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Recognition of Emotion in the Frontal and Temporal Variants of Frontotemporal Dementia

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Emotion · Frontotemporal dementia · Semantic dementia

Abstract
Recent studies have suggested that the frontal and temporal variants of frontotemporal dementia (fvFTD and tvFTD) are both associated with impairments in emotional processing. However, the degree and type of emotional processing deficits in the two syndromes have not been previously compared. We used the Florida Affect Battery to examine recognition of facial expressions of emotion in fvFTD and tvFTD patients who have no evidence of visual perceptual difficulties for faces. In general, both groups were impaired at recognizing emotions compared with age-matched controls. In tvFTD, this deficit was limited to emotions with a negative valence (sadness, anger, fear), while fvFTD patients showed impairment for positive valence (happiness) as well. These results suggest that damage to frontal lobe regions in FTD may lead to more profound impairment in recognition of emotion than when damage is more limited to the temporal lobe.

Introduction

Patients with frontotemporal dementia (FTD) are plagued by profound social impairments affecting daily function. Despite the fact that the disease is anatomically heterogeneous, recent evidence indicates that many social behavioral difficulties are equally prevalent in two major anatomical variants of FTD, specifically the frontal (fvFTD) and temporal (tvFTD) variants [1–3]. Deficits in emotional processing have been proposed as one mechanism leading to these behavioral difficulties, as patients might misinterpret emotional cues that would normally help guide their behavior. Several studies of FTD have demonstrated impairment in the recognition of facial expressions of emotion [4–6]. While earlier studies made no attempt to identify subgroups within their FTD cohort, more recent studies have demonstrated impairments in carefully characterized groups of patients with fvFTD [5] and tvFTD [6]. These latter studies suggested potentially different patterns of impairment in these two variants. While tvFTD appeared to be associated with a selective deficit in recognition of negative emotions, the impairment in fvFTD appeared to include positive emotions. However, the fact that these fvFTD and tvFTD patients were studied at two different centers using differ-

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ent testing batteries makes comparison of the patterns of impairment difficult.

The goal of the present analysis was to compare the patterns of impairment in recognition of facial expressions of emotion in fvFTD and tvFTD.

Methods

Subjects

Patients. Twenty-eight patients with FTD were recruited from among patients evaluated for dementia at the University of California-San Francisco Memory and Aging Center: 13 patients with fvFTD (8 men, 5 women, mean age 64.6 ± 7.9 years) and 15 patients with tvFTD (10 men, 5 women, mean age 64.6 ± 7.9 years). The diagnosis of fvFTD was made if patients met the clinical criteria for FTD as defined in the most recently published research criteria [7] and showed predominantly frontal atrophy by visual inspection on MRI. The diagnosis of tvFTD was made if patients met criteria for semantic dementia as defined in these research criteria and showed predominantly temporal atrophy. All patients were initially evaluated by a neurologist (B.L.M. or H.J.R.) and a nurse and underwent neuropsychological testing to evaluate memory, executive function, language and mood using a previously described standard protocol [8]. Patients were excluded who had impairment in visual perceptual abilities as indicated by a performance greater than one standard deviation below published norms for this age group for the facial identity discrimination subtest of the Florida Affect Battery (FAB; see below).

Controls. Sixteen control subjects (5 men, 11 women, mean age 64.7 ± 9.4 years) were recruited from among individuals participating in normal aging research at the MAC. All control subjects had no history of neurological or psychiatric disorders, no evidence of neurologic disease on examination and no evidence of impairment on neuropsychological testing (obtained in 10 of the 16 patients).

The study was approved by the UCSF committee on human research. All subjects or their surrogates provided informed consent before participating.

Recognition of Facial Expressions of Emotion

Recognition of emotion was assessed using the first 5 subtests of the FAB [9], which consists of photographs of faces (all female) depicting 1 of 5 expressions: happiness, sadness, anger, fear, or neutral (no emotion). The formats of the subtests are as follows.

Facial Identity Discrimination. Two photographs of faces of individuals, both with a neutral expression, are displayed on each trial. Subjects are required to indicate whether the 2 faces are of the same person or of different people.

Facial Emotion Discrimination. Two facial photographs, each with a different identity and facial expression, are displayed on each trial. Subjects are required to indicate whether the 2 faces are depicting the same or different emotions.

Facial Emotion Naming. A single photograph depicting a facial expression is presented on each trial. Subjects are required to name the emotion depicted. Four trials of each emotion are presented.

Facial Emotion Selection. Five photographs of faces of the same individual, each with a different facial expression, are displayed on each trial. Subjects are required to select the face depicting the emotion requested by the examiner. Four trials of each emotion are presented.

Facial Emotion Matching. Two cards are presented simultaneously for this trial: one with a single photograph of an individual depicting a particular emotion, and the other with 5 photographs of faces of different individuals, each with a different facial expression. Subjects are required to choose the face on the second card depicting the emotion shown on the first card. Four trials of each emotion are presented.

Data Analysis

Performance (percent correct) was calculated for each subtest of the FAB. In addition, the percent correct score for each specific emotion was averaged across all subtests on which a single emotion was tested on each trial (the 3rd, 4th and 5th subtests). Differences in neuropsychological performance, performance in specific subtests and in specific emotions were examined across groups using analysis of variance (ANOVA) with Bonferroni correction for multiple comparisons.

Statistical analysis was accomplished using the SPSS software package (version 10.0.5 for Windows, SPSS Inc., Chicago, Ill., USA).

Results

Basic Neuropsychological and Demographic Data

Both FTD groups were impaired on several cognitive tasks (Mini-Mental State Examination, verbal memory, nonverbal and verbal fluency) relative to controls, and the tvFTD group was impaired relative to the fvFTD group in confrontational naming (table 1).

Performance on FAB Subtests

Consistent with the inclusion criteria for the study, neither patient group showed impairment on the identity discrimination subtest (table 2). However, both patient groups were impaired on all the emotion subtests.

Comprehension of Specific Emotions

Two-factor repeated-measures ANOVA revealed a group × emotion interaction ($F_{8,164} = 4.01$, $p < 0.001$). Post hoc testing demonstrated that both patient groups were significantly impaired in recognition of all negative emotions as well as neutral facial expressions (table 3). Only the fvFTD group showed a mild impairment in recognition of positive emotion (happy) faces, which was significant relative to both other groups.

Error Analysis for Specific Emotions

In order to better understand the nature of the errors in the patient groups, the emotion chosen each time an error was committed was tabulated (table 4). Both groups tended to confuse neutral and sad expressions. tvFTD

Table 1. Neuropsychological test results for controls, fvFTD and tvFTD patients

Test/variable	Overall ANOVA	Controls	fvFTD	tvFTD
Age	$F_{2,41} = 2.24$	64.7 (9.4)	61.1 (7.4)	67.6 (7.2)
Males/females		10/12	12/11	16/10
MMSE (max. = 30)	$F_{2,32} = 7.18^{b}$	29.4 (0.7)	24.1 (4.4)[c]	22.9 (5.6)[d]
CVLT-MS, 10 min free recall (max. = 9)	$F_{2,27} = 8.36^{b}$	6.6 (1.2)	3.7 (2.6)[c]	2.2 (2.5)[d]
Modified Rey-Osterrieth Delay (max. = 17)	$F_{2,30} = 2.89$	10.6 (3.3)	7.8 (4.7)	6.6 (3.5)
Digit Span Backwards	$F_{2,30} = 1.36$	4.6 (1.3)	3.8 (1.1)	4.3 (1.3)
Modified trails B, number of errors	$F_{2,31} = 2$	0.4 (0.7)	1.7 (2.5)	0.6 (1.1)
Design fluency	$F_{2,29} = 15.44^{b}$	10.8 (2.9)	5 (2)[d]	6 (2.9)[d]
Phonemic fluency	$F_{2,30} = 6.73^{b}$	14.9 (5.3)	7.8 (5.6)[d]	8.4 (3.6)[c]
Semantic fluency	$F_{2,31} = 50.99^{b}$	21.4 (3.6)	8.6 (4)[d]	6 (3.7)[d]
Abbreviated BNT (max. = 15)	$F_{2,30} = 16.06^{b}$	14.3 (0.9)	12.4 (6.2)	4.4 (3.7)[d,e]
Sentence comprehension (max. = 7)	$F_{2,31} = 3.76^{a}$	6.9 (0.3)	6.0 (1.2)	5.3 (2)[c]
Modified Rey-Osterrieth Copy (max. = 17)	$F_{2,31} = 3.22$	13.9 (3.5)	12.8 (4.7)	15.7 (3.0)
Calculations (max. = 5)	$F_{2,31} = 2.63$	4.5 (0.5)	3.8 (1.2)	4.5 (0.8)
Geriatric Depression Scale (max. = 30)	$F_{2,31} = 3.76^{a}$	3.6 (3.9)	7.3 (5.8)	11.3 (6.6)[c]

MMSE = Mini-Mental State Examination; CVLT-MS = California Verbal Learning Test [16]; BNT = Boston Naming Test [17].

[a] $p < 0.05$ across all groups; [b] $p < 0.01$ across all groups; [c] $p < 0.05$ vs. controls; [d] $p < 0.01$ vs. controls; [e] $p < 0.01$ vs. fvFTD.

Results are means with standard deviations in parentheses.

Table 2. FAB performance (percent correct) for controls, fvFTD and tvFTD patients

Subtest	Overall ANOVA	Controls	fvFTD	tvFTD
Identity discrimination	$F_{2,41} = 1.49$	99 (2.9)	96.5 (4.3)	98.3 (3.6)
Emotion discrimination	$F_{2,41} = 6.39^{a}$	88.1 (8.5)	68.9 (22.3)[c]	77.3 (10.8)
Emotion naming	$F_{2,41} = 9.79^{a}$	92.2 (8.8)	61.9 (25)[c]	75 (19.6)[b]
Emotion selection	$F_{2,41} = 7.86^{a}$	97.8 (4.5)	62.7 (34.7)[c]	67.3 (31.5)[c]
Emotion matching	$F_{2,41} = 16.98^{a}$	94.4 (7.7)	44.6 (33.8)[c]	66.3 (22.8)[c]

[a] $p < 0.01$ across all groups; [b] $p < 0.05$ vs. controls; [c] $p < 0.01$ vs. controls. Results are means with standard deviations in parentheses.

Table 3. Performance (percent correct) on specific emotions in controls, fvFTD and tvFTD patients

Subtest	Overall ANOVA	Controls	fvFTD	tvFTD
Happiness	$F_{2,41} = 6.92^{a}$	98.4 (4.5)	85.3 (16.7)[c,d]	96.7(6.1)
Sadness	$F_{2,41} = 6.32^{a}$	90.1 (14.3)	66.7 (23.8)[b]	64.8 (26.6)[c]
Anger	$F_{2,41} = 8.44^{a}$	93.8 (7.8)	69.2 (27.5)[b]	63.3 (26.1)[c]
Fear	$F2_{,41} = 9.24^{a}$	92.7 (9.1)	62.2 (30.4)[c]	68.9 (18.5)[c]
Neutral	$F_{2,41} = 9.06^{a}$	99 (2.8)	75.6 (21.9)[c]	85 (15.2)[b]

[a] $p < 0.01$ across all groups; [b] $p < 0.05$ vs. controls; [c] $p < 0.01$ vs. controls; [d] $p < 0.05$ vs. tvFTD. Results are means with standard deviations in parentheses.

Table 4. Pattern of errors for each target emotion in tvFTD and fvFTD

Target response	Actual response (% of all errors where this emotion was chosen)				
	happiness	neutral	sadness	anger	fear
Happiness					
fvFTD	–	*34.8*	26.1	17.4	21.7
tvFTD	–	28.6	14.3	*42.9*	14.3
Neutral					
fvFTD	23.7	–	*52.6*	10.5	13.2
tvFTD	20.7	–	*65.5*	6.9	6.9
Sadness					
fvFTD	1.9	*51.9*	–	23.1	23.1
tvFTD	3.1	*40*	–	32.3	24.6
Anger					
fvFTD	14.6	12.5	*41.7*	–	31.3
tvFTD	4.5	7.6	40.9	–	*47*
Fear					
fvFTD	22	6.8	11.9	*59.3*	–
tvFTD	8.9	7.1	14.3	*69.6*	–

The most frequent response for each group is in italics.

tended to mistake anger for happiness, whereas this tendency was not apparent in fvFTD. Although fear and anger were most often confused with each other, fvFTD appeared to have a greater tendency to mistake happiness for these emotions. To examine statistically the tendency of fvFTD patients to mistake happiness for other emotions, we collapsed responses for all negative target emotions and classified each response as happiness, neutral or a negative emotion. The tendency to call negative emotions happiness was significantly higher in fvFTD than tvFTD ($p < 0.05$, χ^2 test).

Discussion

The present results extend previous findings indicating significant impairment in emotional processing in both tvFTD and fvFTD [5, 6]. Our data suggest that both groups have equivalent difficulty in recognizing negative emotions. Moreover, our findings indicate that the degree of emotional processing impairment in fvFTD is more pervasive than in tvFTD as manifest by the decreased ability in fvFTD to discriminate a positive emotion (happiness) from negative emotions. There was no evidence that any of these deficits were due to difficulties with visual perception, as both groups included only patients who performed well in facial identity discrimination. Furthermore, our findings are consistent with those of previous studies in which fvFTD patients have shown impaired recognition of both facial and vocal expressions of negative emotions and happiness [5].

These findings naturally lead to the question of what neuropathological changes underlie emotion recognition deficits in these two groups. In this regard, damage to the amygdala is likely to play an important role. Research in patients with focal neurologic injury has found that damage to the amygdala results in impaired recognition of negative emotions, in particular fear [10–13]. Consistent with this, in tvFTD, deficits in emotion recognition have been correlated with the degree of amygdala atrophy [6]. Considering the two groups studied here, tvFTD is clearly associated with amygdala damage [8], but it is also the case that many patients with fvFTD have substantial involvement of the temporal lobes [3, 14]. Thus, it is conceivable that amygdala damage accounts for impairment in comprehension of negative emotions in both groups. The fact that this impairment is not greater in tvFTD than fvFTD, despite the greater severity of amygdala damage in tvFTD, may suggest a limit to the extent of amygdala-related loss of emotion recognition. Moreover, amygdala injury cannot account for all deficits in emotion recognition – even with severe amygdala atrophy seen in tvFTD, we found recognition of positive emotions in tvFTD patients to remain intact. Our findings that deficits in recognition of positive emotions are associated with damage to frontal regions injured in fvFTD suggest that this brain region is important for this aspect of emotion recognition. Previous research has also underscored the role of frontal brain regions in emotional processing. For example, impaired emotion recognition was found in patients with damage to the orbital frontal and anterior cingulate cortex [15]. Although orbital frontal cortex is severely affected in both tvFTD and fvFTD, anterior cingulate cortex may be more affected in fvFTD [8]. Thus, it may be that anterior cingulate cortex is particularly important in recognition of positive emotions. Future studies will be aimed at exploring further the anatomical correlates of specific emotion recognition deficits in fvFTD and tvFTD.

The brain regions injured in FTD likely play important roles in emotional functioning and these likely play an important role in the disturbances of socioemotional behavior often seen in these patients. Current work in our laboratories is focusing on assessment of other aspects of emotional processing in FTD, including a broader assessment of emotional understanding, as well as measure-

ment of alterations in behavioral and physiologic aspects of emotional functioning. These new studies should lead to a greater understanding of the neuroanatomic basis of emotion, as well as the relationship between emotional processing problems and behavioral dysfunction in FTD.

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