Journal of the International Neuropsychological Society (1999), **5**, 32–40.

Emotion processing in the visual and auditory domains by patients with Alzheimer's disease

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(RECEIVED June 18, 1997; REVISED May 4, 1998; ACCEPTED May 5, 1998)

Abstract

The ability to process emotional information was assessed in 42 individuals: 23 patients with Alzheimer's disease (AD) and 19 healthy elderly controls. Four tasks assessed the ability to recognize emotion in audiotaped voices, in drawings of emotional situations, and in videotaped vignettes displaying emotions in facial expression, gestures, and body movements. Hemispheric dominance for processing facial expressions of emotions was also examined. There were no consistent group differences in the ability to process emotion presented *via* the auditory domain (i.e., nonverbal sounds, such as crying or shrieking, and speech prosody). Controls were, however, significantly better than the AD patients in identifying emotions depicted in drawings of emotional situations and in videotaped scenes displaying faces, gestures, and body movements. These differences were maintained after statistically adjusting for the visuospatial abilities of the participants. After a statistical adjustment for abstraction ability, some of the tasks continued to differentiate the groups (e.g., the emotional drawings task, the videotaped displays of faces), but others did not. These results confirm and extend previous results indicating that AD patients do not have a primary deficit in the processing of emotion. They suggest that the difficulties of the AD patients in perceiving emotion are secondary to the cognitive impairments associated with AD. (*JINS*, 1999, *5*, 32–40.)

Keywords: Emotion processing, Alzheimer's disease

INTRODUCTION

The processing of emotional information has been studied extensively in patients with unilateral brain damage, using stimuli in both the visual and auditory domains. The general conclusion from these studies is that, regardless of domain tested (e.g., visual or auditory) or method of assessment (e.g., drawings or photographs), the right hemisphere plays a dominant role in the perception and expression of emotion. This result has consistently been shown on a wide range of tasks, even after statistically adjusting for the cognitive deficits produced by the brain damage (e.g., by covarying performance on tests of spatial or language skill). Studies of normal adults have, likewise, demonstrated a right hemisphere advantage for the processing of emotional information (for reviews see Borod, 1992; 1993; Bowers et al., 1993; Etcoff, 1989; Silberman & Weingartner, 1986). Thus, for example, the right hemisphere superiority for the processing of facial expressions of emotion has been demonstrated to be independent of the well known role of the right hemisphere in the processing of faces and the processing of visual information in general (for review, see Etcoff, 1989). A right hemisphere advantage has also been seen for emotional nonverbal vocalizations (e.g., shrieks, cries) and for emotional and nonemotional speech prosody (variations in pitch, stress, rhythm, duration, and amplitude), although these findings are not universal (for reviews, see Blonder et al., 1991; Borod, 1993; Etcoff, 1989; Gorelick & Ross, 1987; Ross, 1985).

More recently, attention has turned to the processing of emotion in individuals with a variety of progressive neurologic disorders, particularly dementia (Albert et al., 1991; Allen & Brosgole, 1993; Allender & Kaszniak, 1989; Brosgole et al., 1981, 1983; Cadieux & Greve, 1997; Cohen & Brosgole, 1988; Roberts et al., 1996; Zandi et al., 1992). Demented patients have demonstrated difficulties in the processing of emotion on some affect processing tests, but a number of authors have argued that these deficits are sec-

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https://doi.org/10.1017/S1355617799511053 Published online by Cambridge University Press

ondary to the primary cognitive impairments of the patients (Albert et al., 1991; Cadieux & Greve, 1997; Zandi et al., 1992). For example, patients are not consistently impaired across all domains tested and adjustments for the major relevant cognitive impairments of the patients frequently eliminate the deficit.

One study of patients with Alzheimer's disease (AD) reported impairments in the ability to associate the name of an emotion with its facial expression or to match the emotional tone of a sentence with its appropriate facial expression (Allender & Kaszniak, 1989). Several other studies also reported deficits in the perception of emotion in individuals characterized as "senile geriatric," "senile demented," or "senile elderly," with the nature of the illness unspecified (Allen & Brosgole, 1993; Brosgole et al., 1981, 1983; Cohen & Brosgole, 1988). Two published studies in AD patients have adjusted the scores of the patients by cognitive test scores relevant to the particular experimental tasks and/or the primary cognitive deficits of the patients (Albert et al., 1991; Cadieux & Greve, 1997), as has been done in studies of patients with unilateral brain damage. These studies found patients with AD to be impaired in the processing of emotion in comparison to normal elderly controls; however, after the covariance adjustment, most of the group differences disappeared. Moreover, the most basic affect processing tasks were performed well, independent of other deficits (e.g., accurate identification of emotions from photographs of facial expressions). Both studies concluded that, unlike patients with right hemisphere damage, the deficits of the AD patients were secondary to the primary cognitive deficits related to their disease and not the result of a primary impairment in the processing emotion.

Patients with AD, nevertheless, are impaired on emotion processing tasks and it seems likely that these deficits may have functional consequences in their daily lives. It therefore seems important to more fully explore the nature of the patients' deficits. In this context, it seems particularly important to include dynamic demonstrations of emotion through the use of videotapes. This mode of presentation is the most relevant to the patient's daily life, and such displays have been used successfully to examine affect perception in normal adults (de Meijer, 1989; Dittman, 1987) and patients with unilateral brain damage (Benowitz et al., 1983). Thus, in the present study, emotional information was presented using a variety of domains (i.e., visual and auditory) and methods of assessment (i.e., photographs, drawings, and videotaped vignettes) in order to more fully examine the range of situations in which patients encounter emotional information. Hemispheric bias for processing facial expressions of emotion was also examined in order to determine whether the AD patients demonstrated altered laterality for processing emotional information. If this were the case, it would suggest that focal right hemisphere damage might be the explanation for any impairments observed (e.g., Moreno et al., 1990). The cognitive abilities of the patients were also assessed (e.g., visuospatial ability, abstraction), so that performance on the emotional processing tasks could be statistically adjusted for the relevant cognitive deficits of the patients.

It was hypothesized that, after statistical adjustment for relevant cognitive demands, some emotion processing tasks would show no impairments (particularly those at the more basic levels of ability, such as speech prosody), while others would continue to differentiate between the groups, suggesting that AD does not produce a primary deficit in the perception of emotion. In addition, it was hypothesized that AD patients would not show altered laterality for processing emotional information, but rather would be most impaired on the emotion processing tasks with the greatest degree of complexity. Consistent differences based on emotional valence were not anticipated.

METHODS

Research Participants

This study was conducted at the Hebrew Rehabilitation Center for Aged, a 725-bed long-term care facility. Forty-two residents gave informed consent to participate in the study; 19 were control participants (4 men and 15 women) and 23 were patients with dementia of the Alzheimer type (4 men and 19 women). The mean ages of the two groups were 88.9 and 90.2 years, respectively, which did not differ significantly from one another ($F > 1$).

The cognitive status of the control group was carefully reviewed with family members and the staff of the institution, and there was no history of progressive cognitive decline. The adequacy of their cognitive status was corroborated by two tasks designed to assess overall level of cognitive function: the Cognitive Abilities Screening Test (Korbel et al., 1983) and the Mini-Mental State Examination (Folstein et al., 1975). Laboratory tests to determine general medical health were also given (e.g., SMA-20, vitamin B12 and folate levels, serologic tests, and thyroid function tests). Since the controls were residents in a long-term care facility, they had many chronic medical illnesses (e.g., arthritis, osteoporosis). However, none of the controls had conditions known to cause cognitive deficits (e.g., vitamin deficiency, electrolyte imbalance) or a history of severe head trauma, alcoholism, or psychiatric illness. The hearing and vision of the participants was also evaluated, and all had adequate hearing and visual abilities for the task demands.

The diagnosis of AD was based on a neurologic, psychiatric, and neuropsychologic evaluation. Participants met the National Institute of Neurological Disorders and Stroke/Alzheimer's Disease and Related Disorders Association (NINCDS/ADRDA) criteria for probable AD (McKhann et al., 1984). Medical conditions known to produce dementia were excluded. A large number of laboratory tests (e.g., SMA-20, vitamin B12 and folate levels, thyroid function tests, and serologic tests) were given to rule out various neoplastic, infectious, or metabolic causes for dementia. As with control participants, patients with a record of severe head trauma, alcoholism, or serious psychiatric illness were excluded. All patients with AD received an ischemic score of 4 or less on the Ischemic Scale for assessing the likelihood of multi-infarct dementia (Hachinski, 1978). The hearing and vision of the AD patients was equivalent to that of the controls.

The degree of cognitive impairment among the patients with AD was operationally defined on the basis of their performance on the Mini-Mental State Examination (MMSE), which has a task range of zero to 30 (Folstein et al., 1975). The mean MMSE of the AD patients was 20.3 (±4.1); thus some were mildly impaired and some moderately impaired.

Assessment of Emotion Processing

The test battery for assessing the processing of emotion contained four different tasks, as described below and briefly outlined in Table 1. A fifth task, the Chimeric Faces Test (Levy et al., 1983), was included in the battery in order to assess hemispheric dominance for processing facial expressions of emotion. The test battery was designed to span the range of tasks used in previous studies of emotion processing. The tasks were administered during several brief test sessions, within a period of 2 weeks, in order to maximize the cooperation of the participants and minimize fatigue. Two orders of presentation of the five tasks were counterbalanced across participants, to reduce order effects in the results.

1. *Processing emotion in nonverbal emotional vocalizations*: This task was designed to assess the processing of emotional quality in simple nonverbal sounds, and was adapted from Carmon and Nachson (1973). Three different types of human nonverbal emotional sounds (laughing, shrieking, crying) were produced by a male and a female actor, and were then rated for their affec-tive value by 20 independent judges (female college students); only sounds that elicited greater than 80% agreement among the raters were used as stimuli.

   The participants listened to the nonverbal emotional sounds through earphones, which facilitated adjustment of the sound to the participant's optimal level. Each of the three types of sounds were presented once by the male and once by the female voices, for a total of six trials; sounds were randomly ordered on the stimulus tape. As in the original study by Carmon and Nachson, participants were asked to point to a line drawing of a face depicting the emotion associated with the sound (e.g., a sad face with tears streaming down the face), in response to a question about how the person making the sound was feeling. Participants chose from an array of six faces, three male and three female depicting the three emotions; faces were randomly reordered after each trial to avoid a position bias.

2. *Processing emotion from speech prosody*: This task was designed to assess the processing of emotional communication through speech prosody, and was similar to that used by Heilman et al. (1984). A nonemotional speech prosody task was included as a control for the assessment of emotional prosody. To create the emotional and the nonemotional stimuli, five-to-nine-word semantically neutral sentences were read by a male or female actor, in one of three nonemotional intonation contours (*interrogative*, *imperative*, *declarative*) and one of four emotional tones of voice (*happy, sad, angry, neutral*). Different sentences were used for the two tasks. Speech was filtered from the sentences to obscure their semantic content while preserving their prosody[1]. The sentences were rated for either intonation contour or emotional tone by 28 independent judges (college students); only sentences that elicited over 80% agreement among the judges were used as stimuli. The participants listened to the sentences through earphones, as with the task above.

   The nonemotional prosody task consisted of 12 sentences, four of each type of intonation contour, presented in random order. As in the original study by Heilman et al. (1984), participants were asked to identify the intonation contour by selecting the correct match from an array of three vertically arranged punctuation marks qualified by a verbal label (e.g., "?"—question). Participants were told that they would not be able to understand the words of the sentences and that they would

Table 1. Description of emotion processing tasks administered to patients with Alzheimer's disease and to controls

Test	Description and instructions
(1)	Processing emotion in nonverbal emotional vocalizations: "Point to the picture of the face which matches this voice."
(2)	Processing emotion from speech prosody: a) Emotional prosody – "Point to the picture of the face which matches this voice." b) Nonemotional prosody – "Point to the punctuation mark and verbal label that match this voice."
(3)	Processing emotion from situations portrayed in drawings: "Which of the people in these two pictures is feeling most like the person in this third picture?"
(4)	Processing emotion from videotaped vignettes of facial expressions, gestures, and body movements: "How is this person feeling?"
(5)	Hemispheric bias for processing facial expressions of emotion: "Which one of these two faces looks happier?"

[1] Speech utterances were recorded in the "quiet room" at the MIT Research Lab of Electronics. Tapes were digitized by first applying an analog low-pass filter (cut-off frequency of 4800 Hz) and then sampling the filtered signals at a rate of 10,000 samples/s. Digital band-pass filters were then applied to the sampled waveforms. For the female speaker, the filter had a center frequency of 360 Hz and a bandwidth of 340 Hz; thus, only frequencies between 190 and 530 Hz were retained. For the male speaker, the filter was centered at 260 Hz and a bandwidth of 240 Hz, retaining frequencies between 140 and 380 Hz. In this way, pitch and contour were preserved, while linguistic information was attenuated.

sound muffled; they were told to attend to the tone of voice of the speaker who would be either asking a question or uttering a statement or a command.

The emotional prosody task consisted of 16 sentences, four of each type of emotional tone, presented in random order. Instructions were similar to those in the nonemotional prosody task, with participants being told that the tone of voice would be happy, sad, angry, or neutral, and asked to match the tone of voice to line drawings of faces representing the emotions associated with the four tones of voice. The name of the emotion being portrayed was written below each face. The position of the drawings was reordered after each trial to avoid position bias.

Two different orders of presentation were used for the three auditory tasks (described in Sections 1 and 2 above) to reduce order effects.

3. *Processing emotion from situations portrayed in drawings*: This task was designed to assess the ability to perceive emotions depicted in simple scenes. The scenes were similar to those used in studies with brain damaged patients (e.g., Cicone et al., 1980), with the exception that in the present investigation the emotions depicted in the scenes were portrayed either directly (e.g., falling while ice skating) or indirectly (e.g., attending a funeral). Three emotions (*happy*, *sad*, and *angry*) were portrayed, and neutral situations served as foils. Participants were shown three pictures, two depicting the same emotion and the third depicting a neutral situation. The examiner pointed to one of the emotion drawings and asked the participant to indicate which of the other two drawings (*emotional* and *neutral*) showed a person feeling the same way as the person in the targeted drawing. Participants were asked to describe the pictures to assure that they could perceive all of the drawn elements; only those who were able to describe the scenes adequately were included in the analyses.

4. *Processing emotion from videotaped vignettes of facial expressions, gestures, and body movements*: This task was designed to assess the perception of emotion from facial expression, gestures, and body movements in dynamic videotapes, and was adapted from a paradigm designed by Rosenthal et al. (1979). Facial expressions, gestures, and body movements of emotion were enacted by professional male and female actors in dramatic semiscripted situations designed to elicit particular emotions (e.g., *happy*: someone receiving good news in the mail; *angry*: someone being criticized at work). The actors were coached and rehearsed until they were judged ready to be filmed. Although the actors spoke to each other during the filming in order to increase the life-like quality of the interactions, speech sounds were removed from the final version of the videotape, which was produced by a professional TV production crew. Upon completion of the videotape, scenes were rated for affective value by 40 independent judges (college students); only those scenes that elicited over 80% agreement among the raters were used as stimuli. Three emotions (*happy*, *sad*, *angry*) and neutral expressions (which served as foils) were each portrayed twice. Three conditions were created. In the facial expression condition, the video display focused on the face of the actor. In the gesture condition, participants were told that they would see the bodies of the actors but not their faces, which were masked by electronically blurring the faces. Participants were instructed to attend to the hand movements of the actors. In the body movement condition, in which the faces were also electronically masked, participants were instructed to attend to the body movement of the actors (how they walked, sat, stood). In each condition, participants were asked, "How is this person feeling—happy, angry, sad, or neutral?" The three tasks were presented in two different orders to reduce order effects.

   On all tasks, correct responses were counterbalanced within the task. In addition, the two halves of each test represented each type of emotion and response equally. Practice trials were given before each task to be sure that participants understood the task demands. Only participants who could comprehend the instructions were included in the analyses.

5. *Hemispheric bias for processing facial expressions of emotion*: This task was designed to determine the hemispheric bias for perception of emotional faces. It utilized the Chimeric Faces Test developed by Levy et al. (1983). The stimuli were chimeric faces in which half of the face was smiling and the other half had a neutral expression. Participants were shown 36 pairs of chimeric faces, based on photographs of male posers. For each poser, there were two chimeras, one with a smiling left face and a neutral right face, and one with the smiling right face and a neutral left face. A stimulus pair consisted of a chimera and its mirror image, displayed vertically on a single sheet of paper. Participants were instructed to look at each pair of faces and point to the face that "looks happier." Following the original procedure, participants were allowed to give a "can't decide" response if unable to choose one or the other chimera.

Assessment of Cognitive Function

Several standardized neuropsychological tests were administered to the participants in order to assess their abilities across a variety of cognitive domains, including attention, language, memory, visuospatial ability, and abstraction. Digit Span Forward from the Wechsler Adult Intelligence Scale–Revised (WAIS–R) was used to assess sustained attention (Wechsler, 1981). The CERAD Battery was used to assess verbal fluency, confrontation naming, memory, and visuospatial ability (Morris et al., 1989), and the Similarities subtest of the WAIS–R evaluated abstraction ability (Wechsler, 1981).

Statistical Analysis

Analyses comparing conditions (e.g., emotional prosody *vs.* nonemotional prosody) used percent correct responses, while analyses comparing emotion types within a condition (e.g., happy tones *vs.* sad tones) used number correct responses. A *t* test was used to analyze the Chimeric Faces Test. The remaining tasks were analyzed with analysis of variance (ANOVA; see Table 2) and analysis of covariance (ANCOVA; see Table 3). Planned comparisons were performed to determine if there were selective impairments in processing as a function of a particular emotional type (e.g., anger *vs.* sadness) or valence (positive *vs.* negative).

Table 3. Analysis of covariance comparing patients with Alzheimer's disease with normal controls on tests evaluating emotion processing

	Covariate tests			
	Visuospatial ability		Abstract reasoning	
Test	*F*	*p*	*F*	*p*
Drawings of Emotional Situations	12.7	.002	0.4	.51
Facial Expressions Videos	5.9	.02	2.66	.08
Gestures Videos	8.43	.01	4.70	.01
Body Movements Videos	15.9	.001	7.80	.001

RESULTS

1. *Processing emotion in nonverbal emotional vocalizations*: A 2 (group) × 3 (type of vocalization) repeated measures ANOVA was performed on percent correct responses (NC: 91%; AD: 83%). The groups did not differ in the performance of the task. There was a main effect of vocalization type [$F(2,80) = 9.46$, $p \leq .001$] but no significant interaction of Group × Vocalization type. Planned comparisons looking at group differences in individual types of vocalization indicated that controls were superior to AD participants in recognizing shrieking [$F(1,40) = 4.53$, $p \leq .04$]. There were no group differences in the recognition of laughing or crying.

2. *Processing emotion from speech prosody*: A 2 (group) × 2 (type of prosody) ANOVA with repeated measures was performed on percent correct responses for the emotional and nonemotional prosody tasks, demonstrating a main effect for group, favoring the controls [$F(1,40) = 6.75$, $p \leq .01$]. There was no effect of prosody type (i.e., emotional *vs.* nonemotional), indicating that the groups did not systematically perform better on one type of prosody task than another. In addition, no Prosody × Group interaction was found.

   To examine these differences further, a separate 2 (group) × 3 (type of intonation contour) ANOVA with repeated measures was performed on percent correct responses for the nonemotional prosody task (NC: 61%; AD: 49%). Overall, normal controls were superior to AD patients in identifying nonemotional prosody [$F(1,40) = 5.9$, $p \leq .02$]. There was a main effect of contour type [$F(2,80) = 39.56$, $p \leq .001$], but no interaction between Contour Type × Group. Planned comparisons looking at group differences for contour type revealed no differences on questions, commands, or statements.

   A separate 2 (group) × 4 (type of emotional tone) ANOVA conducted on the percent correct responses for the emotional prosody task (NC: 56%; AD: 45%) was not significant. There was a main effect of emotion type [$F(3,120) = 7.68$, $p \leq .001$], but no interaction of Emotion Type × Group. Although there was a main effect of emotion type, planned comparisons, looking at group differences in perception of specific emotions, revealed no group differences for happy, sad, angry, or neutral tones.

3. *Processing emotion from situations portrayed in drawings*: A 2 (group) × 3 (type of emotion) ANOVA performed on the percent correct responses (NC: 88%; AD: 69%) indicated that controls were better able to identify emotions portrayed in drawings than AD patients [$F(1,37) = 9.0$, $p \leq .005$]. There was a significant main effect of emotion type [$F(2,74) = 5.53$, $p < .006$]. The Group × Emotion Type interaction was not significant. Planned comparisons to examine group differences in the perception of specific emotions revealed that controls were better than AD patients on angry and sad drawings [$F(1,37) = 12.88$, $p \leq .001$; $F(1,37) = 7.47$, $p \leq .01$, respectively], but not on happy drawings.

Table 2. Results of analysis of variance comparing patients with Alzheimer's disease (AD) with normal controls (NC) on tests evaluating emotion processing

Test	Group	*M*%	*SD*	*F*	*p*
Nonverbal Vocalizations	NC	91	11.6	2.8	n.s.
	AD	83	19.8		
Nonemotional Prosody	NC	61	13.4	5.9	.02
	AD	49	17.9		
Emotional Prosody	NC	56	20.3	3.7	n.s.
	AD	45	15.4		
Drawings of Situations	NC	88	13.5	9.0	.005
	AD	69	25.0		
Facial Expressions Video	NC	92	8.4	4.8	.03
	AD	84	14.8		
Gestures Video	NC	90	9.8	9.7	.004
	AD	75	19.2		
Body Movements Video	NC	87	9.2	15.5	.001
	AD	70	16.3		
Chimeric Faces				$t = 0.66$	n.s.

https://doi.org/10.1017/S1355617799511053 Published online by Cambridge University Press

Because of the visuospatial demands of the drawing task, ANCOVA analyses were also performed, adjusting for participants' performance on a test of visuospatial ability (Figure Copying from the CERAD battery; see Table 3). A significant group difference remained, favoring the normal controls after controlling for spatial ability [$F(1,36) = 12.69$, $p \leq .002$]. There was no significant effect of emotion type and no interaction of Emotion Type × Group. Planned comparisons revealed group differences favoring controls on drawings showing anger and sadness [$F(2,36) = 10.11$, $p \leq .003$; $F(2,36) = 12.02$, $p \leq .001$, respectively], but not on drawings portraying happiness.

Since this task also requires abstract reasoning, a second ANCOVA was performed, adjusting for the participants' performance on a test of abstraction (the Similarities subtest of the WAIS–R; see Table 3). With this test score covaried, the difference between the AD patients and controls was eliminated. In addition, there was no significant effect of emotion type and no significant interaction of Emotion Type × Group. Planned comparisons revealed no significant difference between the groups on specific types of emotional stimuli.

4. *Processing emotion from videotaped vignettes of facial expressions, gestures, and body movement*: A 2 (group) × 3 (condition) × 4 (type of emotion) ANOVA with repeated measures was performed on percent correct responses (facial expressions, NC: 92%, AD: 84%; gestures, NC: 90%, AD: 75%; body movements, NC: 87%, AD: 70%). A significant group difference, favoring normal controls, was obtained overall [$F(1,40) = 14.93$, $p \leq .001$]. There was a significant effect of condition (i.e., facial expressions, gestures, and body movements) and emotion type [$F(2,80) = 10.02$, $p \leq .001$; $F(3,120) = 8.72$, $p \leq .001$, respectively] and a significant Condition × Emotion Type interaction [$F(6,240) = 6.02$, $p \leq .001$]. However, there were no significant interaction of Group × Condition or Group × Emotion Type.

To examine these differences further, a separate 2 (group) × 4 (emotion type) ANOVA of the scores for the video showing facial expressions of emotion revealed a main effect for group and for emotion type, favoring controls [$F(1,40) = 4.79$, $p \leq .03$; $F(3,120) = 2.94$, $p \leq .04$], respectively]. However, the interaction of Emotion Type × Group was not statistically significant. None of the planned comparisons to examine differences between types of emotional stimuli were significant.

A separate 2 (group) × 4 (emotion) ANOVA on the scores for gestures revealed a main effect for group, favoring controls [$F(1,40) = 9.66$, $p \leq .004$]. The effect for emotion type was not significant, and the interaction of Group × Emotion Type was, likewise, not significant. Planned comparisons revealed a group difference, favoring controls, on the happy items [$F(1,40) = 7.05$, $p < .02$]; no other comparisons were significant.

A separate 2 (group) × 4 (emotion) ANOVA on the body movements scores revealed a main effect for group and emotion type, favoring controls [$F(1,40) = 15.51$, $p \leq .001$; $F(3,120) = 13.88$, $p \leq .001$, respectively], but no significant interaction of Group × Emotion. Planned comparisons revealed a group difference, favoring controls on the sad stimuli [$F(1,40) = 6.40$, $p \leq .02$], but no differences on the happy, angry, and neutral stimuli.

The overall Group × Condition × Emotion analysis was then repeated with ANCOVA, adjusting for the participant's visuospatial ability (the Figure Copying score from the CERAD battery). Results indicated that controls performed better than AD patients, even after controlling for spatial deficits [$F(1,39) = 15.14$, $p \leq .001$]. There was no significant effect of condition, and no significant interaction of Condition × Group.

To examine these differences further, covariance analyses were performed on each type of video condition (see Table 3). The groups remained significantly different after the covariance procedure, on each of the video conditions, but none of the comparisons for emotion type or Condition × Emotion Type were statistically significant. Planned comparisons to examine differences for specific emotions again found differences between the groups for stimuli demonstrating happiness in facial expressions, gestures, and body movements (ps $\leq .02$). Body movements portraying sadness also remained different between the groups ($p \leq .02$); no other comparisons were significant.

Since this task also requires abstract reasoning, a second ANCOVA was performed, adjusting for the participants' performance on the Similarities subtest of the WAIS–R. With this test covaried, the difference between the AD patients and controls remained for the task overall [$F(1,39) = 7.34$, $p \leq .01$] but there were no longer significant effects of condition, emotion type or an interaction of Emotion Type × Condition.

When separate ANCOVAs were performed for each video condition, the difference between the groups for the facial expression condition was no longer significant, while significant group differences remained for the other two conditions (see Table 3). In the facial expression and gesture condition, planned comparisons revealed group differences, favoring controls, for the happy stimuli ($p \leq .05$); there was no significant group difference for any of the other emotion types.

5. *Hemispheric bias for processing facial expressions of emotion*: A t test was performed on the laterality score (right minus left divided by 36; Levy et al., 1983), which indicated no group difference in hemispheric bias for the perception of affect in faces ($t = 0.66$). For both groups, chimeras with the smile on the left were judged happier than those with the smile on the right. Moreover, 20 of the 23 AD patients had negative laterality scores, reflecting a right hemisphere bias for processing facial expressions of emotion.

https://doi.org/10.1017/S1355617799511053 Published online by Cambridge University Press

6. *Correlations of test scores with severity of disease*: To assess the relationship between degree of cognitive impairment and performance on each of the emotion processing tasks, Pearson product—moment correlations were performed between a measure of overall performance on each task and the participant's MMSE score. There was a significant correlation between the MMSE and the following tasks: nonverbal emotional vocalizations ($r = .40$; $p \leq .01$), nonemotional prosody ($r = .40$; $p \leq .01$), drawings of emotional situations ($r = .55$; $p \leq .0003$), and videotaped facial expressions of emotion ($r = .43$; $p \leq .005$). All of the tasks that were significantly correlated with severity of cognitive impairment also yielded significant group differences, with the exception of the nonverbal emotional vocalization task.

DISCUSSION

The results demonstrate that the performance of AD patients on processing of emotion tasks varies substantially across different types of tasks, and that some of the most basic emotion processing tasks were performed well. There was no consistent difference between AD patients and controls on tasks that utilized auditory stimuli. The performance of the two groups was similar on tests of nonverbal emotional vocalizations (i.e., laughing, shrieking, crying). On the prosody task, the groups differed in their ability to identify nonemotional prosody (with the controls performing better than the AD patients) but not on the emotional prosody task.

There were, however, significant differences between the groups in tasks that assessed the processing of emotion in the visual domain. The AD patients were significantly impaired in comparison to controls when judging emotion through drawings, and in videotaped facial expressions, gestures, and body movements. These differences were generally maintained after the test scores were adjusted for the visuospatial ability of the participants. However, when performance was adjusted for abstraction ability, the group difference was eliminated for the drawing task and for the videotaped displays of facial expressions of emotion. It is interesting to note that the overall level of impairment of the participants, as judged by their MMSE scores, was significantly correlated with all of the affect processing tasks that differentiated the groups.

The foregoing results appear to confirm the findings of previous work in AD patients in which the performance of the participants was statistically adjusted by the most relevant cognitive deficits of the tasks and/or the patients. They suggest that AD patients do not have a primary deficit in processing emotional information, since the AD patients are not impaired relative to controls regardless of the domain tested or the method of assessment, as is the case in patients with right hemisphere damage. Moreover, performance on some of the most basic emotion processing tasks is preserved.

For example, in the auditory domain, the AD patients were most impaired relative to controls on the nonemotional prosody task, suggesting that the difficulty of the patients on prosody tasks is not due to the element of emotion. Likewise, once performance was adjusted by abstraction ability, the performance of the AD patients was not different from controls in the processing of emotion from drawings of emotional situations or in video representations of facial expressions of emotion.

In processing emotion portrayed in drawings, the participant is required to form a concept about what a person in a particular situation would feel, and then compare it with what two other people in two other situations would feel. The absence of a significant difference between the groups in this task, following the statistical adjustment of abstraction ability, suggests that difficulties with abstract reasoning (rather than processing emotion) were responsible for the impaired performance of the AD patients relative to the controls. Likewise, the difference between patients and controls on the video task displaying gestures and body movements (even after covarying abstraction ability) suggests that situations that demand the rapid integration of multiple complex stimuli are the most likely to produce difficulties for the patients.

The similar performance of the two groups on the Chimeric Faces Test indicates that the differences between the groups cannot be attributed to an underlying difference in hemispheric laterality for processing emotion. Thus, the impairments of the patients are not likely to be secondary to focal right hemisphere damage, which typically produces deficits for processing emotional information (Borod, 1992). Moreover, 20 of the 23 AD patients had negative laterality scores, reflecting a right hemisphere for processing facial expressions of emotion. This is consistent with the fact that deficits mimicking focal right hemisphere damage are a rare phenomenon in AD, particularly among patients over the age of 65 (Albert et al., 1990).

The data also do not indicate that AD patients are selectively impaired with respect to controls in perceiving emotions of a particular type (e.g., anger *vs.* sadness) or valence (e.g., positive *vs.* negative). None of the interactions of Group $\times$ Emotion Type were statistically significant. Moreover, the planned comparisons did not demonstrate that perception of a particular type of emotion or valence was selectively altered in the patients.

The finding that AD patients do not appear to have a primary deficit in the perception of emotion (and, in fact, perform better than chance levels on every task), may help to account for the fact that the behavior of most mildly-to-moderately impaired AD patients appears appropriate in casual social settings. Nevertheless, the patients did not perform as well as controls on many of the emotion processing tasks. The present results suggest that this impairment is secondary to the cognitive deficits of AD patients, particularly those related to abstract reasoning. It may be that any interpersonal skill that places demands on abstraction or inferential thinking may be impaired in AD. Thus, for example, difficult inferences regarding what other people know or believe to be true (sometimes known as "theory of mind") may also be impaired in AD patients.

Moreover, it seems possible that misperceptions of emotion, even if secondary to cognitive impairments, may lead to behavioral problems in daily life. If it is possible to understand the underlying nature of these misperceptions, it may be possible to minimize them, and permit caregivers to more effectively tap patients' spared function. Future studies plan to explore this issue.

ACKNOWLEDGMENTS

This research was supported by NIA Grant No. P01-AG04390 to M. Albert. The authors would like to thank Dr. Ken Jones and Dr. Mary Hyde for assistance with statistical analyses and programming. The authors are also grateful to Dr. Kenneth Stevens for assistance with the preparation of the tape recordings used to assess speech prosody.

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