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Emotional processing in patients with mild cognitive impairment: The influence of the valence and intensity of emotional stimuli
The valence and intensity of emotional stimuli influence emotional processing in patients with mild cognitive impairment

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ABSTRACT

We studied the ability of individuals with mild cognitive impairment (MCI) to process emotional facial expressions (EFEs). To date, no systematic study has addressed how variation in intensity affects recognition of the different type of EFEs in such subjects.

Design: Two groups of 50 elderly subjects, 50 healthy individuals and 50 with MCI, completed a task that involved identifying 180 EFEs prepared using virtual models. Two features of the EFEs were contemplated, their valence (operationalized in six basic emotions) and five levels of intensity.

Results: At all levels of intensity, elderly individuals with MCI were significantly worse at identifying each EFE than healthy subjects. Some emotions were easier to identify than others, with happiness proving to be the easiest to identify and disgust the hardest, and intensity influenced the identification of the EFEs (the stronger the intensity, the greater the number of correct identifications). Overall, elderly individuals with MCI had a poorer capacity to process EFEs, suggesting that cognitive ability modulates the processing of emotions, where features of such stimuli also seem to play a prominent role (e.g., valence and intensity). Thus, the neurological substrates involved in emotional processing appear to be affected by MCI.

1. Introduction

Research on mild cognitive impairment (MCI) has received increasing attention as of late [1], particularly since several studies concluded that a proportion of individuals with MCI progress to Alzheimer's disease (AD) [2–6]. Some reports estimate such progress as 10%–15% per year [2,3], although slightly higher annual proportions have been proposed (17.2%, [4]) and up to 50% in three years [5]. As a consequence, there is specific interest in identifying those MCI cases that may evolve into AD, in order to establish early diagnosis and therapeutic criteria [6,7]. In general, such studies have focused on specific cognitive deficits [8,9], yet there is an emerging trend towards the study of affective components, especially that of emotional processing [10,11]. These studies are of particular interest as correct emotional processing is vital in the performance of daily activities and for interpersonal communication.

With regards emotional processing, the ability to identify emotional facial expressions (EFEs) has often been used in such research, with many studies showing that the ability to recognize EFEs declines with age [12–14]. In an extensive review, it was noted that there is a consistent tendency for healthy elderly individuals to identify EFEs worse than younger subjects [13], especially when it comes to EFEs with negative valence like fear, anger and sadness, a tendency that has been corroborated elsewhere [15,16]. Cognitive deficits, such as MCI, seem to worsen the difficulties in recognizing EFEs [17,18], specifically the identification of fear [19,20] and anger [21], and in patients with dementia, such as those with AD, the ability to identify emotions is lost as the disease progresses [22,23]. This deficit affects different basic emotions like sadness [24] fear [25] or anger [26], as confirmed in a neuroimaging study [27]. However, it is not clear whether it is a deficit solely caused by the type of emotion or alternatively, whether other variables may be involved, such as the intensity of these emotions.

Deficits in the processing of discrete emotions and the changes in the neural substrates involved [28], such as the amygdale [29], have been the subject of neuropsychology studies. Various studies have established the relationship between the amygdala and fear recognition [30–32], although it seems that damage to the amygdala also affects the recognition of other emotions like anger and sadness [33]. From this point of view, the worse outcomes are explained to some extent by

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the loss of cognitive resources characteristic of aging [34] and they are more evident in cases of dementia [23]. Along similar lines, several studies indicate that deficits in processing EFEs may also depend on the type of mental operation required to complete the task: identification, and matching [35,36]. Different tasks are employed in the recognition of facial expressions and they require various cognitive resources, which imply that the specific requirements of each task will determine, in part, the results. For example, in a study [36] on explicit emotional processing carried out on young people and elderly patients with AD, interference by a secondary task (an additional visual stimulus) seems to deteriorate the performance of the participants when identifying EFEs. While this was common to both groups of participants, AD patients have the worst outcome.

More recent research showed that the complexity of an emotional stimulus evoked by an EFE influences the ability to process it [37,38]. There are two variables that define this complexity: (1) the facial information that characterizes each basic emotion; and (2) the intensity to which the emotion can be manifested. EFEs with negative valence are generally more difficult to identify [39,40], possibly because they are more complex from a behavioral standpoint than stimuli like happiness, requiring more actions or facial muscle movements according to the Facial Action Coding System (FACS) [41–43]. Little is known about how the intensity of expressions affects the processing of EFEs. It was suggested that older people perceived EFEs worse than younger people when these expressions were weak [44], with older subjects benefitting more when the intensity of the EFEs of anger, fear and sadness increased. Other similar studies also suggest that intensity is important when identifying facial expressions [45–47].

Considering the above, the main objective of this work was to study the possible deficiencies that people with MCI present in the emotional processing of EFEs with distinct characteristics. We worked with the six basic emotions and the five levels of intensity defined by FACS [41,42], studying their recognition in two groups of subjects: healthy elderly individuals and elderly people with MCI. We hypothesized that the correct processing of a particular emotional expression depends partly on the complexity of the emotion. Therefore, people with MCI would perform worse when the identification of the EFE was more complicated, i.e.: those with the largest number of Units of Action (UAs) or those that are less intense. To our knowledge, a combined analysis of the role of stimulus features in processing EFEs has yet to be performed on individuals with MCI. Hence, the results of this work may contribute towards better understanding of the emotional deficits that may accompany MCI, an underappreciated problem that has an important impact on the patients' quality of life.

2. Methods

2.1. Participants

A total of 100 subjects participated in these experiments, divided into 2 groups with a homogeneous sex (50% men and 50% women) and age (between 65 and 80) distribution: 50 healthy elderly individuals and 50 elderly individuals with MCI. The group of healthy elderly individuals was recruited in a randomized manner at a health center and at four homes for the elderly in Santander, Spain. The group of elderly MCI subjects was recruited consecutively at the Memory Clinic of University Hospital "Marqués de Valdecilla" (Santander, Spain).

Patients with MCI were diagnosed by a neurologist and all of them initially fulfilled the Petersen criteria for MCI [1,9]. These patients underwent a complete clinical and neuropsychological evaluation at baseline and one year later. General cognitive function was assessed using the MMSE, data on activities of daily living were collected using the Interview for Deterioration in Daily living activities in Dementia (IDDD), and symptoms of depression were measured using the Hamilton Rating Scale for Depression. The neuropsychological battery employed included tests to assess: memory (California Verbal Learning Test—CVLT), language and semantic memory (15 items short-form of the Boston Naming Test, category fluency), praxis and visuospatial skills (Rey complex figure copy and WAIS block design subtest), and attention and executive function (Symbol Digit Modalities Test, Trail Making part A and B, Stroop interference Test, Frontal Assessment Battery, category and letter fluency). A cognitive domain was considered to be impaired when subjects scored 1.5 SD below the values for age and education matched controls in at least one test. According to the results of the neuropsychological exploration, MCI subjects were classified as: 1) pure amnestic MCI (a-MCI), patients fulfilling Petersen's criteria for amnestic MCI with memory being the only domain affected (27%); 2) multidomain MCI (md-MCI), patients fulfilling a-MCI criteria and with performance in one or more non-memory domain below the cut-off value (60%); and 3) non-amnesic MCI (na-MCI), patients with intact memory performance but scoring below the cut-off score in one or more non-memory tests (13%).

The following factors were used as inclusion criteria for either group: 1) Mini-Mental State Examination (MMSE), scores >27 points for the healthy elderly individuals and ≤26 points for the elderly MCI subjects; 2) Geriatric Depression Scale of Yesavage (GDS) <7 points for either group; 3) Blessed Dementia Scale (BDS) <4 points for either group; and 4) all participants must sign an informed consent form prior to inclusion.

The exclusion criteria for both groups were: 1) suffering from a neurodegenerative disease such as dementia (DSM-IV), AD (NINCDS-ADRDA), or a depressive episode (IDC-10); 2) subjects with significant cerebrovascular disease (Hachinski scale score ≥4); 3) suffering from an acute or chronic diseases not under medical supervision; 4) receiving drug treatment that could affect cognitive ability at the time of the study, such as neuroleptics, antipsychotics, and anxiolytics; 5) diagnosed with major depression; 6) alterations in functional capacity; 7) sensory deficits that impede carrying out the tasks of the study (visual and auditory capacity and ability to respond verbally); 8) inability to attend the consultancy, hold a conversation or read clearly the task instructions; and 9) not having signed the informed consent form.

To verify the compliance with the criteria, we analyzed the descriptive data of both groups, and all subjects met the criteria for inclusion and exclusion. There were no significant age differences between the two groups ($t(98) = -2.24$, $p > 0.05$). Table 1 shows the sociodemographic characteristics and the MMSE, GDS and BDS test scores for each group.

2.2. Experimental tasks

To assess the individual's ability for emotional processing, we used a forced-choice task in which participants had to identify the emotion expressed by a face, choosing one of six possible answers: happiness, sadness, anger, surprise, fear or disgust. Each trial began by presenting a white cross on a black background in the center of a computer screen for 1500 ms after which an audible signal was emitted for 150 ms at a frequency of 500 Hz. Subsequently, an EFE was presented for 1500 ms, followed by a black screen for another 600 ms. The participants then had to identify aloud the emotional expression shown on the face from

Table 1
The sociodemographic characteristics and also the scores obtained in the MMSE, GDS and BDS tests carried out on the two groups of subjects.

	Healthy elderly	MCI elderly	
	M (DT)	M (DT)	t (p)
Age	75.36 (5.47)	77.86 (5.66)	−2.24 (0.271)
Years of education	8.04 (3.75)	6.38 (2.40)	2.63 (0.103)
MMSE	29.52 (0.93)	23.08 (2.17)	19.25 (0.00)*
GDS	0.42 (0.90)	1.34 (1.63)	−3.47 (0.001)*
BDS1	0.050 (0.20)	0.23 (0.44)	−2.60 (0.011)*
BDS2	0.12 (0.52)	0.20 (0.40)	−0.858 (0.393)
BDS3	0.01 (0.07)	0.02 (0.09)	−0.581 (0.562)

* Statistical significance at $p < 0.05$.

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