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Amygdala lesion in temporal lobe epilepsy subjects impairs associative learning of emotional facial expressions

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Abstract

To investigate the role of unilateral amygdala lesions on processing emotions, 22 drug-resistant temporal lobe epilepsy (TLE) subjects (12 with left-sided and ten with right-sided focus) were tested, after anterior temporal lobectomy or selective amygdalo-hippocampectomy on two associative learning tasks containing emotional and neutral facial expressions, respectively. Volumetric lesion analysis was performed on the basis of 3-D MR images. No effects of lesion side were found in TLE subjects. Taken the extent of amygdala damage into account, an interaction effect could be shown between task (learning of neutral facial expressions versus emotional facial expressions) and group (subjects with little versus considerable amygdala damage), indicating worse performance of subjects with considerable amygdala damage in learning emotional facial expressions. Subjects with considerable amygdala damage were also significantly impaired in learning emotional facial expressions when compared with control subjects.

Keywords: Amygdala; Associative learning; Emotional facial expressions; Temporal lobe epilepsy

1. Introduction

Looking for an anatomical correlate of emotion, animal research has pointed to the amygdala as a core structure [16]. The probably best known phenomenon of bilateral amygdala damage in non-human primates is the so-called 'Klüver-Bucy syndrome', producing an extraordinary loss of affective and social behaviour [28]. Anatomical studies have shown that the amygdala has numerous cortical and subcortical connections, receiving extensive convergent sensory input, and projecting it back not only upon unimodal, but also to association areas of the cortex, back-projections being most impressive for the visual system. The consequences of its bilateral destruction are discussed both as a disconnection syndrome, and as a disruption in forming stimulus-reward associations [2].

In humans, selective bilateral amygdala damage is extremely rare, and studies mostly rely on single cases. It does not seem to produce the same serious consequences as in non-human primates, but may disturb conditioning of autonomic responses [5], impair memory for emotional material [8], impair auditory recognition of fear and anger [21], and modulate social and emotional behaviour [25]. A number of studies, concentrating on the recognition of emotional facial expressions in humans with bilateral amygdala damage, have also found deficits, especially in recognising fear (e.g. [1,9]). Thus, bilateral damage to the amygdala in humans may affect processing of emotional stimuli of different sensory qualities.

Unilateral amygdala damage is more common than bilateral amygdala damage in humans, but studies on its consequences regarding processing of emotions are less frequent. Electrophysiological studies on temporal lobe epilepsy subjects with implanted electrodes showed signals from the amygdala, when subjects reported affective experiences evoked by seizure discharge or electrical stimulation [13]. Single case studies with restricted unilateral amygdala damage indicated an impairment in processing emotional material [4,29]. While studies

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based on amygdala-damaged subjects with additional damage to related cortical and subcortical regions found impaired fear conditioning [15], they failed to find an impairment in processing emotional facial expressions [1].

Taken together, there is strong evidence that bilateral amygdala damage in humans has consequences on processing emotional stimuli, while the effect of unilateral amygdala damage on emotion processing is less clear. Taking functional studies (PET, fMRI) with healthy subjects into account, both bilateral [7], and unilateral [18] amygdala activation could be found, while subjects were processing emotional stimuli.

The aim of the present study was to examine the influence of unilateral amygdala damage on the processing of emotional facial expressions as opposed to neutral facial expressions. Since the amygdala is closely related to mnemonic functions [2,17], and also so far, there are no studies on amygdala damage and memory for emotional facial expressions, two associative learning tasks with emotional and neutral facial expressions were applied. We expected that subjects with major amygdala damage should show deficits in learning associations between emotional facial expressions compared with subjects with minor amygdala damage and control subjects, and compared with the learning of associations of between facial identities.

2. Method

2.1. Subjects

Twenty-two subjects (12 females, ten males) with drug-resistant TLE, having undergone epilepsy surgery at the neurosurgical department of the University of Göttingen (between 1995 and 1997), were evaluated postsurgically (see Table 1). At time of testing, all

Table 1
Sociodemographic, clinical, and neuropsychological characteristics of all subjects

	Large amygdala lesion (TLE-A) ($n = 16$)	Small amygdala lesion (TLE-a) ($n = 6$)	Healthy and clinical control group CG ($n = 40$)
	N	N	N
Sex (male:female)	8:8	2:4	18:22
Lesion side (right:left)	6:10	4:2	–
Type of surgery (sAH:aTL)[a]	3:13	3:3	–
	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Age (years)	34 (7)	38 (5)	39 (11)
Schooling (years)	9 (1)[b]	9 (1)[b]	11 (2)
Seizure frequency[c]			
Before surgery	8 (0.4)	8 (1)	–
After surgery	4 (2)	3 (1)	–
Volume (ml)			
Total brain	1091 (81)	1196 (182)	–
Lesioned amygdala	0.5 (0.3)[d]	1.1 (0.1)	–
Non-lesioned amygdala	1.6 (0.3)	1.6 (0.2)	
WMS-R (raw scores)			
Logical memory I	20 (7)[b]	20 (5)[b]	29 (7)
Logical memory II	15 (9)[b]	16 (7)[b]	24 (7)
Visual reproduction I	34 (4)[b]	35 (7)	37 (3)
Visual reproduction II	29 (8)[b]	29 (13)	35 (5)
TMT (s)			
Part A	31 (10)[b]	32 (8)[b]	25 (10)
Part B	67 (35)	74 (44)	50 (23)
Benton facial recognition test (raw scores)	44 (4)	47 (4)	46 (4)
Rating of emotional facial expressions (difference scores)			
Valence	9 (4)	8 (4)	9 (4)
Arousal	8 (5)	11 (5)	7 (3)

[a] sAH, selective amygdalo-hippocampectomy; aTL, anterior temporal lobectomy.
[b] Significantly different (U-test; $P < 0.05$) compared with group CG.
[c] As determined by Engel et al. [11].
[d] Significantly different (U-test; $P < 0.05$) compared with group TLE-a.