and even at advanced stages of the disease, they seemed to better maintain mirror self-recognition and bodily distinction between self and others than self-knowledge and personal identity [50]. In addition, various studies have observed a social self affected in AD patients [34, 51]. Strohminger and Nichols [52] have suggested that the "Moral faculty" plays a primary role in social identity discontinuity in neurodegenerative diseases, whereas other cognitive troubles, including amnesia, have no measurable impact on identity persistence. Furthermore, these studies using the SCQ did not observe a significant correlation between the SCQ and educational level, age, or duration of the disease from diagnosis. However, they revealed a relatively correlation between the SCQ, the dementia severity (assessed by Mini-Mental State Examination) [53], and executive functions (assessed by the Frontal Assessment Short Test [54] and the Wisconsin Card Sorting Test [55]).

Several works also suggested that the deficits of those SC factors were more dependent on an orbitofrontal functioning and related to the DMN [56–59]. The DMN seems to ensure the coherence of the Self and is put into operation at resting states, when the subject is focused on himself (meditation, body/mind wandering state, etc.) [12, 60, 61]. Weiler et al. [62] also proposed that deficits of the Self in AD were underpinned by alterations in DMN functional connectivity cortical midline structures. They also suggested that people with AD lose the ability to coherently update and integrate their Self, due to inefficient resting state functioning resulting from alterations in cortical midline structures and associated DMN functional connectivity. The neurosynth meta-analysis of neuroimaging studies made by the team of Dr. Frewen [56] suggested that the regions of interest for SC neural networks could essentially be the cortical midline structures and insula, besides ventral and anterior/middle medial prefrontal cortex. Nevertheless, there are criticisms of the theory of cortical midline structure and the DMN mediation of Self processing [63–65].

EMOTIONAL SENSORIAL STIMULATIONS

AD preferentially affects the regions of the medial temporal lobe which are also essential in emotional processes, causing cognitive, behavioral, and emotional disturbances [66–68]. The troubles of memory are one of the most important clinical symptoms in AD patients, in particular those of episodic and autobiographical memories [69–72].

Concerning the relationship between SC and memory, autobiographical memory offers information about who I am, was, and can be, and is essentially for Self memory, participating in the construction and maintenance of personal identity and, therefore, playing a fundamental role in the SC [73–76]. Autobiographical memory has been considered as a long-term memory system that serves to encode, store, and retrieve a set of representations, in which the Self is the central theme or axis [34, 77, 78]. Autobiographical memory has two components, one semantic that refers to the general representations of personal events and the other, episodic, referring to personally lived events, very concrete and specific temporally-spatially [78, 79]. This has led to the distinction between noetic consciousness associated with the semantic component, the feeling of familiarity or "knowing" (Knowing) and autonoetic awareness related to the episodic component, with the reactivation of the self-memory of lived events, of re-experiencing experiences [20, 80]. Overall, autobiographical memory seems to be supported especially by network connections in automatic or spontaneous mode as the DMN and the hippocampus [81].

AD patients present more deficits in the episodic component than in the semantic component of autobiographical memory [82-85]. A major characteristic of episodic autobiographical memory in AD is overgenerality, which reduces the ability to produce speci?c per-sonal events [70, 71, 86-88]. It suggests that overgenerality is a result of a diminished ability to mentally relive past events, though they can be familiar for the AD patients [76, 82, 89-91] and it can be related to disruption of the personal identity and the sense of self [74-76, 92]. Thus, the episodic component alterations of autobiographical memory provoke memory deficits about the subjective experience of the speci?c event situated in time and space (details such as feelings, perceptions, thoughts, or visual imagery), which affect social interactions [87, 93], identity [90] and ability to mentally relive past lifetimes [69, 82, 89, 94].

Non-pharmacological interventions have tried to alleviate impairment of autobiographical memory in AD, such as Reminiscence therapy. It uses a voluntary process to recall personal events, but with very limited results [95]. In general, research has shown that non-pharmacological therapies (psycho-cognitive programs, aromatherapy, behavioral therapy, Snoezelen therapy) have moderate efficacy in reducing a variety of difficult cognitive or behavioral troubles in AD [96]. In another meta-analysis, Kong et al. [97] found that only sensory interventions made a significant beneficial difference on symptoms such as agitation in patients with dementia. Thus, Snoezelen therapy in AD consists of auditory, visual, olfactory, and tactile passive stimulation that aims to stimulate a patient's senses instead of using environmental enrichment activities [98]. But the identification of high preference stimuli for the patients is very important in order to obtain positive effects in AD [98, 99]. They suggested that sensorial rich stimulation is not enough to enhance cognitive, affective, and/or behavioral aspects and the sensory elements of the personal environment greatly affect the individual's well-being. In a recent study, Dr. Goto and his team [100] already showed the great importance of sensorial stimulus quality. In this work, they observed less beneficial effects in AD patients using the Snoezelen room than those exposed to a natural environment (Japanese style garden).

Thus, the emotion of sensorial stimuli could become powerful stimuli to enhance positive impact on well-being of individuals. "Emotional sensorial stimulations" using sensorial cues such as music or odor, and focusing on emotion, could activate factors of SC in patients with AD [101].

Emotion is a direct means of relating to memory, a powerful involuntary alliance that can make you remember your life story. Emotion is a key aspect in Sensorial stimulations. Emotions promote action in the human being, intervening in decision making, learning, and communication as well as behavior. Emotions are an integral part of the construction of personal identity, therefore of Self, that is, of being way, of being in the world, and being recognized as such. It is a journey through time that allows the narration of the past, present, and future personal history [102]. In general, most studies on emotion in AD have observed that emotion is not completely abolished, because patients are able to remember the words better with emotional valence than neutral ones [103–105] or to remember better autobiographical events with greater emotional charge [82, 106]. Some episodic autobiographical memories could remain stronger and recalled faster and richer in AD patients, thanks to its relation with emotional intensity of the event, its significance for the personal identity, and concordance with present Self [73, 79, 80] and even visual short-term memory could be improved using emotional pictures in aging and AD populations [107]. Anyway, positive and negative emotions can facilitate memory processes [108–110] thanks

to neural mechanisms involving the amygdala and prefrontal cortices, which participate in information encoding [111].

Considering the devastating consequences of the deterioration of autobiographical memory in SC, the positive effect of autobiographical memories rich in emotional content, evoked directly/automatically [79, 80] by sensorial stimuli such as familiar odor or music, could be used to reestablish/reinforce the permanence and coherence in their Self, because as Dr. Bergson [112] said "consciousness is first memory" and someone does not know if he lives, if he does not experience that he is living in his present life. Thus, we can promote the use of strategies for direct access to personal memories automatically, not voluntarily, but facilitated by sensory stimuli that enhance emotionally-charged memories.

Sensory stimuli such as familiar odors or familiar musical sounds can be powerful facilitators of autobiographical memories that use daily stimuli. The memories evoked by hearing or smell are of an involuntary nature and benefit people with both brain damage with serious declarative and SC mnemonic disorders, as well as the general population. Your emotional memory-activating power could also help control your mood state. Introspection about their own past, facilitated by sensory stimuli such as olfactory ones, would have an adaptive function in the present, reinforcing identity and self-esteem. In this way, works that relate to the exaltation of the SC by music, taste, smell, or a garden with the persistence of an emotional stimulation of an automatic type of the hippocampus (and thus, of memory), through the amygdala, are hopeful in the devastating process of this disease, alleviating their loss of identity, and so, the SC.

These emotionally charged sensory stimulations could help to implement better intervention strategies to improve the well-being of AD patients and their families; hence, the importance of studying potential SC enhancers in AD, using the Emotional sensorial stimulation with odor, musical, or taste cues. The powerful senso-perceptive cues have a beneficial impact on the involuntary retrieval of autobiographical memories in AD, principally by diminishing the time taken to retrieve these memories [113–117]. The involuntary retrieval may promote a direct link between the cue and the memory trace, thus avoiding the complex recovery process involved in voluntary autobiographical remembering. We can mention the following Emotional sensorial stimulations such as odor cues, taste cues, familiar music cues, and multi-cues from healing gardens (Table 2).

Table 2
Emotional sensorial stimulations probably enhancing self-consciousness in Alzheimer's disease

Types of Emotional Sensorial Stimulations	Authors/Studies
Emotional sensorial stimulations using odor cues.	El Haj et al., 2017 [123]
	Glachet & El Haj, 2019 [161]
	Glachet & El Haj, 2020 [163]
	Glachet et al., 2018 [160]
	Glachet et al., 2019 [162]
Emotional sensorial stimulations using the taste/flavor or other types of cues.	No studies.
Emotional multi-sensorial stimulations using ecological environments as the healing gardens.	Gueib et al. (2020) [198]
Emotional sensorial stimulation using musical cues.	Arroyo-Anlló et al., 2013 [241]
	Baird & Thompson, 2018 [240]
	El Haj et al., 2013 [239]
	El Haj et al., 2015 [94]
	El Haj et al., 2016 [91]
	El Haj et al., 2017 [123]
	Foster & Valentine, 2001 [237]
	Irish et al., 2006 [238]
	Kontos, 2014 [243]

EMOTIONAL SENSORIAL STIMULATIONS AND SELF-CONSCIOUSNESS IN ALZHEIMER'S DISEASE

In relation to *Emotional sensorial stimulations using odor cues,* it is first necessary to remember that 85 to 90% of AD cases have olfactory troubles and they appear from the early stages of the disease [118, 119]. The olfactory deficit is at the same time peripheral and central alteration, characterized by troubles of detection, discrimination, memory, recognition, and identification in patients with AD. However, they present a relative preservation of the judgments of intensity, hedonic tone, and edibility of odors [118–120].

Moreover, olfactory memory has two kinds of perceptual-cognitive processing, the olfactory explicit memory which lets the identification of the odor and the olfactory implicit memory which lets

odor-evoked memories which are involuntary, spontaneous, with high emotional content, and without effortful cognitive process [80, 118, 121–124]. The Autobiographical Memory [80, 87] proposes that personal events can be evoked by a direct and indirect way. The indirect access to episodic autobiographical memories is possible if they are associated with powerful senso-perceptual cues. Besides, the indirect or automatic access to information is more preserved in AD than the direct or voluntary access [125–128].

Research into odor-evoked autobiographical memories has suggested that odor cues have a beneficial effect on the recovery of phenomenological details which are characterized by significant mental time travel and more vivid memories [129–134]. Odor-evoked autobiographical memories, the Proust phenomena [135], are old and rare personal events placed in a spatial-temporal context, emotionally rich, vivid, and associated with limbic activation [136]. Unlike other modalities, olfactory stimuli are not relayed by the thalamus during cortical processing [118]. Olfactory signals are directly connected with two key structures involved in memory, particularly associative learning and emotions: the amygdala and the hippocampus [129, 132, 137, 138]. Moreover, the DMN is also involved in autobiographical memory and can be modulated by emotional states [139], since, for example, it shares with the olfactory system, the orbito-frontal cortex, which is the secondary olfactory cortex, responsible for assigning affective value to the stimulus [140]. Additionally, recent studies observe that DMN is activated in tandem with other neural networks such as the fronto-parietal control network in tasks of internal organization of autobiographical memory [141], coming to activate the hippocampus [142].

Odor emotional effect associated involuntarily to a personal event does not obligatorily need the explicit identification of the odor which is altered from the early AD stages [118, 119, 143, 144]. Thus, odor-evoked autobiographical memories trigger significant emotional content [130, 136, 140, 145–148]. Additionally, odor-evoked autobiographical memories were rated as more emotional than those evoked by verbal or visual cues [149] and elicited more positive memories than those by other modalities [124, 132].

Emotional sensorial stimulations using odor cues are based on the cognitive effect of the odors in terms of activation or of cerebral alertness—arousal—and this in close relation with the known emotional effect of the odors [150–152]. A considerable number of experimental data suggest the positive, albeit variable, impact of olfactory stimulation on attentional and intellectual tasks due to an increase in alert level [153, 154]. But when the smell also evokes a memory, positive moods are further enhanced [151, 152, 155], even to a greater extent compared to a musical type stimulation [156–158]. It has also been observed how scents that evoke memories relatively improve the physical health and longevity of the subject, thanks to the beneficial effects on physiological parameters of stress-low heart rate, respiratory, blood pressure, etc., inducing more states of relaxation and meditation [129, 159].

To our knowledge, only five studies have examined the impact of odor on autobiographical remembering in AD [123, 160–163]. All studies have demonstrated the positive effects of odor on personal event memories. In 2017, El Haj et al. [123] investigated the involuntary nature of autobiographical memory in AD triggered by music and odor. They showed that AD patients improved specificity, emotional experience, retrieval time, and mental time travel when memories were cued by odor compared to an odor-free condition. They also observed shorter retrieval time for memories cued by odor than for those evoked by no cue. Glachet et al. [160] found similar results for specificity and recovery time. This study also observed odor-evoked autobiographical memories with higher subjective reliving in AD. They did not find significant effect of odor in terms of specificity and reminiscence in healthy people, suggesting that this type of cueing is particularly efficient when autobiographical memory is impaired. The team of Dr. Glachet [162] also found a positive effect of odor exposure on recent autobiographical memories in AD. Additionally, Glachet & El Haj [161] investigated emotional characteristics (arousal and valence) and subjective reliving of odor-evoked autobiographical memories in AD. They observed higher arousal, subjective reliving, and more positive memories after odor exposure compared with the odor-free condition only in the AD group. And they found that emotion (arousal and valence) and subjective reliving triggered by odor were associated with depressive symptoms in AD. In a recent study of Glachet & El Haj [163], they observed that AD patients and control participants produced more specific and more emotional past and future events after odor exposure than without odor. However, odor exposure did not improve the retrieval time for future thinking in AD participants.

Furthermore, the studies from Charlesworth et al. [164] and El Haj & Antoine [76] observed a positive effect of retrieval of self-related informa-tion on autobiographical memory in AD. Subsequently, El-Had et al. [165] found the reverse effect, that the autobiographical recall in AD also enhanced access to self-related information, in particular to physical, social, and psychological Self. These results suggest a bidirectional relationship between autobiographical memory and the SC factors in AD. Thus, Glachet & El Haj [163] demonstrated positive effects of odor exposure on the ability of AD patients to project themselves into the future or on the Prospective memory factor of SC. However, to our knowledge there is no work that examines the effects of familiar odors evoking autobiographical memories on other factors of SC, such as Introspection or Moral judgements and even less, in patients with AD.

Future studies are necessary to explore the emotional power of familiar odor stimuli to generate a positive effect on SC, due to beneficial impact on mood state, attention, and personal identity [110, 150]. Besides, it would be interesting to take into account some scientific evidence in order to design emotional sensorial stimulations using odor cues to enhance the SC in AD, such as:

a) odor exposure takes a short time due to non-habituation to smell [166,167];
b) the stimulation of the trigeminal nerve could evoke less pleasant memories, although more detailed [168];
c) the association between smell and memory is very resistant to retroactive interference [169,170];
d) influence of the culture on odors [171];
e) the intensity of the smell due to greater intensity, greater unpleasant perception of smell [172];
f) gender, because women are usually more sensitive to smell, more emotionally reactive, and more susceptible to emotional conditioning with smell than men [90,173-175], although it seems there are no differences at an advanced age [159];
g) some personality traits such as emotional lability, neuroticism, etc. [176,177].

Regarding the *Emotional sensorial stimulations using the taste/flavor cues*, it is interesting to remember that the receptors in the olfactory and gustatory cortex are very related, although the nerve pathways of smell and taste are anatomically differentiated. They are closely related in the act of eating and tasting food. The sensations of taste are associated with those of smell that precede the ortho-nasal (inspiratory) and posterior, retro-nasal (expiratory) from the mouth to the nostrils. The perceptions obtained from these sensory organs affect the brain areas involved in memorization and their emotional component, as in the case of the Proust cupcake phenomenon. The perception of taste is different from the general sensitivity of the tongue. Taste cells are provided with specific receptors for five flavors: salty, sweet, bitter, acid (sour), and umami. These limited taste perceptions are enriched with those contributed by smell, which explains why flavors essentially are a combination of taste and smell. In addition to taste and smell, others perceptions emanate from the sight, because food also enters through the eyes (colors, shapes, materials, etc. of food) or from the oral cavity, such as the texture of the substances and the auditory component of chewing and crunching. Few studies have described isolated taste alterations, rather they reveal a loss of smell [178]. In AD, patients showed more flavor alterations at the associative level than at that of perceptive, as well as the verbal identification troubles [179]. Few isolated taste disturbances have been described, rather they reveal loss of smell.

To the best of our knowledge, there are no studies about the impact of the perception of flavors on SC factors in AD. Future studies would be interesting to measure the effect of the familiar odors-flavors stimuli on SC, which could also intensify the nutritional conditions of the dementia population. Besides, we did not find any study concerning the effect of other kinds of sensorial stimulation (e.g., vibration, visual, tactile stimulations) on SC in AD, in order to evaluate the potential capacity of enhancing SC factors in patients. Nevertheless, Clements-Cortes et al. [180] found more positive effects of stimulating the somatosensory system, using 40 Hz sound than those using visual stimulation, on mental status, emotion, and behavioral aspects in AD patients. Scherder et al. [181] examined the effects of Transcutaneous Electrical Nerve Stimulation (TENS), tactile stimulation, and a combination of the two on memory and affective behavior of AD patients. The results suggested that patients improved in visual short-term memory, verbal and visual long-term memory, and verbal fluency. In addition, some studies have shown that tactile massage or musical stimulation improved physical relaxation and psychological well-being, as well as reducing aggressiveness and stress levels in patients with dementia [182–184].

Additionally, there could be other considerations like *Emotional multi-sensorial stimulations using*

ecological environments such as the healing gardens, where people can smell, taste, and move, as well as listen to nature. To be in touch with nature is a source of multisensory active and passive stimulation. The link between nature and health has been well recognized since antiquity, as well as the benefits of nature on health [185–187], even on AD health particularly, on psycho-behavioral disorders in AD [188]. Thus, several studies have found environmental therapy, based on the interaction between patients and the natural environment, reduced aggression and improved satisfaction and quality of life in patients with dementia [189–192]. Individuals with AD who participated in horticultural therapy showed delayed mental deterioration [193] and increased cognitive functioning [194]. Additionally, other studies have shown that even passive exposure to nature fosters psychological well-being, reduces stress, and promotes physical health [195]. Thus, Friedrich [196] has also reported that exposure of AD subjects to a garden setting can help address memory deficits in patients, relieve stress, and improve the sense of well-being for them, as well as staff and family members. These healing gardens are designed with features that provide a safe accessible therapeutic environment for visitors, staff, and patients that are tailored to fit the specific needs of dementia patients, such as non-reflective walkways and wide continuous paths that provide direct exposure to nature. In addition, a recent single-blind randomized controlled trial on indoor therapeutic gardens in AD patients with behavioral and psychological symptoms has shown the diminution of behavioral and psychological disturbances, medication intake, and cortisol levels in AD patients after 6 months of an indoor therapeutic garden [197]. Furthermore, Goto et al. [100] found that the Snoezelen environment did not induce comparable effects to those obtained with a therapeutic garden in dementia patients. The patients viewing a Japanese garden improved behavioral and physiological aspects, while the responses of the subjects using Snoezelen were worsening.

Concerning the effect of healing gardens stimulations on SC in AD, a recent study has assessed the impact of the environment by comparing, in routine care, patients with dementia hospitalized in a cognitive-behavioral unit who solely remain indoors with others, who use the "Art, Memory and Life" healing garden [198]. They found a significant decrease in SC due to an increase in anosognosia during the hospitalization of patients who remained indoors. In contrast, the patient group using the garden showed a positive effect on overall SC, particularly on the SC factor of Body representation.

Regarding the *Emotional sensorial stimulation using musical cues,* AD may compromise several musical competences, such as tone recognition [199], pitch perception and tonal working memory [115, 200–204], timbre [205], or rhythm [206], but other studies have observed relatively preserved ability to detect basic acoustic changes in music such as pitch [115, 207, 208], timbre, or rhythm [115, 209]. Most studies on musical memory in AD have observed relatively spared familiar music [208, 210–214], depending more on semantic musical memory and emotion. In contrast, heterogeneous results have been found using unfamiliar music [115–117, 214, 215–218], exploring more episodic musical memory, although studies have observed non-musicians and musician patients who could learn and recall new music, even during severe stages of dementia [219, 220].

Several studies using music-evoked autobiographical memories [221] have found that the AD patients increased personal memories after listening to favorite music and even after listening to no familiar classical music [222, 223]. These personal event memories appeared very fast after musical listening with a high emotional content. But the neuro-cognitive processes involved in this musical facilitation of personal memories remained acknowledged (arousal stimulation or emotional stimulation, or involuntary association?). Anyway, familiar music has an enormous power to evoke personal emotions and memories [224]. Research into musical emotions in AD have found that the patients can perceive and recognize emotions conveyed by music, as well as recognize the melodies and titles of familiar songs [200, 207, 208, 224–226]. Moreover, music therapy in AD has shown beneficial impact on mood, attentional capacity, autobiographical memory, and behavior, and an even more positive effect than using art therapies or occupational activities [227–229].

The notion that music can construct and enhance the sense of Self has been proposed by several authors [27, 230–234]. Dr. DeNora [230] and Dr. Firth [231] observed how music is a regulator of emotions and an active ingredient in the organization of the Self, through the direct musical experiences it offers to the body, time, and sociability. Dr. DeNora [230] and the team of Dr. MacDonald [234] also conceptualized the music-evoked autobiographical memories as crucial in creating and sustaining the personal and social identities. In addition, Dr. Elvers [235]

identifies three processes that arise during music listening that underpin musical self enhancement: a) empathetic listening (the notion that when listening to music, people imagine the feeling state of either the person responsible for making the music), b) social cohesion (the capacity for music making and listening to create and strengthen social bonds and social identity), and c) pleasure or the tendency for music to evoke positive affect and emotions. Various studies have observed a reduction of agitation in people with dementia, using favorite music evoked autobiographical memories [234, 236].

Thus, emotional sensorial stimulations use musical cues in order to activate SC of AD patients. Several studies observed better performances to retrieve personal events, using musical-evoked autobiographical memories, probably thanks to an involuntary access in AD patients [76, 91, 94, 237–241]. Additionally, Baird & Thompson [240] suggested that music-evoked autobiographical memories may contribute to improve mood, behavior, and cognitive functions as well as sense of Self in people with dementia. They proposed that music has seven specific features from Thompson & Schlaug [242] (physical movements, synchronization of movements, social, emotional, personal memories, engaging and persuasive), which interact with some or all 5 factors of the self from Dr. Neisser [26], in order to promote overall well being. They described two cases of women with severe AD, who resided in an aged care facility (one musician and another non-musician) and they showed the positive impact of music features on the five factors of self in the patients.

In 2013, the team of Dr. Arroyo-Anlló [241] presented an empirical study about the impact of familiar music on SC in an AD group, using the SCQ [22]. They explored the effect of regular listening of a favorite song on SC. The patients were assessed by this questionnaire pre- and post-music intervention and the participants completed this in oral form. The intervention group was comprised of 20 patients with mild-moderate AD who listened to their favorite music for 2–4 minutes, three times a week for 3 months and another 20 AD patients who listened to unfamiliar songs. The results showed a positive effect of familiar music and its emotional power on SC in a group of patients with AD in comparison to non-familiar music. They observed that the musical intervention through familiar songs for patients with AD significantly stabilized or improved the factors of SC, except those of the Prospective memory and Introspection. Nevertheless, there were the limitations of this empirical study, such as the brief exposure to one song only, that could be considered for the future research. Interestingly, this study found that one of the important musical effects was on Body representation factor. The music is incorporated into the body schema and it is highly embodied [243, 244]. Maes et al. [244] reviewed empirical evidence supporting how the motor system and its actions can reciprocally influence music perception. They argued that the integration of action and perception is established through associate learning processes, which are relatively spared in AD.

Moreover, Wilkins et al. [245] explored functional brain connectivity in response to songs of varying preference (favorite, liked, or disliked) in healthy people, using magnetic resonance imaging and they found that while listening to preferred music, the precuneus was consistently interconnected with all regions of DMN, including the lateral parietal and medial prefrontal cortex. However, the precuneus was relatively isolated from the DMN when listening to music that was disliked. This is in line with previous studies showing that familiar and favorite music is more likely to elicit music evoked autobiographical memories [239, 246], as well as have an impact on SC.

CONCLUSION

This work found research supporting the notion that emotional sensorial stimulations can exalt, even temporarily, memory, affective state, and personal identity, that is, the SC in AD. The results support the power of sensorial cues associated with emotion which could enhance SC in AD patients. The emotional sensory stimulations could be used as a tool to activate the SC in AD and therefore to improve the quality of life of patients and caregivers.

Currently, non-pharmacological therapies in AD and in other neurodegenerative diseases have the main objective of improving the quality of life of patients and their caregivers. From a perspective of "care", neuropsychology is focused on the subject, on the unrepeatable perspective of the patient, on his well-being and not, on the disease. In this context, the caregivers adapt to the patient and the AD clinic characteristics, trying to understand better how AD changes the Self of patients and the relationships between the patient and the environment.

The representation that a subject has of himself (Self) includes his feelings, emotions, experiences,

profession, socio-family interactions, opinions, ideals, and moral-ethics. Thus, the way in which a subject manages and expresses his emotions is a component of his "character", of the set of distinctive features of his personality that makes his reactions predictable and allow him to remain himself, his Self [6, 110]. AD provokes that patients progressively lose their personal identity, their capacity to recall their present, past, and future history, ideology, and feelings as well as the spatio-temporal context where their personal events took place, generating a decontextualization of their lives, a depersonalization that reflects the change from an autonomic to a noetic consciousness, as we indicated earlier. AD varies the weight and value of SC factors in the dynamic constitution of SC pattern.

Thus, the approach based on Emotional sensorial stimulations intends to minimize the devastating consequences of AD on SC. They can better reorganize the factors of SC and so, the personal pattern of SC in order to build and maintain the sense of Self. For that, we seek to empower the patients and that is where SC and the power of emotion come into play. Emotional sensorial stimulations can exalt even temporarily, memory, affective state, and personal identity, that is, the SC. Thanks to emotion in general, and the emotional power of the sensorial cues in particular, autobiographical memories in patients could involuntarily emerge with a richer and more personal content, allowing the patient to contextualize their life history, changing that simple feeling of familiarity in relation to certain personal facts, to a "relive them", returning to "travel to the past", even for a short period of time, in that present that puts you back on track in your life trajectory, on your personal road. Thus, focusing on emotion, we focus on something essential in life, which can be stimulated by daily activities such as smell, taste, and music, because although the patient is unable to identify/name the smell, the dish, or the musical piece, the patient can relive situations, and find the emotions that contribute to it, recognizing itself.

It is an approach of socio-clinical relevance in AD, where Emotional sensory stimulations could be used as a tool to activate the SC and the quality of life. In this same sense, we recently find caring programs for people with AD such as "Carpe Diem" [247] where these stimulations are used. Future studies would be interesting to measure the impact of Emotional sensory stimulations on SC in other neurodegenerative diseases such as Parkinson's disease and frontotemporal dementias.

DISCLOSURE STATEMENT

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