

ERP-Evidence on Emotional Prosody Perception in BG-Patients: Selective Impairments for Vocal Expressions of Disgust and Fear?

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Introduction

One critical issue in studying emotion perception in patients is to understand which underlying mechanisms constituting an emotion are affected by a lesion. For example, it has been suggested that the basal ganglia (BG) as well as right hemispheric cortical structures play an important role in the recognition of emotional stimuli. In particular, there is evidence that the BG modulate perception of *disgust* as patients with Parkinson's disease (Pell & Leonard, 2003) or Huntington's Disease (Sprengelmeyer et al., 1996) display deficits in the recognition of facial as well as vocal cues of *disgust*. However, while controversial, there is also evidence, that the BG are involved in the recognition of facial-*fear*, but not in vocal-*fear* expressions (Kan et al., 2002). Furthermore, certain BG lesions also result in facial-*anger* recognition impairment (Calder et al., 2004). Latter evidence is supported by fMRI evidence on vocal-*anger* expressions (Kotz et al., 2003).

Motivation 1

Here, we tested the perception of emotional prosody in BG lesion patients using vocal expressions of *anger*, *fear*, *disgust* and *happiness* compared to a *neutral* baseline. Previous evidence (Paulmann & Kotz, 2005a) suggests that different emotional prosodies can be differentiated in an early event-related brain potential (ERP) component, the P200. The main motivation was to directly compare vocal expressions of emotions in one paradigm to find support for a distinct or a unified emotion system(s).

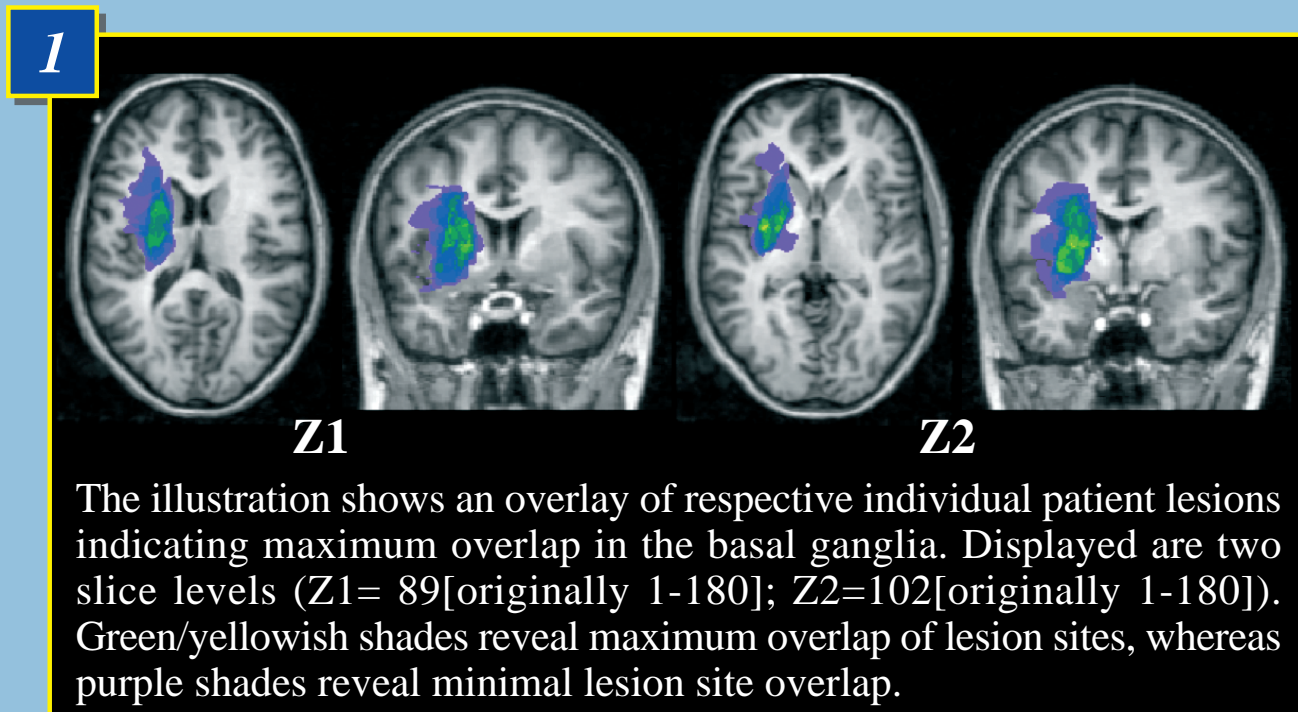
Motivation 2

Emotions are de- and encoded via different information channels (e.g. facial, acoustical, verbal). In particular, emotional prosody is strongly connected to emotional semantics. Here, this interaction was investigated by means of a cross-splicing method to isolate emotional prosody from semantic content. Previous ERP-evidence suggests that the time-course of emotional prosody and emotional semantics differs (Paulmann & Kotz, 2005b). While a pure violation of a prosodic contour elicits a positivity, a violation of both emotional prosody and semantics elicits a negativity. The obtained results suggest that emotional prosody and semantics contribute differently to the interaction of both information types.

Methods

Participants:

Twelve patients (1 female, all right-handed) with lesions in the striatum participated in the current study. Lesions resulted from left hemisphere insults: ischemic stroke (n=3), embolic stroke (n=3), hemorrhage, (n=3), intracerebral bleeding (ICB; n=3), or arterio-arterial infarction (n=1). The average time since lesion in the basal ganglia was: 4.6 years (range 1.8 - 7.11). Lesion sites were determined by (T1- and T2-weighted) anatomical MRI datasets from a 310 T system (Bruker 30/100 Medspec) and evaluated by an experienced neuroanatomist. In addition, twelve neurologically intact healthy control subjects took part in the experiment. The groups were matched for age and educational level. See Illustration 1 for graphical display of lesions and Table 1 for patient information.



The illustration shows an overlay of respective individual patient lesions indicating maximum overlap in the basal ganglia. Displayed are two slice levels (Z1= 89[originally 1-180]; Z2=102[originally 1-180]). Green/yellowish shades reveal maximum overlap of lesion sites, whereas purple shades reveal minimal lesion site overlap.

Violation		
Neutral Start	End of Sentence	
Er hat (He has	das Paar gereizt und aufgebracht. teased and upset the couple).	— ANGER
Hung set	das Vermalet gereubt ind verpreusst.	
Er hat (He has	die Müllhalde bewohnt und gestunken. lived in the dump and stunk).	— DISGUST
Hung set	die Spulza verbrutet ind nogelackt.	
Er hat (He has	die Spuren verwischt und verschleiert. blurred and disguised his traces).	— FEAR
Mon set	die Sonität verfrieget ind geschweugen.	
Sie hat (She has	die Trauung verkündet und gelächelt. announced the wedding and smiled).	— HAPPY
Hung set	den Nestol verbarsicht ind gekobelt.	

1000 ms	~3000 ms	RTmax ms	1500 ms
+	⚡⚡⚡⚡⚡	Schatz	
Fixation cross	sentence presentation	probe presentaiton	ISI

Table 1 Patient History:

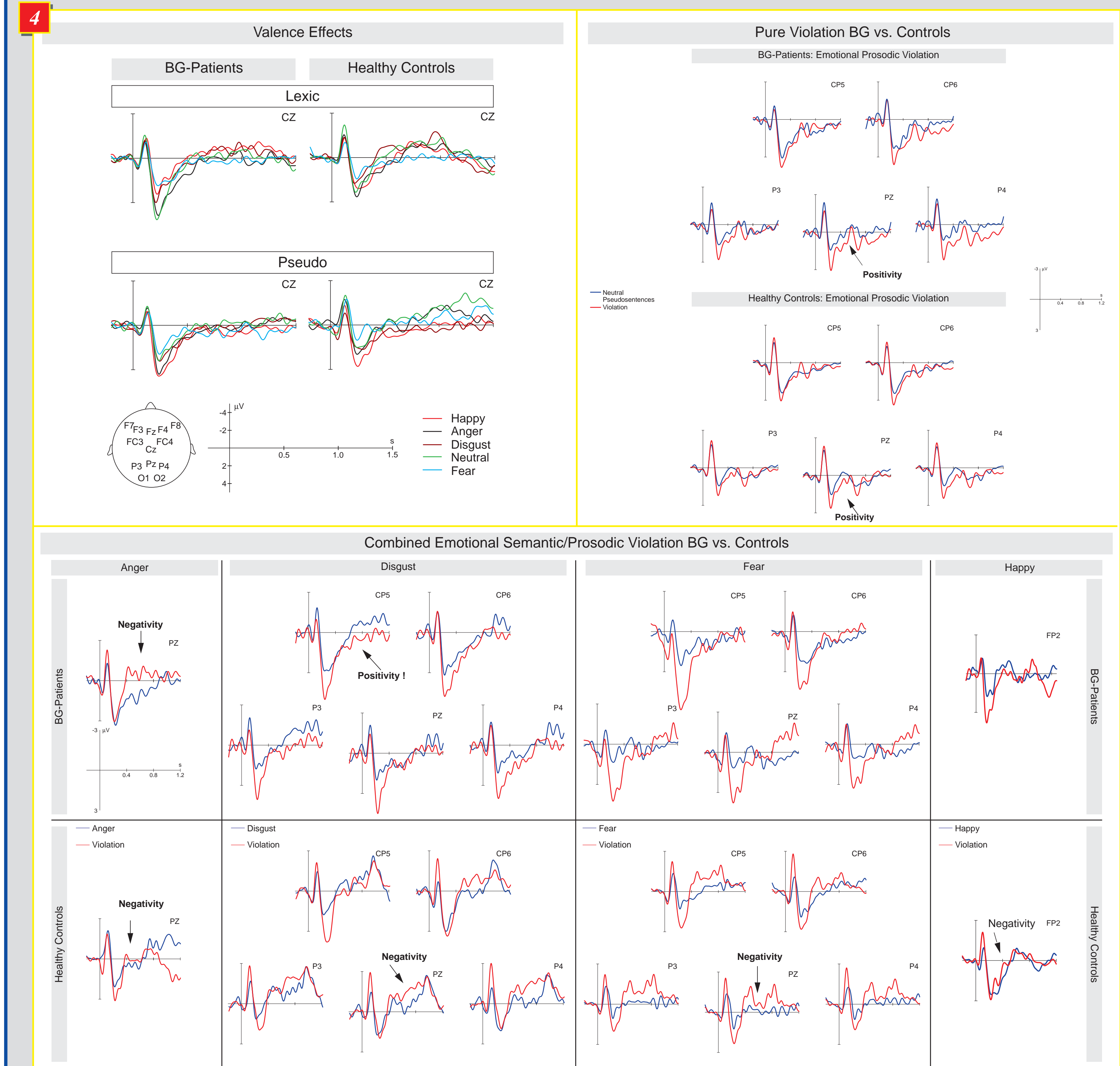
Patient	Sex	Age at test (years)	Time since lesion (years)	Etiology	Lesion description
1	m	63	7.04	Hemorrhage	ant. GPe, ant. IC
2	m	53	6.01	ICB	post. Put., GPe, post. EC, IC, lat. Thal.
3	m	48	5.01	ICB	Put., GPe, EC, ant. IC, reduced volume of Caud.
4	m	31	5.05	Ischemic Infarct	post. Put., Caud. (body), middle Ins., parietal operculum
5	m	68	4.04	Ischemic Infarct	Caud. (ant. body), ant. Put., GPe, EC, ant. IC, ant. Ins., preinsular WM
6	f	40	3.03	Arterio-Arterial Infarct	Caud. (body), Put., GPe, ant. IC, EC, parietal operculum, post. Ins.
7	m	59	4.11	Ischemic Infarct	Caud. (body), Put., GPe, IC, EC
8	m	66	7.11	Hemorrhage	Caud., Put.
9	m	33	6.0	Embolic Infarct	Put., Caud.
10	m	28	1.08	Hemorrhage	post. Put., Caud.
11	m	26	3.05	ICB	Thal., post. Put., Caud.
12	m	75	4.11	Embolic Infarct	Caud. (body), Put.

Note: m = male, f = female, ICB = intracerebral bleeding, ant. = anterior, post. = posterior, Caud. = caudate nucleus, EC = external capsule system, IC = internal capsule, Ins. = insula, GPe = globus pallidus externus, GPi = globus pallidus internus, Put. = Putamen, Thal. = thalamus, WM = white matter.

Table 2 Predictions towards expected ERP components:

Theoretical View	EXPECTED ERP COMPONENTS		
	Emotional Perception Valence Effects (P200)	Emotional Prosody Prosody Violation (Positivity)	Emotional Integration Combined Violation (Negativity)
Unified Model	- P200 all emotional categories	- positivity all emotional categories	- negativity all emotional categories
Distinct Model	- P200 single emotion	- positivity single emotion	- negativity single emotion

Results



Summary of Effects:

BG Group	Valence Effects	
	Lexical Modality	Pseudo Modality
	P200 all emotional categories + extended P200 latency single emotion (fear)	P200 single emotion (happiness) + extended P200 latency single emotion (fear)
Healthy Controls	P200 all emotional categories	P200 single emotion (happiness)

BG Group	'Pure' Emotional Prosodic Violation			
	ANGER	DISGUST	FEAR	HAPPINESS
	positivity	positivity (trend p < .05)	positivity	positivity
Healthy Controls	positivity	positivity (trend p < .05)	positivity	positivity

BG Group	Combined Emotional Prosodic/Semantic Violation			
	ANGER	DISGUST	FEAR	HAPPINESS
	negativity	positivity	-	~
Healthy Controls	negativity	negativity	negativity	negativity

Discussion

BG-Patients suffer from an on-line processing difficulty for fearful vocalizations (reflected in the prolonged P200). Whether this prolonged effect reflects solely timing differences in emotional processing, or a general processing deficit for fearful stimuli, remains an open question. The current results provide additional evidence that BG-Patients suffer from difficulties processing fearful stimuli. Here, this discussion is extended to vocal emotional stimuli. Results suggest that lesions to the BG do not influence processing of violations to emotional prosodic contours early on. Contrary to our expectations, BG-Patients did not show a selective emotional prosody processing deficit to any of the

valences tested. In contrast, however, results for the combined emotional prosodic and emotional semantic violation revealed processing differences between BG-Patients and their age- and education-matched controls. Impairment was observed in BG-Patients during processing combined violations to emotional prosody and emotional semantic information channels of *disgust* and *fear*, in particular. This was reflected in a missing modulation in the case of fear and a reversed pattern in the case of disgust. It is assumed that strong semantic content helps to identify the corresponding emotional prosody of a sentence. It appears that due to this additional information impairment in on-line processing becomes apparent.

Conclusions

The current results provide evidence that the BG are engaged in the processing of *fearful* and *disgust* stimuli and extends this evidence to vocal emotional stimuli. Also, the present results suggest that processing difficulties become obvious when emotional prosody is accompanied by emotional semantics, suggesting that BG lesions lead to an integration problem between emotional prosody and emotional semantics.

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