Acta Neuropsychiatrica 2008: 20: 236–250

DOI: 10.1111/j.1601-5215.2008.00315.x

ACTA NEUROPSYCHIATRICA

Review article

The recognition of facial expressions of emotion in Alzheimer's disease: a review of findings

McLellan T, Johnston L, Dalrymple-Alford J, Porter R. The recognition of facial expressions of emotion in Alzheimer's disease: a review of findings.

Objective: To provide a selective review of the literature on the recognition of facial expressions of emotion in Alzheimer's disease (AD), to evaluate whether these patients show variation in their ability to recognise different emotions and whether any such impairments are instead because of a general decline in cognition.
Methods: A narrative review based on relevant articles identified from PubMed and PsycInfo searches from 1987 to 2007 using keywords 'Alzheimer's', 'facial expression recognition', 'dementia' and 'emotion processing'.
Conclusion: Although the literature is as yet limited, with several methodological inconsistencies, AD patients show poorer recognition of facial expressions, with particular difficulty with sad expressions. It is unclear whether poorer performance reflects the general cognitive decline and/or verbal or spatial deficits associated with AD or whether the deficits reflect specific neuropathology. This under-represented field of study may help to extend our understanding of social functioning in AD. Future work requires more detailed analyses of ancillary cognitive measures, more ecologically valid facial displays of emotion and a reference situation that more closely approximates an actual social interaction.

Tracey McLellan[1,2], Lucy Johnston[1,2], John Dalrymple-Alford[1,2], Richard Porter[3]

[1]Department of Psychology, University of Canterbury, Christchurch, New Zealand; [2]Van der Veer Institute for Parkinson's and Brain Research, Christchurch, New Zealand; and [3]Department of Psychological Medicine, University of Otago, Christchurch, New Zealand

Keywords: Alzheimer's disease; dementia; emotion; facial expressions

Tracey McLellan, Department of Psychology, University of Canterbury, Private Bag 4800, Christchurch, New Zealand.
Tel: +64 3 3642987;
Fax: +64 3 3642181;
E-mail: tlm36@student.canterbury.ac.nz

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that is characterised by deterioration of intellectual functioning and change in personality. For the diagnosis of AD, the initial dysfunction necessarily requires impaired memory, but varying impairments in visuospatial abilities, language skills, complex attention and mental speed are common changes that support its clinical delineation and trajectory (1). The majority of research interest has focused on the cognitive and psychiatric profiles associated with AD. Surprisingly, few studies have examined how AD influences social functioning.

Interpersonal and social problems are often, however, a feature of AD. These problems are associated with the increase in caregiver burden (2) and are potentially a major factor in decreased quality of life (3). The degradation of social skills and social comprehension also affects the management of behavioural problems. The behavioural and psychiatric symptoms of dementia are reported to occur in approximately 90% of dementia patients (4) and are the most important factor for caregivers considering institutionalisation (5). Poor social functioning may well contribute to the anxiety and phobia behaviours found to be problematic in AD (2) as well as the agitation and aggressive behaviours often associated with the management of those with AD (2).

The interpersonal problems with social functioning in AD are likely to be influenced by impaired emotional processing and in particular, deficits in the ability to recognise the affective state of another person (6). Given that successful communication

and appropriate interaction requires an ability to detect and react to the felt state of others, there exists a need to establish whether AD diminishes such fundamental skills associated with emotional processing.

Arguably, the most accessible information specifying an individual's affective state is the information conveyed through the facial expression. Ekman and Friesen (7) provide convincing evidence for the universality of basic expressions of happiness, sadness, fear, anger, disgust and surprise. There are clear commonalities when normally functioning adults from different cultures are asked to pose or recognise the basic expressions (8). Studies of emotion processing generally examine the recognition of basic facial expressions (9–11). Generally, prototypical expressions are readily identifiable and marked confusion is rare among normally functioning adults. A growing literature has subsequently developed concerning when such abilities are impaired and which disorders affect such abilities.

Recently, several studies have addressed the impact of normal adult ageing on facial expression recognition. The recognition of sadness (10,12–16), anger (10,12,15,17,18) and fear (10,12,13,17,18) has proved problematic for older adults compared with younger adults. By contrast, recognition of disgust (12–16) and happiness (12,14,16,18) are largely spared in the healthy elderly, while there is even some evidence that the expression of disgust is more readily identified in advancing years (10). The latter finding is of considerable interest because disgust is normally recognised at a similar level to sadness, anger and fear in young adults (10,13,16). The disparate negotiation of these expressions in older adults suggests that any aged impairment, like that found for sad, anger and fear, is not likely the result of them being harder expressions to recognise.

Impaired facial expression recognition may well result from pathology affecting neural substrates specific to emotion processing (19–22). A large range of structures participate in the recognition of facial expressions (9,23), but the amygdala (24–27), medial prefrontal cortex (28) and fusiform cortex (27) are thought to provide key components in the distributed neural systems responsible for general vigilance of salient affective information. The superior temporal sulcus (25,27,29–31), ventral striatum (32–34), anterior cingulate (9, 28, 31) and insula (9, 28, 31) have also been implicated in emotional information processing. Specific emotions have also been associated with certain brain regions, and although the evidence to suggest which brain areas subserve which emotion is tentative, there is sufficient agreement that partially dissociable neural pathways are involved with the processing of specific emotions. For example, activations in the anterior cingulate and subcallosal cingulate have been associated with sadness (28), while the amygdala is consistently linked with fear (25,28,35) and the insular and basal ganglia with disgust (36,37).

In normal adult, ageing frontal and striatal regions are affected by ageing earlier and more profoundly than other regions (38–42). Subregions within the frontal cortex show different age-related changes, specifically, stronger volume loss in lateral and orbital frontal grey matter (43). Cell loss and decreased dendritic branching underlies the vulnerability of the prefrontal cortex to normal ageing, with distinct rates of decline in dorsal vs. anterior regions (42,44). Normal ageing also affects the medial temporal lobe, particularly the hippocampus (44, 45). The impact of normal ageing on brain regions implicated in emotion processing might explain the difficulty experienced with the recognition of certain facial expressions.

Individuals with AD experience far more pervasive structural and morphological changes in the brain than that shown by normal ageing. Early pathology is known to preferentially affect the medial temporal lobe structures; in particular, characteristic neurofibrillary tangles are found in the entorhinal cortex, hippocampus and amygdala (46–49). As stated, several studies highlight the central role of the amygdala in emotion processing (23,25,50,51), and the hippocampus and/or amygdala–hippocampal junction have also been implicated in the modulation of facial expression perception (52,53). It appears reasonable, therefore, to hypothesise that people suffering from AD may well experience a specific impairment in the ability to process affective information, and in particular, that this will manifest in an impaired ability to recognise facial expressions of emotion. It may well be, given the preferential impact of ageing on the recognition of specific expressions, that the neurodegeneration associated with AD affects some emotions more than others.

Search strategy

An electronic search was conducted from PubMed© and PsycInfo© using combinations of the keywords 'Alzheimer's', 'facial expression recognition', 'dementia' and 'emotion processing'. The reference lists of retrieved articles were also searched for additional relevant studies. Only studies in English were included.

Fifteen studies were identified that investigated the ability to recognise facial expressions of

emotion in well-defined AD samples. (The following studies were omitted because respective samples were potentially not limited to AD patients. Zandi T, Cooper M, Garrison L. Facial recognition: a cognitive study of elderly dementia patients and normal older adults. Int Psychogeriatr 1992;**4**:215–221. Allen R, Brosgole L. Facial and Auditory Affect Cognition in Senile Geriatrics, The Normal Elderly and Young Adults. Int J Neurosc 1993;**68**:33–42. Washburn A, Sands P. Social cognition in nursing home residents with and without cognitive impairment. J Gerontol 2006;**61**:174–170.) Many of these studies have also focused on other modes of emotion recognition such as prosody and postural cues; however, the present review only addressed findings related to facial expressions. We addressed the following questions. (a) Do AD patients have an impaired ability to recognise facial expressions of emotion? (b) Is there evidence that such impairment is because of specific emotion-processing deficits? (c) Is there a selective impairment of specific emotions? Table 1 presents a summary of all studies. Studies that appear with an asterisk were included in the review of findings. Studies without an asterisk were excluded as a result of methodological issues that are discussed in the following section.

Methodology

Standard criteria were used to identify AD and to exclude participants in 13 of 15 studies. There are variations, however, with regard to characteristics such as cognitive status/dementia severity, age, sample size and sex ratio. Variations in methodology are also noted in relation to the experimental tasks including the type of stimuli used, expressions investigated, task difficulty and control tasks. What follows is a review of the most salient points of methodological similarity and variation with regard to participant characteristics and experimental tasks.

Participant characteristics

Diagnoses of possible or probable AD in 10 studies were made according to criteria of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS/ADRDA) (55–60, 62,64,66,68) or based on the DSM-III and DSM-IV guidelines (6,61,63). Computed tomography and/or magnetic resonance imaging examinations were occasionally also used to confirm the diagnosis (6,54,59,61,63,66). The specific diagnostic criteria used to isolate possible or probable AD were unclear in two studies (65,67).

Comparable exclusion criteria between studies have also been reported (e.g. prosopagnosia; profound visual or hearing deficits; severe cardiovascular disease), as have reasonably stringent strategies with regard to excluding participants with other forms of dementia or other disorders that are known to impact on both cognitive status (i.e. neurological disorders, alcohol abuse or dependence and psychiatric illness) and emotion processing (clinical depression). Control participants have been carers of AD patients (64,67), non-dementia patients in institutionalised/hospital care (57,58) and community-based healthy elderly (56,59,62,65,66). While control groups are reported not to have a history of cognitive decline that might be indicative of impending dementia, the level of actual functioning is often not described. Two studies (6,63) did not compare AD participants to healthy controls (HC) and were therefore excluded from the review.

Examination of Mini-Mental State Examination (MMSE) (69) scores across studies highlights a wide range of cognitive impairment in the patient groups (Table 1). This global mental status measure is difficult to interpret without additional information regarding cognition or ancillary measures such as level of education. The mean MMSE scores range from a low 12.9 (63) to a very mildly impaired 24.8 (66). Seven of the 13 studies that compare AD patients with HC groups report a mean MMSE or Dementia Rating Scale (70) score indicative of mild AD, five of moderate, while the MMSE in the remaining study was indicative of very mild AD.

The mean age of participants varied across studies. The mean age ranged from 70.1 years (66) to 90.2 years (58) and in two studies HC were significantly younger than AD participants (56,67), and therefore, as stated, will not be included in the review of findings. Sample size also varied and ranged from 9 AD patients (66) to 31 AD patients (57). Overall, more than double the numbers of female compared with male AD patients have participated in the reviewed studies, which reflect the prevalence of AD between the sexes (71–73).

Groups were generally matched on level of education (54,57,59,62,64,66,67). Handedness, however, was rarely used as a control strategy with three studies opting to include only right-handed participants, while the remainder do not report the handedness of participants (56,62,64). Few showed comparable depressive symptom matching (62,65)

Table 1. Summary of research on the recognition of facial expressions in AD

Author	Participants	Stimuli and emotions	Tasks	Control tasks	Results
Allender and Kaszniak (54)*	ADyoung = 13; mean age = 66.3; mean DRS = 107.6 ADolder = 17; mean age = 79.9; mean DRS = 111.4 HC = 13; mean age = 68.1; mean DRS = 137.5	Izard photos: interest, joy, surprise, sadness, disgust, anger, shame and contempt	Identification: instructions – name emotion expressed; verbal/point response from printed list of nine options	Identity discrimination: indicate whether same or different person (Benton Facial Recognition Test)	ADY = ADO<HC Facial and vocal emotion tasks most strongly correlated with each other Both naming ability (BNT) and control task relate to emotion task but do not entirely explain relationship. Specific emotion-processing deficit in AD
Albert et al. (55)*	AD = 19; mean age = 89.6; m/f = 4/15; mean DRS = 101 HC = 19; mean age = 87.5; m/f = 6/13	Ekman photos: happy, sad, anger, neutral	Identification: instructions – name emotion the person is feeling; verbal response; verbal list option Selection: (same/different person): instructions – point to the sad face; point response to one of four alternatives Discrimination: (same/different person): instructions – do these people feel the same of different; verbal response to pairs of same or different people Identification accounted for by verbal memory (not BNT) No impairment in perception of affect independent of cognitive deficits	Identity discrimination: indicate whether same or different person	Identification, selection and discrimination in AD<HC Discrimination accounted for by control task Selection accounted for by BNT
Cadieux and Greve (56)	Low verbal AD = 10; mean age = 77.6; m/f = 2/8; mean DRS = 121.3 Low spatial AD = 8; mean age = 75.9; m/f = 1/7; mean DRS = 123.6 HC (community senior citizen) = 15; mean age = 69.1; m/f = 1/14; mean DRS = 141.2	FAB: happy; sad; anger; fear; neutral	Identification: instructions – name emotion expressed; verbal response; verbal list options Selection: instructions – select one of five bearing named expression; point response from five different faces and expressions Matching: instructions – select one of five bearing same expression as stimulus face; point response from five different faces	Identity discrimination: indicate whether same or different person .	All tasks in LV-AD<HC All accounted for by control task/ BNT (not general cognitive decline) Selection and discrimination in LS-AD<HC

Table 1. Continued

Author	Participants	Stimuli and emotions	Tasks	Control tasks	Results
			Discrimination: instructions – indicate whether expressions are same or different; verbal response to pairs of different people		Impairment independent of language (control/BNT)
					No impairment of affect processing in LV-AD independent of language dysfunction Impairment of affect processing in LS-AD
Roudier et al. (57)	AD = 31; mean age = 80.47; m/f = 2/29; mean MMSE = 16.18	Ekman photos: happy, sad, anger, indifference	Identification (verbal/point condition): instructions – Is this person happy, sad, angry or neutral/ point to happy face; verbal/point response from verbal list/four photos of same person with different expressions	Identity discrimination: (same/different emotion): indicate whether same or different person	Identification in AD<HC
	HC (hospitalised non-neurological) = 14; mean age = 81.07; m/f = 1/13; MMSE = 26.07		Discrimination (same/different person): instructions – is emotion expressed same or different; verbal response from pairs of same and then different people		Discrimination in AD = HC
					Control task in AD<HC Operations of facial discrimination and emotion discrimination are distinct Impairment in identification likely to be the result of verbal deficit
Koff et al. (58)*	AD = 23; mean age = 90.2; m/f = 4/19; mean MMSE = 20.3	Videotaped vignettes: no speech; actors; scripted; posed; >80% naïve rater agreement	Identification: instructions – how is person feeling – happy, sad, angry or neutral; verbal response from verbal list options	Visuospatial ability – figure copying (CERAD)	Identification in AD<HC
	HC = 19; mean age = 88.9; m/f = 4/15			Abstraction ability – Similarities (WAIS-R)	Accounted for by abstract reasoning Difficulties are secondary to cognitive deficits
Lavenu et al. (59)	AD = 20; mean age = 70.7; m/f = 4/16; mean MMSE = 22.9	Ekman photos: happy, sad, anger, fear, surprise, disgust, contempt	Identification (trial 1): instructions – point to label that best describes the emotion of person; point to one of seven options on card		Identification in AD = HC>FTD
	HC = 12; mean age = 65.7; m/f = 6/6; mean MMSE = 29.5		Consistency (trial 2): as above, then rate intensity with score between 0–8		Detection in AD = HC = FTD

Table 1. Continued

Author	Participants	Stimuli and emotions	Tasks	Control tasks	Results
	FTD = 18; mean age = 67.6; m/f = 7/11; mean MMSE = 24.9		Detection: instruction – which face expresses emotion; point to neutral or expressive photo of same person		Identification of fear and contempt in AD = FTD<HC Different neural substrates underlie recognition of various emotions
Ogrocki et al. (60)	AD = 17; mean age = 73.9; m/f = 7/10; mean MMSE = 21.8; CDR n = 1 mild n = 16 moderate	Ekman photos: happy, sad, anger, neutral	Identification: instructions – is this person feeling - or -? Verbal response from two verbal options		Identification in AD = HC Reduced visual exploration in AD
Shimokawa et al. (61)	AD = 25; mean age = 80.2; m/f = 6/19; mean MMSE = 13	Line drawings: happy, sad, anger, fear, surprise	Matching: instructions – match target face with one of four alternatives; point/verbal response to another example of same emotion & three other expressions	Figure identification: Select target from three other distractors from same category (objects and expressions)	Total affect tasks in AD<HC
	HC = 12; mean age = 76.5; m/f = 5/7; MMSE = 28.		Selection: instructions – point to the sad faces/choose face that matches situation; point response to one of four alternatives		Total affect tasks in AD>VD
	VD = 25; mean age = 78.9; m/f = 9/16; mean MMSE = 14.4.				General cognition in AD = VD Visuoperception in AD = VD No affect task correlated with MMSE in AD All affect tasks correlated with MMSE in VD Relationship between cognitive and emotion deficits differ according to dementia type
Shimokawa et al. (6)	AD = 38; mean age = 79.5; m/f = 12/26; MMSE = 15.4	Line drawings: happy, sad, anger, surprise	Same as Shimokawa et al. (61)	Same as Shimokawa et al. (61)	Impaired emotion recognition correlated with impaired behaviour Impaired emotion recognition not correlated with cognition Emotion recognition deficits, not cognitive deficits, influence impaired behaviour
Hargrave et al. (62)*	AD = 22; mean age = 74; m/f = 12/10; mean MMSE = 18.5	JACFEE colour photos: posed; FACS coded. Happy, sad, anger, fear, surprise, disgust	Identification: instructions – select emotion label that reference face depicts; verbal or point response to seven option printed below	Identity discrimination: indicate whether same or different person (Benton Facial Recognition Test)	Identification in AD<HC=PC

Table 1. Continued

Author	Participants	Stimuli and emotions	Tasks	Control tasks	Results
	HC = 14; mean age = 68; m/f = 4/10; mean MMSE = 29.1		Matching: instructions – match reference face with one of six alternatives; verbal or point response to another view of reference emotion & five different people distracters		Matching and discrimination in AD = PC<HC
	PC = 10; mean age = 70; m/f = 9/1; mean MMSE = 28.6		Discrimination: instructions – state whether depicting same or different emotion; verbal response to pairs of different people		Impairment in facial emotion processing independent of deficit in facial processing
	HC = 14; mean age = 68; m/f = 4/10; mean MMSE = 29.1.				Selective identification impairment for sad
Shimokawa et al. (63)	AD = 16; mean age = 81.8; m/f = 4/12; mean MMSE = 12.9	Line drawings and Ekman photos: happy, sad, anger, surprise	Same as Shimokawa et al. (61) with two additional but similar tasks.	Same as Shimokawa et al. (61)	Total affect tasks in AD>VD
	VD = 15; mean age 78.3; m/f = 3/12; mean MMSE = 13.1.				No affect task correlated with MMSE in AD All affect tasks correlated with MMSE in VD Relationship between cognitive and recognition of facial expression deficits differ according to dementia type
Bucks and Radford (64)*	AD = 12; mean age = 75.5; m/f = 4/8; mean MMSE = 18.8	FAB: happy, sad, anger, fear, neutral	Identification: instructions – name emotion expressed; verbal response; verbal list options	Identity discrimination: indicate whether same or different person	Selection in AD<HC
	HC = 12; mean age = 74.4; m/f = 5/7; mean MMSE = 28		Selection: instructions – select from five alternatives the expression that matched verbal label; point response from five different faces and expressions		Other facial affect tasks in AD = HC
			Matching: instructions – select one of five bearing same expression as stimulus face; point response from five different faces		Ability preserved relative to general cognitive ability
			Discrimination: instructions – indicate whether expressions are same or different; verbal response to pairs of different people		Poor selection performance may be due to cognitive load associated with this more difficult task
Burnham and Hogervorst (65)	AD = 13; mean age = 76; m/f = 8/5; mean MMSE = 21	Ekman photos: happy, sad, anger fear, surprise, disgust	Identification: instructions – say or point to label that best describes the expression; point/verbal response to one of six options on card		Identification in AD = HC

Table 1. Continued

Author	Participants	Stimuli and emotions	Tasks	Control tasks	Results
	HC = 13; mean age = 73; m/f = 10/3; mean MMSE = 29		Matching: instructions – say or point to face showing the same expression; point/verbal response to another example of same expression and three other expressions		Matching fear, sad and happy in AD<HC Impairment may be due to visuospatial dysfunction
Fernandez-Duque and Black (66)*	AD = 9; mean age = 70.1; m/f = 5/4; mean MMSE = 24.8	Ekman photos through touch screen computer: happy, sad, anger, fear, surprise, disgust	Identification: instructions – How is s/he feeling? Is s/he …; point response to one of seven labels on same screen	Sex discrimination: Indicate whether same or different sex (congruent and incongruent sex/expression)	Identification in AD = HC>FTD
	HC = 10; mean age = 65.1; m/f = 4/6; mean MMSE = 29		Discrimination: instructions – indicate whether expressions are same or different; verbal response to pairs of different people (half same/different sex)		Discrimination in AD = HC>FTD Sex discrimination in AD = FTD<HC No impairment in AD found overall or for any specific expression
Kohler et al. (67)	AD = 20; mean age = 75.9; m/f = 11/9; mean MMSE = 22.7 HC = 22; mean age = 69.4; m/f = 9/13; mean MMSE = 29.5	Genuine expressions of emotion: happy, sad, anger, fear, neutral	Identification		Identification in AD<HC
			Identify intensity		Accounted for by general cognition
			Differentiate intensity		Impaired at recognising both happy and sad when an intensity judgment was added to the task
			No information regarding procedure		Impaired at sad intensity differentiation

BNT, Boston naming test; CERAD, Consortium to Establish a Registry for Alzheimer's disease; DRS, Dementia Rating Scale; FAB, Florida Affect Battery; FACS, Facial Action Coding System; HC, healthy control; JACFEE, Japanese and Caucasian Facial Expressions of Emotion; LS, low spatial patients; LV, low verbal patients; m/f, male/female; VD, vascular dementia; WAIS-R, Wechsler Adult Intelligence Scale-Revised.
*Studies that were included in the review of findings.

and only one study matched for anxiety at the group level (62). No studies appear to have adopted a more stringent case matching design with regard to these factors; likewise, participant groups were not matched on premorbid IQ.

Experimental tasks and stimuli

Still photographs from the Ekman and Friesen 'Pictures of Facial Affect' series have been used by the majority of studies (55, 57, 59, 60, 62, 63, 65, 66). Others have used Izard photographs (54) or The Florida Affect Battery (56,57), with facial affect subtests consisting of black and white photographs of female actors depicting emotional expressions. Line drawings of cartoon-like facial expressions have also been used in studies attempting to assess facial expression recognition (6,63). The only dynamic stimuli were vignettes generated by actors instructed to 'act out' specific emotional scenarios (58). Only one study (67) employed facial stimuli that had been generated as a result of evoked, that is, felt emotional experience.

Initial interpretation across studies is made difficult given the stimuli vary according to ecological validity and likely intensity. The information available in line drawings, for instance, is very different to that in grey-scale photographs and again in colour photographs. Consequently, studies that employed line drawings (6,63) will not contribute to the final review of findings because of their poor ecological validity. Similarly, the information available in posed/deliberate expressions and genuine/spontaneous expressions is likely to differ with regard to symmetry (74–78), specific muscle contractions/combinations (78–80) and temporal characteristics (81,82), all of these factors are associated with meaningful recognition of facial expressions. Given the vast majority of studies, employing posed/deliberate facial stimuli within recognition assessment in general, let alone within the limited present scope, is not practical to address the limitation by applying this as exclusion criteria.

Facial expressions of happiness, sadness and anger were examined in all studies. Table 1 shows that seven studies included facial expressions of fear and surprise. Only four studies looked at the recognition of facial expressions of disgust and only six studies included neutral expressions in their design. A self-paced unlimited presentation of stimuli material was used in testing tasks across studies with the exception of a limited (30 s) exposure identification task during eye tracking (60). As can be seen in Table 1, the response options often differed with the requirements of a verbal, point or key press forced choice format, the former option surely equating to a more difficult task, especially for cognitively vulnerable individuals with AD.

Variable terminology, such as naming, identification, detecting, processing, matching, selection, discrimination and differentiation, has been used to describe what essentially the three most frequent procedures are: emotion identification, emotion discrimination and emotion matching. Different procedures engage the participant in different ways and require different cognitive skills. For instance, the participant must access semantically meaningful information about each of the alternative response options and apply this to a single exemplar in emotion identification tasks. When only verbal response options are provided, the participant must also remember each option.

In contrast, discrimination tasks require the assessment of two stimuli but can be completed by visuoperceptual comparisons that may have little to do with access or understanding of emotional information and more to do with configurations of visual stimuli. Emotion matching tasks, in further contrast, require the participant to scan several photographs and retain defining information about each, so a match to the target can be made. Visuoperceptual information devoid of emotional content can also be used to complete this task. Table 1 presents a summary of the specific tasks used in each of the initial studies including the main findings.

Although there are several methodological inconsistencies across studies, the present review has established exclusion criteria to remove studies in which a significant age difference was found between healthy elderly controls and AD participants. As discussed earlier, age has been shown to influence the ability to recognise facial expressions; accordingly, age matching is necessary to eliminate age as a possible explanation for any deficits found in AD. It is also important to control for face-processing deficits, and although most studies report no diagnosed problems with prosopagnosia *per se* in their samples, studies that did not include a face-processing control task will not contribute towards the review of findings.

Of the 15 studies that met the initial search criteria, two were excluded because they did not compare AD participants to healthy elderly controls. Two further studies were removed because HC were significantly younger than AD participants were, and another five studies did not meet our criteria of including a face-processing task to control for problems processing facial information not specific to emotion. What follows is a summary of results from the remaining six studies pertaining

to the application of respective identification, discrimination and matching tasks.

Review of findings

Identification of facial expressions

Tasks defined as identification tasks involved the presentation of a single photo whereby the participant is required to choose which emotion label best accounts for the expression shown.

Each of the six studies investigated the ability of AD patients to identify expressions. No significant difference in performance was found between AD and HC in two studies (60,64). Of the four studies that did find that AD patients performed significantly worse than the HC group, only two attribute this impaired performance to a specific emotion-processing deficit (54,62). The remaining two studies either attribute poor performance to verbal deficits because the task required linguistic operations (62) or difficulty with verbal memory because group differences that were not accounted for by either an identity discrimination control task or naming ability were eliminated when the contribution of verbal memory was assessed (55). Unfortunately, in the former study, an effective measure of verbal ability was neither obtained nor controlled. The conclusion reached in the later study is also difficult to evaluate without an appropriate control task. Participants did have to recruit verbal memory skills to respond to the verbal list of response options provided at each trial, but the simple 'yes/no' identity discrimination task used does not account for the verbal memory skills required to complete the verbally more complex identification task. Whether this indicates that poor performance was secondary to verbal memory skill is unclear. It may well be that both verbal memory and expression recognition are effected by AD pathology.

Discrimination of facial expressions

A discrimination task requires the participant to look at pairs of photographs and indicate whether the expressions shown are the same or different.

Emotion processing was assessed by discrimination tasks in five studies; three of which found no impaired performance of AD compared with HC (57,64,66). Two found that AD participants performed significantly worse than controls (55,62) and only one (62) concluded this deficit was because of a specific emotion-processing impairment. This study covaried an identity discrimination score on the basis that it had a similar verbal requirement as the expression discrimination task and found the significant impairment in the AD group remained. The poorer emotion discrimination performance was accounted for by the identity control task in the remaining study (55).

Matching and selecting facial expressions

Matching and selecting tasks require the participant to match a target expression to one of several alternative expressions and select a target expression from several alternatives, respectively.

Four selection and/or matching tasks were performed in three studies (55,62,64). As with the discrimination task, the poor performance in matching and selecting was accounted for by an identity control task in the first study (55). AD participants did not have any difficulty with the matching task in the second study (64) but did show impairment in the selection task. The authors concluded that the more difficult selection procedure of scanning and identifying the emotion present in five alternative expressions might have resulted in the poor performance, particularly as this was the only task in their study to show deficits compared with HC. AD patients in the final study (62) did not appear to have the same difficulty with the matching task as they had with both the identification and discrimination tasks. While a poorer performance was found, the group difference was only marginally significant once the scores on the control task were controlled for.

Performance with specific emotions

All the reviewed studies used expressions depicting several of the basic emotions as task stimuli in their respective emotion-processing tasks. Only three studies, however, considered the performance of groups on specific emotions separately (62,64,66). Of these three, only one established the relative performance score between emotions and found a deficit with regard to sad expressions relative to the other misidentified expressions of surprise and disgust (62). A potential deficit found with happy expressions (64) is likely because of a ceiling effect as HC performed happy discriminations without error. No deficit was found overall or for any particular expression in the third study (66).

Summary of past findings

In summary, two studies identified consistent problems and found AD participants were impaired relative to controls in all three tasks (55,62),

although only the later study concluded that this was because of a specific emotion-processing deficit. The same conclusion was reached by another study (54), although they only assessed skills using an identification task. A fourth study consistently found that AD participants were not impaired as evidenced by performances similar to HC in all tasks (66). The remaining two studies produced inconsistent findings across tasks, one demonstrated that individuals with AD had difficulty with facial expression identification but not with the discrimination of expressions (57) and the other found the ability to process facial expressions was preserved except when assessed using a selection task (64).

A comparison across these six studies is difficult because of a couple of methodological inconsistencies, specifically, the response formats chosen by respective studies contained either a list of verbally presented response options or a list of printed response options, the former option equating to a higher level of task difficulty. For instance, of the four studies that found impaired identification performance in AD, the two that minimised the requirements of verbal memory by providing printed response options concluded that deficits exist in emotion processing independent of the decline in cognitive skills. In contrast, the two studies that relied on verbal response options both concluded that observed difficulties were because of verbal deficits associated with AD, although as stated above, this was not assessed adequately. It is also noteworthy that the AD participants in the two studies that did not find any impaired performance across any of the tasks (64,66) had the mildest AD sample (according to MMSE scores) as well as the smallest sample size ($n = 12$ and 9, respectively), both factors potentially impacted on the ability to find meaningful group differences.

The studies reviewed for the present paper have largely set about to determine if people with AD have an impairment in emotion processing, that is, does AD affect the ability to perceive the affective state of another person. To do this, the ability to recognise facial expressions of emotion has been investigated in individuals with AD. Given the overlap between the neural structures affected by AD pathology and the areas thought to be implicated in emotional processing, it would have appeared reasonable to hypothesise that such specific deficits would be shown. While the studies often employed very similar identification, discrimination and matching tasks, several methodological limitations and inconsistencies have resulted in only a limited number of studies from which to draw conclusions.

What conclusions, if any, can we make with regard to our three questions? Firstly, do AD patients have an impaired ability to recognise facial expressions of emotion? AD patients do demonstrate poorer performance in facial expression recognition, with 61% of recognition tasks performed poorly compared with healthy aged-matched controls (Table 2). Secondly, whether this performance reflects a specific emotion-processing impairment is less clear, although 45% of tasks continued to show group differences independent of face processing or specific cognitive abilities. Lastly, information relating to deficits in specific emotions could only be garnered from three studies and no consistent impairment was found, although it is noteworthy that sad expressions were problematic for AD participants relative to the difficulty they had even with other problematic expressions (62).

The limited number of studies from which to draw conclusions or rather the high number of studies that were removed from consideration prompted the identification of two particular limitations in the existing literature. The following section discusses these two limitations as possible avenues to extend the current literature and, therefore, establish a better position within which to address our three questions in the future.

Control tasks and task difficulty

The most frequent control task used to account for general perception of faces was an identity discrimination task, which simply required participants to indicate whether the photographs of people were the same or different. While useful in terms of expression discrimination analyses, the task is quite dissimilar to identification tasks. Several studies showed differences in performance between identification and discrimination tasks and suggest that different abilities underlie the successful completion of each. It seems that researchers may need to administer additional control tasks. This is particularly relevant to clinical samples such as AD groups as the cognitive skills required to complete identity discrimination

Table 2. Percent of studies showing a deficit in recognition of emotion tasks

Task	%AD = HC	%AD<HC	%AD<HC after control*
Identification ($n = 6$)	33	67	50
Matching/selection ($n = 4$)	25	75	50
Discrimination ($n = 5$)	60	40	40
Total	39	61	45

*Facial identity task or cognitive decline

tasks may not account for subtle deficits in cognition that may hinder the successful completion of emotion identification tasks.

A more suitable control for expression identification tasks would comprise the individual presentation of non-emotional facial information and require the participant to respond to non-emotional response options that closely mirror the emotional counterpart (i.e. choose from a list of six alternative labels). That is, processing faces to identify, through a labelling response, some other aspect of person not related to emotion. An age-band labelling/identification task may suffice as a suitable control task.

The majority of research investigating recognition of facial expressions of emotion has employed the three main types of experimental tasks. Often these tasks require skills that place a cognitively vulnerable participant under a substantial working load. The identification tasks, for instance, may require the participant to remember the verbal options provided, while matching and selection tasks require that the participant scan several photographs and make several identifications and discriminations. In addition, while these procedures require a variety of cognitive skills that arguably overshadow or even interfere with emotion recognition, they also suffer from poor face validity in respect to the reference situation of an actual social interaction. Researchers may well benefit from designing laboratory experiments that more closely capture the everyday exposure to facial emotion.

The association between expression recognition and general cognitive ability (as measured by MMSE) is also unclear. A significant relationship was found between cognitive ability and expression identification (57,58) but not with expression discrimination (57). Although present with regard to vascular dementia patients (63), three particular studies showed no relationship between cognition and emotion recognition in AD patients (6,61,67). The former found everyday behaviour however was associated with emotion recognition. The variation in the relationship between MMSE as a measure of general cognition and facial expression recognition scores suggests that this is not a straightforward relationship. It appears other factors may be pertinent that research has not accounted for.

The relationship found between behaviour and emotion recognition (6) together with the dissociation found with cognition further serves to remind researchers of the importance of investigating potential impact on subsequent behaviour. As previously noted, the ability to recognise the affective state of another person allows the perceiver to respond in an appropriate or advantageous manner. It follows, therefore, that such a subsequent behaviour would be of interest to flesh out more fully the ability to accurately perceive facial emotion.

Facial displays of emotion

It may be that two separate questions are potentially being asked when investigating the recognition of facial expressions of emotion. (a) Can participants recognise facial expressions? (b) Can participants recognise facial emotion? If the aim of an investigation is to answer a question relating to whether participants have or preserve the ability to detect the affective state of another person through their facial expression then the expressions from which they are asked to make judgments should contain information relevant to how the target feels. Acted or posed expressions are 'representative of' not 'evidence of' emotion and as such provide different information to the social perceiver. Several studies have shown that perceivers are sensitive to the differences between posed and genuine expressions (82,83) and that this sensitivity then has an impact on subsequent behaviour (84). Indeed, individuals with paranoid schizophrenia have shown deficits in the recognition of posed expressions that are not evident in the recognition of genuine expressions (85). The neural structures or pathways innervated during the fundamental detection of felt emotion might differ from the neural recruitment necessary for the perception of configurations that represent emotion.

Only one of the initial studies (67) addressed affective state adequately by using genuine expressions of felt emotion. The other studies reviewed have used facial expressions potentially unrelated to emotional experience. The terms 'emotion' and 'expression' are often used as if synonymous, not only in general discussion but also in various procedures. In three studies, for instance (58,60,66), the participant was asked how the person was feeling and given acted displays where the relevant information was simply not present. The participant can answer what this person was showing or what emotion is being represented, but they are unable to answer how the person is feeling when the facial expression provided has been decoupled from the affective state. In addition to imposing potential confusion in the judgement process, such a reliance on posed displays may also dilute the area of investigation into a means to examine the recognition of facial expressions rather than an attempt to examine the perception of affective state.

Conclusion

Despite the existing research, questions remain as to whether AD patients do have impairments in their ability to accurately decode facial expressions of emotion.

It is also somewhat unclear whether any such impairment reflects the general cognitive decline and/or verbal or spatial deficits associated with AD or whether it is indicative of pathology affecting specific emotion-processing mechanisms. Research looking at the differences in affect perception between AD and fronto-temporal dementia (FTD), for instance, cite comparable levels of cognitive decline yet show more impairment in expression recognition by participants with FTD (68). Likewise, within AD, comparable cognitive status but incomparable emotion recognition was found and cognitively comparable control and affect tasks were negotiated with disparate success. Certainly, no clear relationship between traditionally measured cognitive status and traditionally measured affect recognition skill can be concluded.

Similarly, there is no clear evidence for a specific emotion-processing deficit, independent of perceptual skills non-exclusive to facial affect recognition. Individuals with AD did not appear to have difficulty with any particular expression compared with healthy age-matched controls, as no particular impairment was replicated within the remaining reviewed studies. The difficulty posed by sad expressions, however, was found to result in poorer performance relative to even the other expressions that were not recognised well. As discussed earlier, sad facial expressions are often problematic for healthy elderly, therefore, a potential deficit over and above a vulnerable baseline is worthy of particular attention.

To investigate AD and the perception of facial expressions and consequently the detection of affective state in another, future research needs to adopt a more systematic approach. Firstly, the distinction between facial expressions and facial expressions of actual emotion needs to be acknowledged and secondly, tasks that more closely approximate even basic social interaction should be employed, with an eye to whether and how this might affect subsequent behaviour and the social functioning of people with AD. Due diligence to such methodological considerations may help shed light on the cause or causes of emotion-processing deficits, whether they be cognitive or specifically emotional in nature, as well as promote the need to emphasise the consequences to individuals who have difficulty in accurately perceiving and processing the facial expressions of emotion.

References

1. Hodges JR. Alzheimer's centennial legacy: origins, landmarks and the current status of knowledge concerning cognitive aspects. Brain 2006;**129**:2811–2822.
2. Chiu MJ, Chen TF, Yip PK, Hua MS, Tang LY. Behavioral and psychologic symptoms in different types of dementia. J Formos Med Assoc 2006;**105**:556–562.
3. Buhr GT, White HK. Difficult behaviors in long-term care patients with dementia. J Am Med Dir Assoc 2006;**7**:180–192.
4. Tariot PN, Mack JL, Patterson MB et al. The Behavior Rating Scale for Dementia of the Consortium to establish a registry for Alzheimer's disease. The American Journal of Psychiatry 1995;**152**:1349
5. Steele C, Rovner B, Chase GA, Folstein M. Psychiatric symptoms and nursing home placement of patients with Alzheimer's disease. Am J Psychiatry 1990;**147**:1049
6. Shimokawa A, Yatomi N, Anamizu S et al. Influence of deteriorating ability of emotional comprehension on interpersonal behavior in Alzheimer-type dementia. Brain Cogn 2001;**47**:423–33.
7. Ekman P, Friesen WV. Constants across cultures in the face and emotion. J Pers Soc Psychol 1971;**17**:124–129.
8. Ekman P. Universal facial expressions in emotion. Studia Psychologica 1973;**15**:140–147.
9. Phillips ML, Drevets WC, Rauch SL, Lane R. Neurobiology of emotion perception I: the neural basis of normal emotion perception. Biol Psychiatry 2003; **54**:504–514.
10. Calder AJ, Keane J, Manly T et al. Facial expression recognition across the adult life span. Neuropsychologia 2003;**41**:195–202.
11. Surguladze SA, Young AW, Senior C, Brebion G, Travis MJ, Phillips ML. Recognition accuracy and response bias to happy and sad facial expressions in patients with major depression. Neuropsychology 2004;**18**:212–218.
12. Sullivan S, Ruffman T. Emotion recognition deficits in the elderly. Int J Neurosci 2004;**114**:403–432.
13. Keightley ML, Winocur G, Burianova H, Hongwanishkul D, Grady CL. Age effects on social cognition: faces tell a different story. Psychol Aging 2006;**21**:558–572.
14. Suzuki A, Hoshino T, Shigemasu K, Kawamura M. Decline or improvement? Age-related differences in facial expression recognition. Biol Psychol 2007;**74**:75–84.
15. Phillips LH, MacLean RDJ, Allen R. Age and the understanding of emotions: neuropsychological and sociocognitive perspectives. J Gerontol 2002;**57B**:P526.
16. MacPherson SE, Phillips LH, Della Sala S. Age, executive function, and social decision making: a dorsolateral prefrontal theory of cognitive aging. Psychol Aging 2002;**17**:598–609.
17. Isaacowitz DM, Lockenhoff CE, Lane RD et al. Age differences in recognition of emotion in lexical stimuli and facial expressions. Psychol Aging 2007;**22**:147–159.
18. Sullivan S, Ruffman T, Hutton SB. Age differences in emotion recognition skills and the visual scanning of emotion faces. J Gerontol B Psychol Sci Soc Sci 2007; **62**:P53–P60.

19. Adolphs R, Tranel D, Damasio AR. Dissociable neural systems for recognizing emotions. Brain Cogn 2003; **52**:61–69.
20. Phillips ML, Drevets WC, Rauch SL, Lane R. Neurobiology of emotion perception II: implications for major psychiatric disorders. Biol Psychiatry 2003;**54**:515–528.
21. Benuzzi F, Meletti S, Zamboni G et al. Impaired fear processing in right mesial temporal sclerosis: a fMRI study. Brain Research Bulletin 2004;**63**:269–281.
22. Biseul I, Sauleau P, Haegelen C et al. Fear recognition is impaired by subthalamic nucleus stimulation in Parkinson's disease. Neuropsychologia 2005;**43**:1054–1059.
23. Adolphs R. Neural systems for recognizing emotion. Curr Opin Neurobiol 2002;**12**:169–177.
24. Habel U, Windischberger C, Derntl B et al. Amygdala activation and facial expressions: explicit emotion discrimination versus implicit emotion processing. Neuropsychologia 2007;**45**:2369–2377.
25. Vuilleumier P, Pourtois G. Distributed and interactive brain mechanisms during emotion face perception: evidence from functional neuroimaging. Neuropsychologia 2007;**45**:174–194.
26. Haxby JV, Hoffman EA, Gobbini MI. Human neural systems for face recognition and social communication. Biol Psychiatry 2002;**51**:59–67.
27. Winston JS, O'Doherty J, Dolan RJ. Common and distinct neural responses during direct and incidental processing of multiple facial emotions. Neuroimage 2003;**20**:84–97.
28. Phan KL, Wager T, Taylor SF, Liberzon I. Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI*1. Neuroimage 2002;**16**:331–348.
29. Norris CJ, Chen EE, Zhu DC, Small SL, Cacioppo JT. The interaction of social and emotional processes in the brain. J Cogn Neurosci 2004;**16**:1818–1829.
30. Simon D, Craig KD, Miltner WHR, Rainville P. Brain responses to dynamic facial expressions of pain. Pain 2006;**126**:309–318.
31. Britton JC, Taylor SF, Sudheimer KD, Liberzon I. Facial expressions and complex IAPS pictures: common and differential networks. Neuroimage 2006;**31**:906–919.
32. Sprengelmeyer R, Jentzsch I. Event related potentials and the perception of intensity in facial expressions. Neuropsychologia 2006;**44**:2899–2906.
33. Burgdorf J, Panksepp J. The neurobiology of positive emotions. Neurosci Biobehav Rev 2006;**30**:173–187.
34. Leppanen JM. Emotional information processing in mood disorders: a review of behavioral and neuroimaging findings. Curr Opin Psychiatry 2006;**19**:34–39.
35. Whalen PJ, Rauch SL, Etcoff NL, McInerney SC, Lee MB, Jenike MA. Masked presentations of emotional facial expressions modulate amygdala activity without explicit knowledge. J Neurosc 1998;**18**:411–418.
36. Phillips ML, Williams LM, Heining M et al. Differential neural responses to overt and covert presentations of facial expressions of fear and disgust. Neuroimage 2004;**21**: 1484–1496.
37. Sprengelmeyer R, Schroeder U, Young AW, Epplen JT. Disgust in pre-clinical Huntington's disease: a longitudinal study. Neuropsychologia 2006;**44**:518–533.
38. Allen G, Barnard H, McColl R et al. Reduced hippocampal functional connectivity in Alzheimer disease. Arch Neurol 2007;**64**:1482–1487.
39. Grieve SM, Clark CR, Williams LM, Peduto AJ, Gordon E. Preservation of limbic and paralimbic structures in aging. Hum Brain Mapp 2005;**25**:391–401.
40. Paul R, Grieve SM, Chaudary B et al. Relative contributions of the cerebellar vermis and prefrontal lobe volumes on cognitive function across the adult lifespan. Neurobiol Aging 2007 (Epub ahead of print). doi: 10.1016/j.neurobiolaging.2007.07.017
41. Tisserand DJ, Jolles J. On the involvement of prefrontal networks in cognitive ageing. Cortex 2003;**39**:1107–1128.
42. Rajah MN, D'Esposito M. Region-specific changes in prefrontal function with age: a review of PET and fMRI studies on working and episodic memory. Brain 2005;**128**:1964–1983.
43. Tisserand DJ, Pruessner JC, Sanz Arigita EJ et al. Regional frontal cortical volumes decrease differentially in aging: an MRI study to compare volumetric approaches and voxel-based morphometry. Neuroimage 2002;**17**:657–669.
44. Burke SN, Barnes CA. Neural plasticity in the ageing brain. Nat Rev Neurosci 2006;**7**:30–40.
45. Gutchess AH, Welsh RC, Hedden T et al. Aging and the neural correlates of successful picture encoding: frontal activations compensate for decreased medial-temporal activity. J Cogn Neurosci 2005;**17**:84–96.
46. Poulin P, Zakzanis KK. In vivo neuroanatomy of Alzheimer's disease: evidence from structural and functional brain imaging. Brain Cogn 2002;**49**:220–225.
47. Wenk GL. Neuropathologic changes in Alzheimer's disease. J Clin Psychiatry 2003;**64**(Suppl. 9):7–10.
48. Boccardi M, Laakso MP, Bresciani L et al. The MRI pattern of frontal and temporal brain atrophy in frontotemporal dementia. Neurobiol Aging 2003;**24**:95–103.
49. Rosen HJ, Wilson MR, Schauer GF et al. Neuroanatomical correlates of impaired recognition of emotion in dementia. Brain 2005;**28**:2612–2625.
50. Adolphs R, Spezio M. Role of the amygdala in processing visual social stimuli. Prog Brain Res 2006;**156**:363–378.
51. Blair RJ, Morris JS, Frith CD, Perrett DI, Dolan RJ. Dissociable neural responses to facial expressions of sadness and anger. Brain 1999;**122**(Pt 5):883–893.
52. Holt DJ, Weiss AP, Rauch SL et al. Sustained activation of the hippocampus in response to fearful faces in schizophrenia. Biol Psychiatry 2005;**57**:1011–1019.
53. Reinders AA, Glascher J, de Jong JR, Willemsen AT, den Boer JA, Buchel C. Detecting fearful and neutral faces: BOLD latency differences in amygdala-hippocampal junction. Neuroimage 2006;**33**:805–814.
54. Allender J, Kaszniak AW. Processing of emotional cues in patients with dementia of the Alzheimer's type. Int J Neurosci 1989;**46**:147–155.
55. Albert MS, Cohen C, Koff E. Perception of affect in patients with dementia of the Alzheimer type. Arch Neurol 1991;**48**:791–795.
56. Cadieux NL, Greve KW. Emotion processing in Alzheimer's disease. J Int Neuropsychol Soc 1997;**3**:411–419.
57. Roudier M, Marcie P, Grancher AS, Tzortzis C, Starkstein S, Boller F. Discrimination of facial identity and of emotions in Alzheimer's disease. J Neurol Sci 1998;**154**:151–158.
58. Koff E, Zaitchik D, Montepare J, Albert MS. Emotion processing in the visual and auditory domains by patients with Alzheimer's disease. J Int Neuropsychol Soc 1999; **5**:32–40.
59. Lavenu I, Pasquier F, Lebert F, Petit H, Van der Linden M. Perception of emotion in frontotemporal dementia and Alzheimer disease. Alzheimer Dis Assoc Disord 1999;**13**:96–101.
60. Ogrocki PK, Hills AC, Strauss ME. Visual exploration of facial emotion by healthy older adults and patients with

Alzheimer disease. Neuropsychiatry Neuropsychol Behav Neurol 2000;**13**:271–278.
61. Shimokawa A, Yatomi N, Anamizu S et al. Comprehension of emotions: comparison between Alzheimer type and vascular type dementias. Dement Geriatr Cogn Disord 2000;**11**:268–274.
62. Hargrave R, Maddock RJ, Stone V. Impaired recognition of facial expressions of emotion in Alzheimer's disease. J Neuropsychiatry Clin Neurosci 2002;**14**:64–71.
63. Shimokawa A, Yatomi N, Anamizu S, Torii S, Isono H, Sugai Y. Recognition of facial expressions and emotional situations in patients with dementia of the Alzheimer and vascular types. Dement Geriatr Cogn Disord 2003;**15**: 163–168.
64. Bucks RS, Radford SA. Emotion processing in Alzheimer's disease. Aging Ment Health 2004;**8**:222–232.
65. Burnham H, Hogervorst E. Recognition of facial expressions of emotion by patients with dementia of the Alzheimer type. Dement Geriatr Cogn Disord 2004; **18**:75–79.
66. Fernandez-Duque D, Black SE. Impaired recognition of negative facial emotions in patients with frontotemporal dementia. Neuropsychologia 2005;**43**:1673–1687.
67. Kohler CG, Anselmo-Gallagher G, Bilker W, Karlawish J, Gur RE, Clark CM. Emotion-discrimination deficits in mild Alzheimer disease. Am J Geriatr Psychiatry 2005;**13**:926–933.
68. Lavenu I, Pasquier F. Perception of emotion on faces in frontotemporal dementia and Alzheimer's disease: a longitudinal study. Dement Geriatr Cogn Disord 2005;**19**: 37–41.
69. Folstein MF, Folstein SE, McHugh PR. ''Mini-mental state''. A practical guide for grading the cognitive state of patients for the clinicians. J Psychiatr Res 1975;**12**:189–198.
70. Molloy DW, Standish TI. A guide to the standardized Mini-Mental State Examination. Int Psychogeriatr 1997;**9**(Suppl 1):87–94; discussion 143–150.
71. Azad NA, Al Bugami M, Loy-English I. Gender differences in dementia risk factors. Gend Med 2007;**4**:120–129.
72. Hebert LE, Scherr PA, McCann JJ, Beckett LA, Evans DA. Is the risk of developing Alzheimer's disease greater for women than for men? Am J Epidemiol 2001;**153**: 132–136.
73. Waite LM, Broe GA, Grayson DA, Creasey H. The incidence of dementia in an Australian community population: the Sydney Older Persons Study. Int J Geriatr Psychiatry 2001;**16**:680–689.
74. Skinner M, Mullen B. Facial asymmetry in emotional expression: a meta-analysis of research. Br J Soc Psychol 1991;**30**:113–124.
75. Rinn WE. The neuropsychology of facial expression: a review of the neurological and psychological mechanisms for producing facial expressions. Psychol Bull 1984;**95**:52–77.
76. Gosselin P, Perron M, Legault M, Campanella P. Children's and adults' knowledge of the distinction between enjoyment and nonenjoyment smiles. J Nonverbal Behav 2002;**26**:83–108.
77. Brown WM, Moore C. Smile asymmetries and reputation as reliable indicators of likelihood to cooperate: An evolutionary analysis. In: Shohov SP ed. Advances in psychology research, Vol. 11. Hauppauge: Nova Science Publishers, Inc, 2002;19–36.
78. Ekman P, Davidson RJ, Friesen WV. The Duchenne smile: emotional expression and brain physiology: II. J Pers Soc Psychol 1990;**58**:342–353.
79. Ekman P, Friesen WV, O'Sullivan M. Smiles when lying. In: Ekman P, Rosenberg EL, eds. What the face reveals: basic and applied studies of spontaneous expression using the Facial Action Coding System (FACS). Series in affective science. New York: Oxford University Press, 1997:201–216.
80. Kohler CG, Turner T, Stolar NM et al. Differences in facial expressions of four universal emotions. Psychiatry Res 2004;**128**:235–244.
81. Hess U, Kleck RE. Differentiating emotion elicited and deliberate emotional facial expressions. Eur J Soc Psychol 1990;**20**:369–385.
82. Frank MG, Ekman P, Friesen WV. Behavioral markers and recognizability of the smile of enjoyment. J Pers Soc Psychol 1993;**64**:83–93.
83. Miles L, Johnston L. Not all smiles are created equal: perceiver sensitivity to the differences between posed and genuine smiles. In: Flinn-Fletcher CM, Haberman GM, eds. Cognition and language: perspectives from New Zealand. Queensland: Australian Academic Press, 2006:51–64.
84. Peace V, Miles L, Johnston L. It doesn't matter what you wear: the impact of posed and genuine expressions of happiness on product evaluation. Soc Cogn **24**:137–168.
85. Davis PJ, Gibson MG. Recognition of posed and genuine facial expressions of emotion in paranoid and nonparanoid schizophrenia. J Abnorm Psychol 2000;**109**:445–450.