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PERCEPTION OF EMOTIONS IN MILD COGNITIVE IMPAIRMENT AND ALZHEIMER'S DEMENTIA: DOES INTENSITY MATTER?

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Abstract

Background: To provide a review of the literature on the perception of emotion in Alzheimer's dementia (AD) and Mild cognitive impairment (MCI), and to evaluate if emotion intensity matters.

Methodology: A systematic literature search of PubMed database was carried out using combinations or truncated versions of the keywords "MCI", "Alzheimer", "emotion recognition", "facial emotion recognition", "social cognition" or "emotion perception". Twenty-eight articles were found to meet the inclusion criteria.

Results: Overall, AD patients performed worse on emotion perception than MCI patients and healthy controls. Half of the studies found an emotion-specific deficit for MCI patients on the emotions anger, sadness and fear. However, studies taking emotion intensity into account are still scarce.

Conclusions: An emotion-intensity based approach may be more sensitive to detect subtle impairments in facial emotion recognition. Future studies need to take emotion intensity into account and also consider confounding factors such as overall cognition and mood.

Keywords

• Emotion perception • Social cognition • Dementia • Face perception • Mild cognitive impairment

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Introduction

Dementia due to Alzheimer's disease (AD) is characterized by severe cognitive dysfunction in at least two cognitive domains, such as impaired ability to acquire and remember new information, impaired reasoning and handling of complex tasks, impaired visuospatial abilities or impaired language functions, which hampers everyday functioning [1]. Mild cognitive impairment (MCI) reflects the pre-dementia stage of AD, in which cognitive deficits and neurodegeneration are already present, but are not yet severe enough to meet the dementia criteria. The current articulation of the concept of MCI thus reflects an intermediate stage of cognitive impairment and is considered a transitional phase from cognitive changes of normal ageing to those typically found in dementia. It is characterised by a poorer performance in one or more cognitive domains than would be expected based on the patient's age and educational level, with unimpaired activities of daily living (i.e., no dementia) [2]. A further distinction between amnestic MCI (aMCI), non-amnestic MCI (naMCI) and single or multiple-domain MCI can be made, with the amnestic subtypes most likely progressing to Alzheimer's dementia.

In addition to cognitive impairments, neuropsychiatric and behavioural symptoms such as depressive mood, anxiety, hallucinations, delusions or apathy are common in patients with Alzheimer's dementia. The origin and nature of these behavioural impairments, like agitation, depression, wandering and aggression, are unclear, but have been linked to impaired emotional processing, in particular to deficits in the ability to perceive and recognize the affective state of others [3]. However, it is still unknown whether these defects in emotion perception are the result of AD, or related to nonspecific mood effects. Philips *et al.*, for instance, found that older adults with a mood disorder were mildly impaired in identifying emotional expressions compared to healthy elderly [4]. Hortnagl *et al.* reviewed the literature and showed that deficits in social cognition are linked to depressive symptoms [5]. Since about half of the patients with AD present with depressive symptomatology, it is important to take mood into account.

Philips *et al.* identified three processes important for affective processing: 1) identification of the emotional significance of a stimulus; 2) production of an affective state in response to this identification; and 3) regulation of the affective state [6]. Recognition of emotional expressions is considered an important prerequisite for interpersonal functioning and quality of life. This ability can be examined by presenting photographs of faces expressing the six universal emotions: happiness, sadness, fear, anger, disgust and surprise [7]. Emotion perception has been shown to rely on a ventral affective system, including the amygdala, insula, ventral striatum, and ventral regions of the anterior cingulate gyrus and prefrontal cortex [6]. Regions in this ventral system, including the amygdala, are also susceptible

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to atrophy already in the MCI stage [8]. Indeed, a recent review by McCade *et al.* shows that emotion processing in MCI is compromised [9]. There is at least some evidence suggesting that negative emotions are more compromised, but the research is limited and the variability in findings is large [9].

Very few studies have examined the effect of varying the intensities of facial emotional expressions. Most studies have used full-blown emotional expressions, which may result in near-ceiling performances that may obscure actual differences between AD, MCI and healthy controls. Possibly, the performance of MCI or AD patients on a facial emotion recognition task is influenced by the intensity of facial expressions.

In addition, many studies suffer from methodological inconsistencies (e.g., small sample sizes, lack of a matched control group and the extent in which potentialy confounding factors like facial processing, disease severity and visuospatial deficits are taken into account). A review by McLellan *et al.* on the recognition of facial emotional expressions in AD patients concluded that these patients recognized facial expressions worse than healthy controls, with particular difficulties in the perception of sad expressions [10]. In addition, a longitudinal study showed a decline in the recognition of emotion with the progression of the disease in all patients with AD, a finding which was not related to changes in global cognitive scores [11].

Although these findings are relevant, improvements in future research design are needed [9,10]. One recommendation is that more ecologically valid facial displays of emotion - such as more subtle emotional expressions or dynamic stimuli – are required. Also, the performance on emotion perception tasks should be related to real-life interpersonal behaviour and social functioning. This review extends and updates previous reviews on this topic, as we are the first to directly compare the findings in MCI and AD.

Methods

Criteria for study inclusion

Only studies comparing emotion recognition in patients with AD and/or MCI to older adults without cognitive impairments were included. Emotion recognition was defined as the ability to recognize and label emotional facial expressions using either static or dynamic facial stimuli (i.e., morphs). We chose not to include studies using video clips depicting full-body people showing emotions or emotional events to minimize the methodological differences. Reviews, editorials, letters or other articles that did not contain original data were excluded as well.

Electronic search and data extraction

A systematic literature search using the PubMed database (last search completed on April 1, 2015) was carried out using combinations or truncated versions of the keywords "MCI", "Alzheimer", "emotion recognition", "facial emotion recognition", "social cognition" or "emotion perception". Only papers published in English were reviewed. Studies lacking healthy controls were excluded. Case reports, reviews and editorials were only included if they provided empirical data. For each study included in the review, a manual search of the reference list was also conducted to identify additional studies. Effect sizes (Cohen's *d*) were computed for each study based on the available data comparing AD or MCI patients with controls.

Results

Based on these criteria, the initial search identified 44 articles. The title and abstract of each reference were examined to investigate whether it would meet the inclusion criteria. If so, the full papers were read and compared to the inclusion criteria. Fifteen additional articles were identified from the reference lists. After the full text of each article had been examined, 28 articles were found to meet the inclusion criteria. Table 1 lists the studies that were included.

Participant characteristics

Diagnosis of possible or probable Alzheimer's disease in seventeen studies were made according to criteria of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimers Disease and Related Disorders Association (NINCDS/ADRDA) [4,12,13,15-17,19,21,23,25,27,28,31,33,35,38,39], or based on the DMS-IV TR criteria [18,22,24,31]. Other studies also used biomarkers [14] or a geriatric evaluation [18] and in one study the specific criteria used to isolate possible or probable AD were unclear [26]. Inclusion criteria for MCI were consistent with the Petersen criteria [40] in 10 articles [13,20,24,29,30,32,35,36,37,39]. Some studies encompassed a more heterogeneous perspective, in line with the modified criteria of Peterson *et al.* [40] including MCI participants with deficits in multiple cognitive domains [29,30,36,39]. One study [24] did not report a differentiation of MCI subtypes in the sample.

Control participants included informal caregivers of the AD patients [15,25,26], spouses [25], other relatives [4,39], community-based healthy elderly [4,15,16,17,19,24,25 ,29,30,35,38,39], non-demented patients from (neurological) hospitals [13,22,34,37], outpatient clinics [22,23], research centres [36], paid volunteers [20] or residents of a long-term care facility [12,33]. In some studies the control group was not specified [14,18,21,27,28,31,32]. Control participants were included if they had no history of cognitive decline. In all but three studies [12,17,28], the MMSE score [41] was a key part of the neuropsychological evaluation.

Groups were generally matched on level of education [14,17,18,23-27,29,30,32,33], age [13,14,16,18,23-33,36,39] and sex [13,23,24,26,27,29,31,32,33,36]. One study also matched a semantic dementia patient group with an AD patient group on Clinical Dementia Rating (CDR) scores and frontotemporal dementia (FTD) rating scale scores [25] and another study matched participants on depressive symptoms and attentional performance [39]. Four studies had a significantly older patient group compared to the controls [21,22,26,38] and one study had a control group with higher levels of education [4].

Various exclusion criteria were applied across studies, including prosopagnosia, profound visual or hearing deficits, psychiatric or neurological disorders, and history of substance abuse. Some studies used additional exclusion criteria, such as use of some types of medication [13,15,16,20,32], intellectual

Table 1. Characteristics of the studies examining emotion perception in MCI and AD.

Author	Year	Subjects characteristics			Emotional tasks	Emotions	(Control) Tasks	Results	Effect sizes (Cohen's d)
		AD	MCI	HC					
Albert *et al.* [12]	1991	N: 19 A 89.6; G 21% M;		N: 19 A 87.5; G 31.6% M	FEEST	Hap, Sad, Ang, Indif	Cognitive Abilities Screening Test, MDRS, standard neuropsychological testing	AD < HC: labelling	-1.48
Bediou *et al.* [13]	2009	N: 10 A 72±9; G 50% M; MMSE 21±2	N: 10 A 73±9; G 50% M; MMSE 27±2	N: 10 A 70±6; G 50% M; MMSE 30	Morphed photographs	Hap, Fear, Ang, Dis, Neu	RL/RI-16 test; TMT B; Verbal fluency; picture naming task; BDI; facial gender task	AD < HC: overall, Ang aMCI = HC (overall); AD < HC 60% morphing intensity	-1.09 -0.76 -0.34 0.99
Bertoux *et al.* [14]	2014	N: 33 A 71.6±9.9; G 48.48% M; MMSE 24.2±2.9		N: 30 A 66.2±9.9; G 43.33% M; MMSE 29±0.9	FEEST	Hap, Sad, Fear, Ang, Sur, Dis, Neu	Frontal Assessment Battery	AD < HC: overall, Hap; Sad; moderate AD < HC: Hap; Dis; Sur; Ang; Sad; Moderate AD < mild AD: Ang Sad	-0.89 -0.45 -0.64 -0.86 -0.80 -0.85 -0.81 -1.42 -0.98 -1.38
Bucks & Radford [15]	2004	N: 12 A 75.5±7.5; G 33.33% M; MMSE 18.8±2.9		N: 12 A 74.4±7.1; G 58,33 % M; MMSE 28±1	FAB	Hap, Sad, Ang, Fear	Facial identity discrimination	AD < HC: total FAB score; Facial affect selection AD = HC: facial affect naming	-2.11 -1.13 -0.40
Burnham *et al.* [16]	2004	N: 13 A 76±8; G 61.5% M; MMSE 21±7.3		N: 13 A 73±5 G 76.9% M; MMSE 29±.08	FEEST	Hap, Sad, Fear, Ang, Dis, Sur	CAMDEX, expression matching	AD = HC	No data available
Cadieux & Greve [17]	1997	N: 8 low spatial A 75.9±6.5; G 12.5% M N: 10 low verbal A 77.6±5.5; G 20% M;		N: 15 A 69.1±4.9; G 6.67% M;	FAB	Hap, Sad, Ang, Fear, Neu	BNT, WISC-R Block Design, MDRS	Low spatial AD<HC: Facial affect selection Discrimination Affect naming Low verbal AD<HC: Facial affect selection Discrimination Affect naming	 3.06 2.08 0.02 -1.62 -1.76 -1.42
Drapeau *et al.* [18]	2009	N: 7 A 74±9; G 42.9% M; MMSE 23.3±4		N: 16 A 72±6; G 31.25% M; MMSE 27.9±1.0	FEEST	Hap, Sad, Fear, Ang, Sur, Dis		AD < HC: Sad Fear Dis	-0.99 -0.83 -0.99
Fernandez-Duque & Black [19]	2005	N: 9 A 70.1±7; G 55.5% M; MMSE 24.8±2.0		N: 10 A 65.1±8.4; G 40% M; MMSE 29±0.7	FEEST	Hap, Sad, Fear, Ang, Sur, Dis	Neuropsychological assessment, Cornell Scale, NPI, BFRT	AD = HC labelling	0.00

continued Table 1. Characteristics of the studies examining emotion perception in MCI and AD.

Author	Year	Subjects characteristics			Emotional tasks	Emotions	(Control) Tasks	Results	Effect sizes (Cohen's d)
		AD	MCI	HC					
Fuije *et al.* [20]	2008		16 aMCI A 71.7±7.1; G 25% M; MMSE 27.2±2.3	14 HC A 74.1±3.2; G 28.57% M; MMSE 28.8±1.4	FEEST	Hap, Sad, Fear, Ang, Sur, Dis, Neu	ADAS, BFRT, logical memory WMS-R	aMCI < HC: overall, Ang Sad	-0.88 -0.85 -0.98
Freedman *et al.* [21]	2013	N: 21 A 71.6±13.3; G 57% M; MMSE 24.6±3.4		N: 31 A 65±11; G 47.6% M; MMSE 29.1±0.9	FEEST	Hap, Sad, Ang, Neu	BFRT, WCST	AD = HC	-0.18
Guaita *et al.* [22]	2009	N: 79 A 80±8; MMSE 14.28±5.33		N: 64 A 76±7; MMSE 27.83±3.35	7 male and 7 female faces	Hap, Sad, Fear, Dis, Bored, Ang, Sur	CDR, BI	AD = HC	No data available
Hargrave *et al.* [23]	2002	N: 22 A 74±8.8; G 54.5% M; MMSE 18.4±4.4		N: 14 A 68±6.1; G 28.6% M MMSE 29.1±1.4	Facial Emotion Matching, Facial Emotion Labelling, Same-different Emotion Differentiation	Hap, Sad, Fear, Ang, Sur, Dis	BFRT, HDS, STAI	AD < HC: overall Sad Sur Dis	-1.38 -1.08 -0.71 -0.87
Henry *et al.* [24]	2009	N: 34 A 79.4±6.12; G 47% M; MMSE 26.0±3.6	N: 38 A 78.7±4.53; G 50% M MMSE 27.9±1.5	N: 34 A 77.2±4.3; G 44% M MMSE 28.6±1.4	FEEST	Hap, Sad, Fear, Ang, Sur, Dis	Verbal Fluency, TMT	AD < MCI: overall AD < HC: overall Hap best recognized, then Sur, Sad, Dis, Ang, and Fear lowest.	-0.90 -1.59
Hsieh *et al.* [25]	2012	N: 12 A 62.9±8.2; G 75% M; MMSE 24.8±3.4		N: 20 A 66.5 ± 7.2; G 65% M; MMSE 29.2±0.9	FEEST	Hap, Sad, Fear, Ang, Sur, Dis	ACE-R, BNT-15, MBEA-scale, Animal Fluency, RCFT-copy	AD=HC	No data available
Kohler *et al.* [26]	2005	N: 20 A 75.9 ± 9.1; G 55% M; MMSE 22.7±4.2		N: 22 A 69.4 ±7.6; G 42.9% M; MMSE 29.5±0.9	Penn Emotion Recognition Test PEAT	Hap, Sad, Ang, Fear, Neu	Emodiff	AD < HC: overall Hap Sad Fear AD = HC: Ang Neu higher intensity, better recognition (no group effects)	-1.43 -0.66 -1.21 -1.02 -0.52 -0.62
Lavenu *et al.* [27]	2005	N: 20 A 70.7 ± 6.0; G 20% M; MMSE 22.9±3.2		N: 12 A 65.7.4 ±6.9; G 50% M; MMSE 29.5±0.5	FEEST	Hap, Sad, Fear, Ang, Sur, Dis, Cont	MDRS, neuropsychological battery	AD = HC: overall AD < HC: Fear Cont	-0.90 -0.89 -0.98
Maki *et al.* [28]	2013	N: 12 A 81.1 ± 9.2		N: 17 A 76.8 ± 3.5	Coloured face images, averaged by morphing	Hap, Sad, Fear, Ang, Sur, Dis	GDS – short form	AD < HC: Sad Sur Ang	-0.89 -0.83 -2.39

continued Table 1. Characteristics of the studies examining emotion perception in MCI and AD.

Author	Year	Subjects characteristics			Emotional tasks	Emotions	(Control) Tasks	Results	Effect sizes (Cohen's d)
		AD	MCI	HC					
McCade *et al.* [29]	2013		N: 19 aMCI A 69.63 ± 7.25 G 58.33% M MMSE 26.9±1,8 N: 18 naMCI A 63.78 ± 8.2 G 38.89% M MMSE 28.6±1.2	N: 19 A 64.79 ± 8.45 G 47,47% M MMSE 29.3±0.8	FEEST, emotion identification task, movie stills task	Hap, Sad, Fear, Ang, Sur, Dis	Digit Span, Logical Memory (WAIS-III), RCFT, semantic fluency, BNT, TMT A&B, COWAT, BFRT	aMCI < HC: Ang	-0.95
McCade et. al. [30]	2013		N: 29 aMCI A 68.97 ± 7.30 G 41,37% M MMSE 27.2±1.8 N: 27naMCI A 64.48 ± 8.53 G 48,15% M MMSE 28.6±1.4	N: 22 A 65,18 ± 8.37 G 40,41% M MMSE 29.3±0.8	FEEST	Hap, Sad, Fear, Ang, Sur, Dis	WTAR, HDS, BFRT, neuropsychological tests, WHODAS-II, ZBI	aMCI < naMCI: Ang aMCI < HC: Ang	-0.63 -1.02
Ogrocki *et al.* [31]	2000	N: 17 A 73.9 ± 7.8 G 41% M MMSE 21.8±3.8		N: 15 A 72.7 ± 4.1 G 33% M MMSE 29.2±0.7	FEEST	Hap, Sad, Ang, Neu	Complete neuropsychological assessment, Lighthouse Near Visuel Acuity Chart, Pelli-Robson Contrast Sensitivity Chart 4K	AD = HC	-0.27
Phillips *et al.* [4]	2010	N: 27 A 74.37±9.03 G 44.44% M MMSE 22.1±4.2		N: 30 A 72.97±7.51 G 30% M MMSE 29.4±1	FEEST	Hap, Sad, Fear, Ang, Sur, Dis	GDS-15, QoL-AD; BFRT, Letter fluency, Stroop	AD < HC: overall 100%: Sad, Ang Sur Fear 75%: Hap Sad Fear Ang Sur Dis	-1.19 -0.55 -0.78 -0.55 -0.73 -0.69 -0.65 -0.55 -0.84 -0.93 -0.68
Richard-Mornas *et al.* [32]	2012		N: 12 A 68.5±5.3; G 41.7% M; MMSE 26.4±1.3	N: 17 A 70±5.3; G 58.8% M; MMSE 30±0.7	Morphed faces Bediou et al. [16]	Hap, Ang, Fear, Neu	BFRT, Apathy Evaluation, GDS - short form	aMCI < HC: Fear	1.02
Roudier *et al.* [33]	1998	N: 31 A 80.47±8.94; G 6.45% M; MMSE 16.2±1.7		N: 14 A 81.07±7.09; G 7.14% M; MMSE 26.07±1.79	FEEST	Hap, Sad, Ang, Indif	Raven's Progressive Matrices	AD < HC: discrimination of facial identity; verbal identification of emotions AD = HC: discrimination of emotional expression	-0.83 -0.74 -0.15

continued Table 1. Characteristics of the studies examining emotion perception in MCI and AD.

Author	Year	Subjects characteristics			Emotional tasks	Emotions	(Control) Tasks	Results	Effect sizes (Cohen's d)
		AD	MCI	HC					
Shimokawa *et al.* [34]	2000	N: 25 A 80.2±6.5; G 24% M; MMSE 13.0±4.4		N: 12 A 76.5±4.5; G 41.67% M; MMSE 28±1.3	Drawings of emotional faces and emotional situations	Ang, Hap, Sad, Sur	Figure identification task	AD < HC: overall	-1.74
Spoletini *et al.* [35]	2008	N: 50 A 72.68±6.89; G 50% M; MMSE 22.0±3.3	N: 50 A 71.2±7.49; G 54% M; MMSE 26.7±2.5	N: 50 A 71.84±7.35 G 44% M; MMSE 27.8±1.8	Penn Emotion Recognition Test (8 low and 8 high intensity of each emotion)	Hap, Sad, Ang, Fear, Dis, Neu	MDB, RCFT; BFRT, Stroop	AD < aMCI & HC: Hap Sad Ang Fear AD < HC dis aMCI = HC all emotions High intensity: AD < HC: Hap AD < aMCI & HC: Sad Ang, Fear aMCI = HC. Low intensity: AD < aMCI & HC: Hap Sad AD < HC: Dis Fear	 -0.55 -0.60 -0.71 -0.62 -0.43 -0.07 – -0.35 -0.36 -0.53 -0.82 -0.74 -0.60 -0.48 -0.42 -0.41
Teng *et al.* [36]	2007		N: 9 aMCI A 79.4±3.8; G 77.8% M; MMSE 26.9±2.8 N: 14 naMCI A 72.8±7.7; G 50% M; MMSE 26.4±2.7	N: 68 A 69.5±9.5; G 57.4%M; MMSE 29.2±0.9	FAB	Hap, Sad, Ang, Fear	Facial identity discrimination task	naMCI<aMCI & HC aMCI = HC	-0.54 no data available
Varjassyová *et al.* [37]	2013		N: 10 aMCI A 74.0 ± 5.0 G 30% M MMSE 28.4±1.8 N: 12 naMCI A 77.8 ± 10.0 G 50% M MMSE 26.8±2.3	N: 18 A 69.3 ± 7.6 G 33.3% M MMSE 29.3±0.9	FEEST	Hap, Sad, Fear, Ang, Dis, Sur	Famous faces identification, GDS, Hachinski Ischemic Scale, neuropsychological evaluation	naMCI < aMCI: overall naMCI<HC overall	-1.33 -1.25
Wiechetek Ostos *et al.* [38]	2011	N: 12 A 80.6±6.3 G 41.7% M MMSE 23.4±3.2		N: 12 A 70.5±6.0 G 16.7% M MMSE 29.7±0.5	Multimodal Emotion Recognition Test	Hap, Sad, Fear, Ang, Dis	CDR, cognitive assessment, HDS, NPI, Questionnaires	AD < HC: overall Dis Fear	-1.27 -1.49 -1.20

continued Table 1. Characteristics of the studies examining emotion perception in MCI and AD.

Author	Year	Subjects characteristics			Emotional tasks	Emotions	(Control) Tasks	Results	Effect sizes (Cohen's d)
		AD	MCI	HC					
Weiss *et al.* [39]	2008	N: 32 Early AD A 76.7±8.0 G 31.25% M MMSE 22.5±1.5	N: 21 MCI-SD A 72.8±6.5 G 28.57% M MMSE 27.0±1.0	N: 35 A 70.8±7.5 G 28.57% M MMSE 28.9±1.0	Penn Emotion Recognition Test	Hap, Sad, Ang, Fear, Neu	GDS	MCI-SD=MCI-MD; MCI-SD=HC; MCI-MD < HC: overall Sad Fear Neu Early AD < HC: overall sad fear neutral	 -1.34 -0.71 -0.75 -1.38 -1.39 -0.74 -1.04 -0.69
		23 Moderate AD A 80.1±6.2 G 30.43% M MMSE 16.3±2.7	30 MCI-MD A 74.3±7.0 G 33.33% M MMSE 26.0±1.1					Moderate AD < HC: overall Hap Sad Fear Neu	-1.87 -1.04 -0.98 -1.48 -1.40

A = Age; ACE-R = Addenbrooke's Cognitive Examination – Revised; AD = Alzheimer's dementia; aMCI = Amnestic MCI; BDI = Beck Depression Inventory; BFRT = Benton Facial Recognition Test, BI = Bartel Index; BNT = Boston Naming Test; CAMDEX = Cambridge Mental Disorders of the Elderly Examination; CDR = Clinical Dementia Rating Scale; CI = cognitive impairment; COWAT = Controlled Oral Word Association Test; MDRS = Mattis Dementia Rating Scale; FAB = Florida Affect Battery; FEEST = Facial Expressions of Emotion: Stimuli and Tests; G = Gender,; GDS = Geriatric Depression Scale; HC = healthy controls; HDS = Hamilton Depression Rating Scale; M= Male, MCI-SD = MCI single domain, MCI-MD = MCI multi domain, MDB = Mental Deterioration Battery; MMSE = Mini Mental State Examination; naMCI = Non-amnestic MCI; NPI = Neuropsychiatric Inventory; STAI = State-Trait Anxiety Inventory; TMT = Trail Making Test; PEAT = Penn Emotion Acuity Test; RCFT = Rey Complex Figure Test; WCST = Wisconsin Card Sorting Test ; WISC-R = Wechsler Intelligence Scale for Children-Revised

disability [29], inability to comprehend task instructions [23], abnormal vitamin B12, rapid plasma reagin and/or thyroid function tests [36], scores lower than 110 on the Dementia Rating Scale [17], or less than 100 [27], scores higher than five [37] or seven [28] on the Geriatric Depression Scale and lack of a reliable caregiver [35].

Emotional stimuli

In all of the studies participants were asked to discriminate, label, identify or match a range of facial emotional expressions to photographs or cartoons. Most research was performed using static stimuli from the Ekman and Friesen "Pictures of Facial Affect" series [4,12,14,16,18-21,24,25,27,29,30,31,33,37]. Others used the Florida Affect Battery [15,17,36]. Spoletini *et al.* [35] used the Penn Emotion Recognition Test, as well as Weiss *et al.* [39]. Hargrave *et al.* used standardized photographs from the Japanese and Caucasion Facial Expressions of Emotion [23]. Some researchers developed their own stimuli [13,22,28]. Richard-Mornas *et al.* [32] used faces from the database of Bediou *et al.* [13]. Shimokawa *et al.* used drawings of emotional faces or emotional situations [34]. Most studies used simple facial images, but some used morphed facial images [4,13,32].

Not all of the studies included all six basic emotions. Facial expressions of happiness and anger were examined in all studies. Only ten studies included neutral expressions [13, 14,17,20,21,26,31,32,35,39], all studies except two [13,32] included facial expressions of sadness, all but five [12,21,31,33,34] used fear, 18 used disgust [4,13,14,16,18,19,20,22-25,27-30,35,37,38], and 17 used surprise [4,13,14,16,18,19,20,22-25,27-30,34,37]. Only four studies used other emotions than the six universal emotions: two studies [12,33] included 'indifferent' facial expressions, one study used bored [22] and one used contempt [27].

Only four studies incorporated emotional stimuli that varied in emotional intensity [4,13,26,35]. All other studies used full-blown facial emotional expressions.

Control tasks

The most frequently used control task to account for overall face perception was the Benton Facial Recognition Task [4,19-21,23,29,30,32,35]. Some researchers chose to use other facial control task, such as a Facial Gender task [13], Facial Identity Discrimination task from the Florida Affect Battery [15,17,36], expression matching [16,18], and the Emodiff [26]. Ogrocki *et al.* used the Lighthouse Near Visual Acuity Chart and the Pelli-Robson Contrast Sensitivity Chart 4K to examine visual acuity and contrast sensitivity [31]. Varjassyová *et al.* used famous faces that had to be identified as such [37].

Lavenu *et al.* designed an emotion detection task based on the Ekman and Friesen photographs in which participants had to indicate which face out of two showed an emotional expression [27]. Albert *et al.* [12], Fernandez-Duque [19], and Roudier *et al.* [33] used a similar task, in which participants had to decide whether two facial expressions showed the same emotion or different emotions. While these matching tasks also measure emotion perception, they do not require verbal labelling of individual emotions. As a result, we did not consider these as the primary outcome measure but as control tasks.

Synthesis of findings

Six studies [16,21,22,25,27,31] found no significant difference in overall performance for AD patients relative to healthy controls. Thirteen studies found significant

differences in overall performance for AD patients relative to healthy controls [4,12-15,17,23,24,26,34,35,38,39]. Fernandez-Duque and Black did not find significant differences between AD patients and healthy controls on labelling emotions, but they reported a worse performance on a task in which participants had to indicate whether a pair of faces depicted the same or a different emotion [19]. In contrast, Roudier *et al.* found a worse performance in the AD group on emotion labelling, but unimpaired emotion discrimination [33]. Emotion-specific deficits were reported in AD patients for recognizing anger [4,13,14,28,35], sadness [4,14,18,23,26,28,35,39], surprise [4,14,23,28], disgust [14,18,23,35,38], happiness [14,26,35,39], fear [4,18,26,27,32,35,38,39,] and contempt [27].

From the seven studies that examined aMCI patients, only one reported MCI patients performing worse overall compared to healthy controls on emotion perception [20]. In four of the seven studies emotion-specific deficits were reported in MCI participants in recognizing anger [20,29,30], sadness [20] and fear [32]. A study of McCade *et al.* revealed that impaired emotion recognition in aMCI patients extended beyond facial emotion recognition [29]. aMCI patients were also less accurate in their ability to use nonfacial, peripheral cues (i.e., head and body posture and hand gestures) to recognize the emotional content of scenes, compared with healthy aged-matched controls. Four studies examining aMCI patients [13,35,36,39] did not find deficits in emotion perception compared to controls. However, two of these studies [36,37] showed that non-amnestic MCI patients performed significantly worse than aMCI patients and healthy controls. Finally, studies which compared MCI patients to AD patients directly [13,35] showed that AD patients performed worse than the MCI patients.

Emotion recognition and mood

Only a small number of studies have assessed depressive symptoms, either using the Geriatric Depression Scale [4,28,32,37,39], the Cornell scale for depression [19] or the Hamilton Depression Rating scale [23,30,38]. Maki *et al.* [28] excluded participants who scored more than 7 on the short form of the Geriatric Depression Scale and Varjassyová *et al.* [37] excluded participants who scored higher than five.

Phillips *et al.* reported that older adults with mood disorders, but without cognitive impairments, had mild deficits in identifying facial expressions of emotion but were not biased toward particular negative emotions when evaluating faces [4]. Also, problems in the ability to identify emotions correlated with self-rated quality of life in older adults. Weiss *et al.* found that depression was significantly associated with poorer recognition of overall emotion and neutral faces, but depression was not found to act as a moderator or mediator variable [39]. McCade *et al.* did not find significant associations between emotion recognition and depressive symptoms in MCI patients [30]. Despite the fact that depressive disorders may affect emotion perception, these cannot explain the pattern in emotion perception that is seen in patients with MCI or AD.

Only a few studies have related emotion recognition to everyday social functioning (e.g., quality of life [4] and caregiver burden [30]). McCade *et al.* found that the burden of MCI caregivers was significantly associated with worse recognition of anger in the MCI patients themselves, and worse anger recognition was significantly associated with increased difficulties in "getting along with others" as perceived by their caregivers [30]. One study found evidence that impaired emotion recognition affects quality of life in patients with AD [4].

Face perception and overall cognition

Some of the studies did not include a non-emotional face-processing control task [12,14,18,25,28,39]. From the 21 studies that included a face-processing control task, six found no significant differences between AD patients and controls [13,16,17,21,27,33] or MCI patients and controls [13,37]. Burnham *et al.* stated that it is unclear whether the problems in processing facial expressions of emotions originate from deficiencies secondary to other cognitive processing problems [16]. However, Bediou *et al.* found no significant correlation between cognitive performance and emotion recognition performance [13]. In addition, Shimokawa *et al.* adjusted the emotion perception performance for general cognitive and visuoperceptual deficits [34]. They still found deficits in the ability to recognize emotions in AD patients. They also did not find a correlation between the MMSE score and the performance on emotion recognition tasks in patients with AD. Furthermore, Fernandez-Duque and Black showed that impaired performance on the emotion recognition task could not be explained by a general cognitive decline, because AD patients were equally impaired in cognitive tasks as the FTD group, yet emotion perception in the AD group was superior to that of the FTD patients [19].

In contrast, Albert *et al.* showed that when performance on the perception of affect tasks was adjusted for the severity of the overall cognitive deficits, none of the affective perception tests differentiated the AD patients and the healthy controls [12]. Wiechetek Ostos *et al.* found that the CDR score significantly predicted face emotion recognition [39]. The results of Bertoux *et al.* showed that MMSE scores were significantly correlated with the performance on their facial emotion recognition task in AD [14]. As a result, overall cognitive impairment and severity of the dementia are important to take into account when assessing facial emotion recognition in AD.

Does emotion intensity matter?

Only four studies have examined the effect of different emotion intensities [4,13,26,35]. Three of them reported specific effects of emotion intensity [4,13,35]. Phillips *et al.* found that at 100% intensity sadness, anger, fear and surprise were poorly recognized by AD patients, whereas at 75% intensity AD patients also showed deficits in recognizing happiness and disgust [4]. Bedoui *et al.* showed that aMCI patients performed at the same level as healthy controls at higher intensities of emotions and similar to mild AD patients when emotional expressions were more subtle (i.e., presented at lower intensities) [13]. Spolettini *et al.* also reported that aMCI patients only differed from healthy controls on the low-intensity fearful

faces, but not on the high intensity faces [35]. This finding highlights the importance of using low-intensity emotional faces, rather than only focusing on full-blown emotional expressions. In addition, low-intensity facial expressions may also be encountered more frequently in daily life, making these stimuli more ecologically valid.

Discussion

This review provides an analysis of the literature on emotional processing impairments in MCI and AD patients and aimed to answer the question whether intensity of emotion matters. Our findings support the notion that AD patients have more severe impairments in emotion perception than patients with MCI and healthy older adults. The effect sizes are generally large, with just a few studies reporting medium effect sizes [4,14,19,26,30,35,36]. However, several studies failed to find deficits in the patients compared to controls, with small effect sizes [13,15,19,31,33,55]. The detection of negative emotions (anger, sadness and fear) is affected to a greater extent than the emotion happiness, which shows high accuracy in both AD and MCI patients. This is in line with findings in healthy participants who also show better performance on the recognition of happy faces compared to the other emotions [42]. Alternatively, this discrepancy can be explained from a neurocognitive perspective. That is, both hippocampal and amygdala atrophy have been demonstrated in early AD and MCI [43-45], which may explain the deficit in recognizing fear, which relies on this brain circuitry [46,47].

Research on emotion intensity in the field of MCI and AD is still limited. That is, only four studies examined the effect of varying emotion intensities, three of which showed that this indeed affected the performance, with aMCI patients having more difficulty interpreting lower intensity emotional expressions. aMCI patients perform similar to healthy controls at high intensity emotions, and at the level of AD patients at the lower intensity emotions. However, interpreting the results so far should be done with caution, as the mixed results from the studies identified in this review may be due to inconsistencies in the methodological approaches taken. Studies differed in the type of stimuli used, the types of emotions examined and the type of control groups (for instance, healthy volunteers, non-demented patients, or relatives). Five studies had a significantly older patient group compared to controls [17,21,22,26,38] and one study had a control group with significantly more years of education [4] than the controls.

The deficits in emotion perception appear to occur in the context of unimpaired face perception, but findings on the impact of general cognitive decline and verbal deficits associated with AD and MCI are mixed. Some studies found that overall cognitive performance impacts the performance on the emotion perception tasks in AD patients, but other studies demonstrated emotion recognition deficits independent of cognitive performance. So far, only two studies directly related emotion recognition to social functioning, showing that impaired emotion recognition affects quality of life and caregiver burden [4,30]. Therefore, for future studies it is important to focus on early screening and intervention for emotion processing deficits in MCI and AD.

We can conclude that there is a growing body of evidence suggesting impaired emotion recognition in MCI and AD. However, the frequency, extent and clinical implications are not yet clear. The question of whether emotion recognition deficits affect specific emotions to a greater extent is still open, as is the question of how these deficits affect everyday social (dys)function. Large-scale and longitudinal studies are needed to investigate emotion perception in relation to behavioural changes in MCI and AD. Potentially confounding factors such as overall cognitive decline and mood need to be addressed. Studies including neuroimaging data, such as volumetric analyses of the amygdala, may also provide a greater understanding in the processes surrounding emotional recognition in MCI and AD patients. Methods that more closely approximate social interaction should be employed; for instance, using dynamic and low-intensity facial expressions that may resemble everyday life encounters, which may be more sensitive for the assessment of subtle impairments. Emotion recognition tasks may possibly help in diagnosing the neurocognitive deficits in MCI or AD and aid their early diagnosis. Also, identification of these deficits may be useful for developing interventions that are specifically targeted at these core affective problems.

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