Does the N170 occipito-temporal component reflect a face-specific structural encoding stage?

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Background

Many neuroimaging studies have increased our knowledge of the neural correlates of face processing (e.g. 1-3), but the temporal aspects of this function remain largely unclear.

Recently, it was suggested in several event-related potentials studies (4-12) that face processing differs from visual object processing at 170 ms following stimulus onset. The electrophysiological component at which this dissociation takes place is best recorded at occipito-temporal sites, bilaterally, and has been termed the N170 (4). The N170 has been interpreted as reflecting a face-specific "structural encoding stage", performed prior to the recognition of a face as familiar or not (4-8).

This interpretation is based on findings that:

i) the N170 component is either absent (4) or strongly reduced (7) for non-face objects;

ii) it is considered to be insensitive to scrambling of a face's features (4) and to face inversion (5); and

iii) it is unaffected by face familiarity (6,11).

Here we test the claims that the N170 component is face-specific, and that it reflects a «structural encoding» stage for faces.

Is the N170 a face-specific component?

Potential limitations of previous ERPs studies:

- **Compared faces to a *single category* (Can we find signifcant differences in the N170 between nonface categories?)**
- **The differential amplitude of the N170 for faces and objects may reflect differences in low-level visual features (e.g. spatial frequencies.)**
- **The differential amplitude of the N170 for faces and objects may reflect differences in visual familiarity (or attentional bias) for faces compared to other categories.**

To avoid these confounds, we:

Use faces and a variety of mono-oriented objects.

Compare each stimulus category, including faces, to its inverted presentation.

Does the N170 reflect a stuctural (face) encoding stage?

The face structural encoding stage is the extraction of an *invariant* face representation, namely an abstract visual representation that is established from different views of faces and which captures those aspects of the structure of a face essential to distinguish it from other faces. However, this stage occurs prior to recognition of a face as familiar or not, or to its identification (18).

Whether or not the N170 reflects face-specific processes, *the claim that it corresponds to a structural encoding stage (4-8) has not been tested.*

To test this assumption, we:

Record ERPs in a prosopagnosic patient strongly impaired at the level of the structural encoding stage.

EXPERIMENT 1: NORMAL SUBJECTS

- 14 subjects (7 females, mean age 25)
- 6 categories of stimuli:

faces **cars** **shoes** **houses** **chairs** **Greebles**

- Each image presented upright or inverted for 500 ms (ISI between 1500 and 2000 ms).

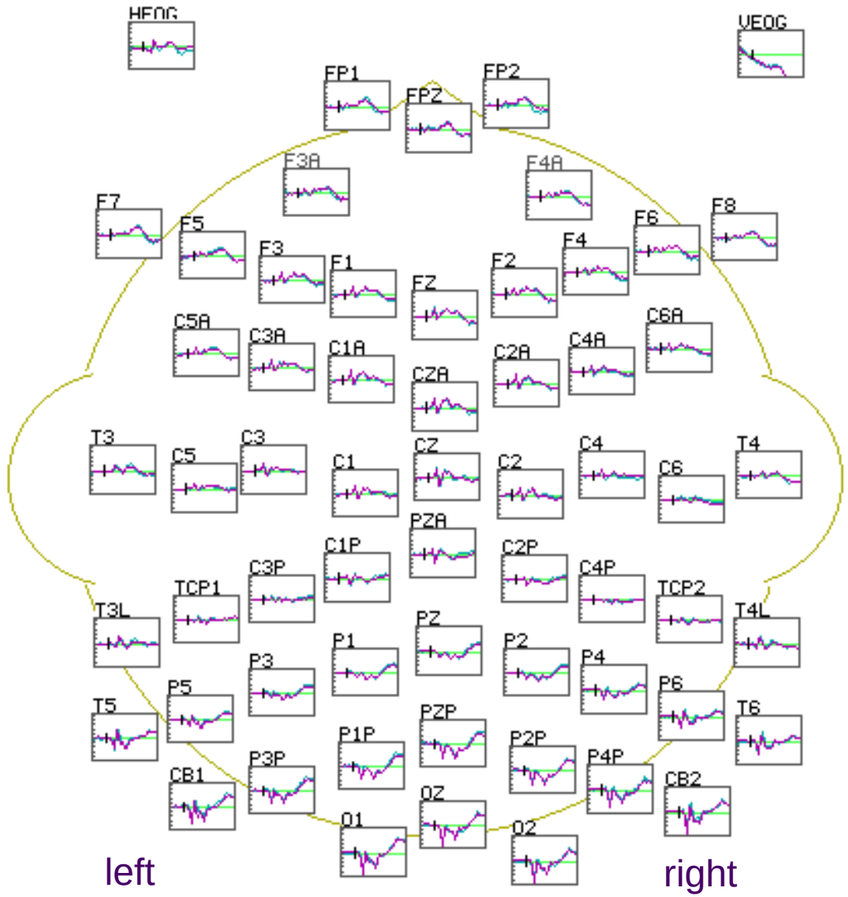
- 12 blocks of 120 trials (10 images x 6 categories x 2 orientations), categories intermixed.

- **TASK**:press one of 2 keys according to the object orientation.

- **EEG were recorded from 58 electrodes (earlobe reference)**

ERP ANALYSIS:

- Analysis time: -200 to 800 ms, acquisition rate: 500 Hz.
- Average waveforms (**common average reference**) were low-pass filtered at 30Hz.
- Dependent measures: peak amplitudes and latencies of the N170 at T6 and T5 electrodes, with respect to a 200 ms pre-stimulus baseline.
- All effects reported are significant at $p<.05$.



Experiment 1 : results

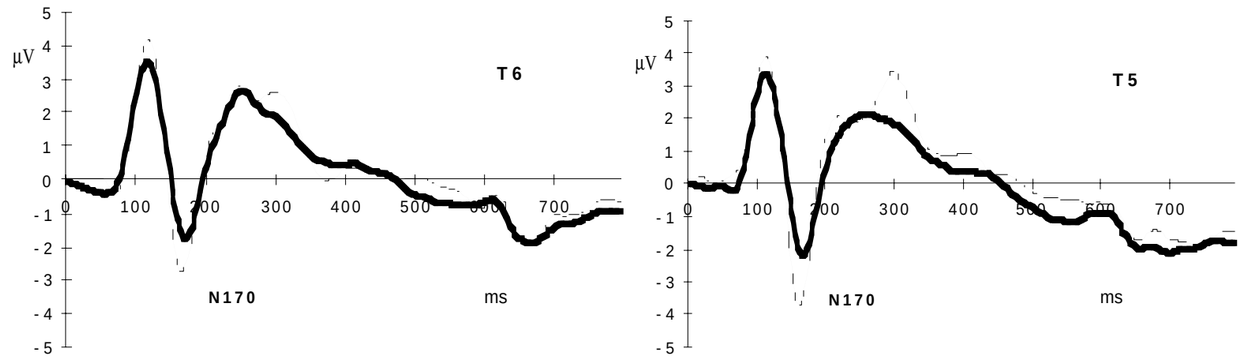
All subjects elicited a N170 for all visual categories.

Behavioral Results:

Accuracy between 92% and 96 %.
RTS between 556 ms and 615 ms.

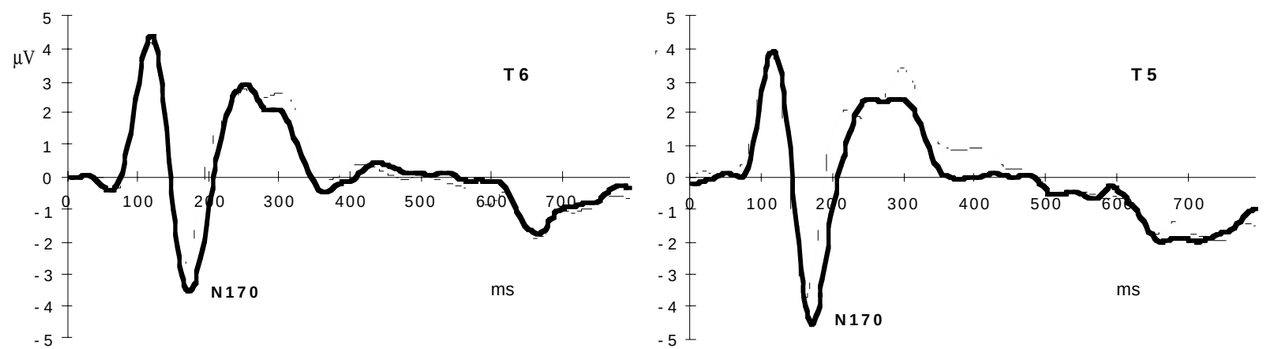
significant effects
for RTs:
upright < inverted
cars < other categories < greebles
for accuracy:
orientation x category interaction
(no orientation effect for Greebles and shoes)

Larger N170 for faces than for other visual categories.



Faces
Objects

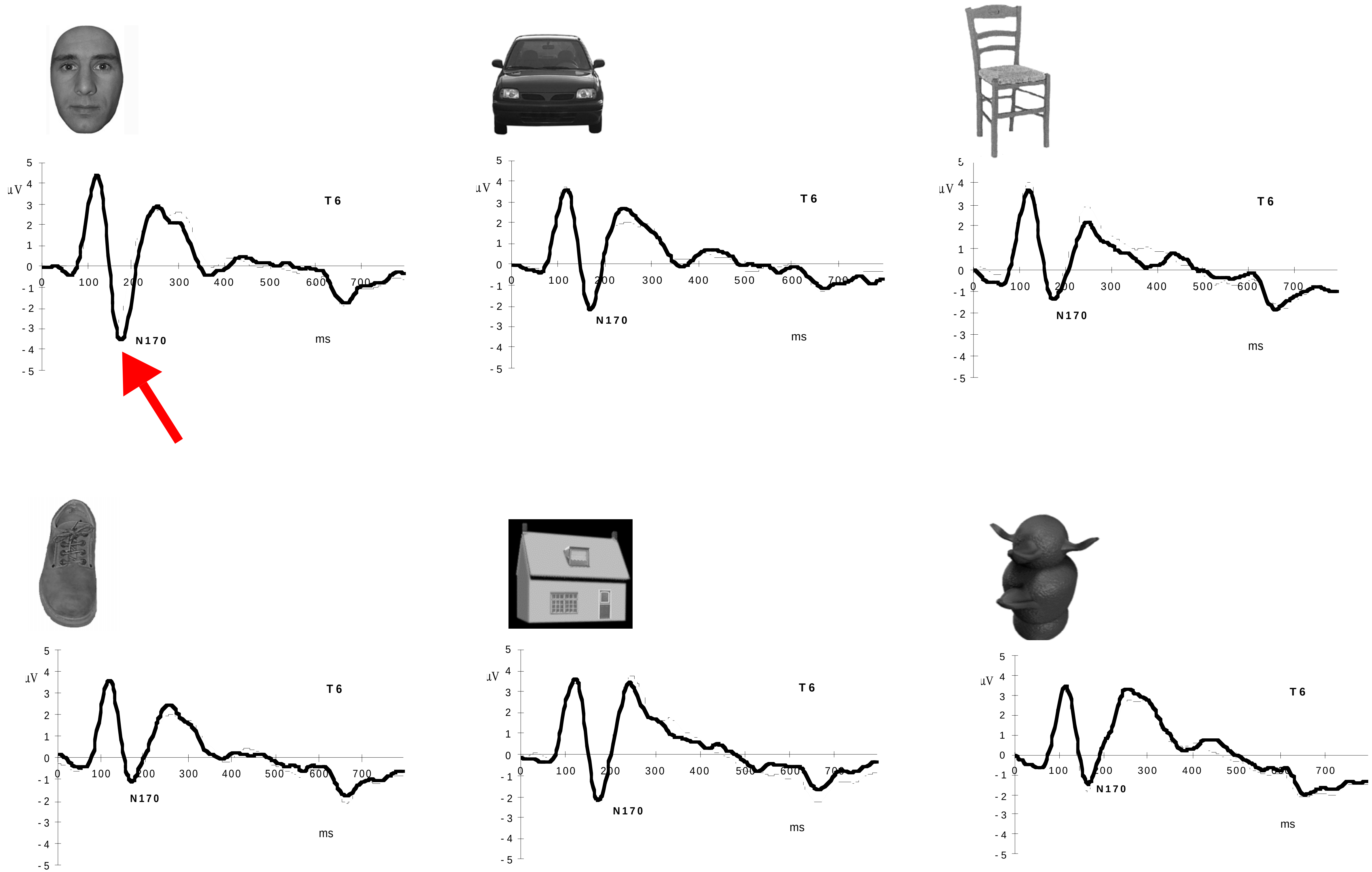
N170 delayed and larger for inverted faces as compared to upright faces.



Faces
Inverted faces

Absence of any orientation effect for the non-facial object categories

UPRIGHT
INVERTED



EXPERIMENT 2: Patient XB

XB is a 48 year-old male who sustained a closed head injury after being hit by a car 8 years ago. CT scans and MRI indicated bilateral temporal and occipito temporal contusions with a right hemisphere predominance.

Recent neuropsychological tests

- markedly impaired in verbal and visual **long term memory**.
- visual **short term memory** is impaired.
- **visual acuity** is perfect, as is contrast and color perception.
- perfect with **overlapping figures** and letters (BORB).
- excellent **copying** of objects.
- severly impaired at **recognizing and naming** line drawings, photographs and real objects; at an object decision task and in mental imagery tasks.

→ **XB can be defined as a visual *associative* agnosic.**

However, when tested with limited presentation times (10 sec. max) with novel objects (http://www.cog.brown.edu/~tarr/) or objects from a visually homogeneous category (e.g. discriminating among cars) presented *from different viewpoints*, he is markedly slow. He is also impaired at a *possible/impossible* object decision tasks.

→ **XB is impaired at extracting an invariant repesentation of an object.**

Tests of face processing

- Warrington test (face memory): 27/50
- Recognition of famous faces: 1/25
- **Benton test** (Benton & Van Allen, 1968): 40/54 (impaired, very slow; 34/48 for trials in which he has to match across changes in face viewpoint)
- **Face matching** on computer (3/4 and full-front facess presented simultaneously): 65%; 3718 ms (aged-matched control subjects: 96%, 2351 ms)
- Impaired at age and gender processing from faces, face expression.
- Absence of any inversion effect in AX or ABX tasks, with or without a memory component (delay between probe and target).

→ **XB is strongly impaired at recognizing faces from different viewpoints (test of structural encoding).**

Experiment 2: results

Patient XB showed a normal N170 for all object categories, larger for faces (same pattern as controls).

Peak Latencies (ms) of the N170 for patient XB and 14 control subjects.

	T6 (right hemisphere)				T5 (left hemisphere)			
	XB		CONTROLS		XB		CONTROLS	
	Upright	Inverted	Upright	Inverted	Upright	Inverted	Upright	Inverted
Faces	168	168	164	172	168	174 *	164	170
Greebles	164	162	166	164	170	170	162	166
Cars	164	164	166	167	170	172	164	164
Chairs	168	168	170	170	172	164	167	169
Houses	170	168	175	171	178	178	171	172
Shoes	162	162	166	166	168	166	165	166

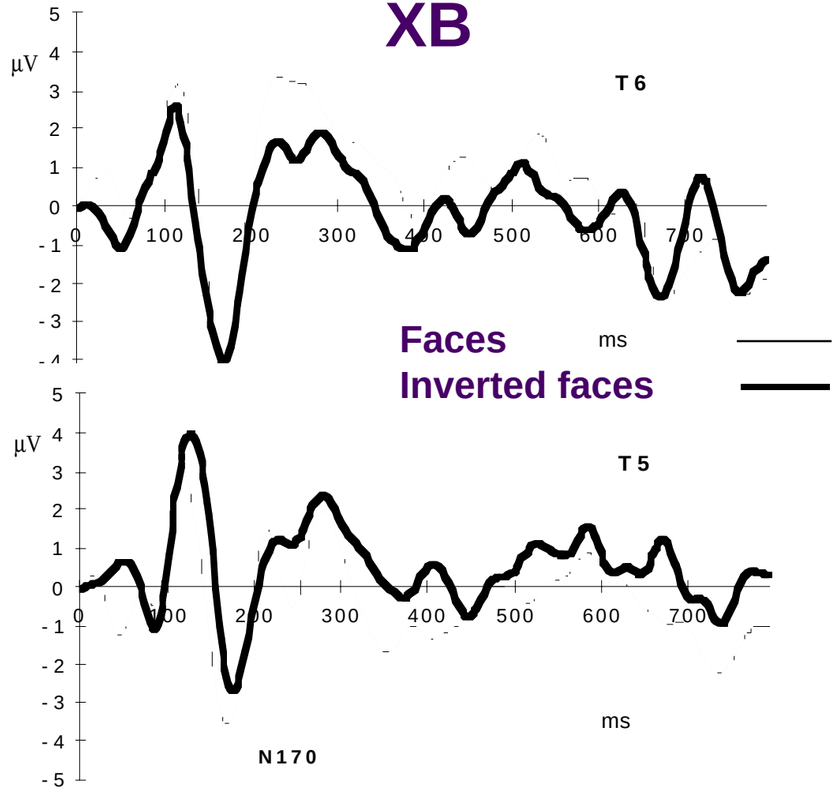
Amplitudes (mV) of the N170 for patient XB and 14 control subjects.

	T6 (right hemisphere)				T5 (left hemisphere)			
	XB		CONTROLS		XB		CONTROLS	
	Upright	Inverted	Upright	Inverted	Upright	Inverted	Upright	Inverted
Faces	-4.21	-4.03	-3.22	-4.65	-3.59	-2.67	-4.28	-5.48
Greebles	-3.45	-4.83	-2.31	-1.36	-3.18	-2.43	-2.72	-1.89
Cars	-3.06	-3.83	-3.34	-3.02	-2.69	-2.52	-2.95	-2.80
Chairs	-2.56	-3.54	-2.03	-2.27	-2.97	-2.94	-0.63	-1.69
Houses	-2.53	-1.53	-3.35	-2.50	-2.03	-1.32	-1.99	-1.82
Shoes	-2.98	-3.63	-1.43	-1.44	-1.59	-2.35	-1.55	-1.79

- As in normal subjects, the N170 was larger for faces then other objects for XB.
- The *only difference* between XB and controls is the absence of an N170 inversion effect for faces in XB (consistent with the absence of any behavioral inversion effect).

* The delay between normal and inverted faces at T5 for XB is due to a 8 ms delay for inverted faces at the P1 peak (see Figure 5). Such a P1 delay was absent for control subjects.

- **Considering only a subset of 8 of the male control subjects,** we observed a latency delay of the N170 peak for inverted faces in **all** subjects at T6 and T5 electrodes. The mean delay was 10.5 ms at T6 and 7.75 ms at T5.



Discussion

•**The N170 is not specific to faces**, as claimed in previous studies (4-5). Here it was obtained for a variety of nonface objects.

•**The N170 is larger to faces than to many control objects**, extending previous evidence (7, 8) *but the difference in voltage amplitude can be as large between non-facial categories (e.g. cars and shoes) than between faces and some categories (e.g. cars).*

→ The larger amplitude for inverted faces as compared to normal faces may be due either to the particular difficulty associated with inverted faces (14) or to the recruitment of both face- and object-selective regions for inverted faces, as evidenced recently by fMRI studies (15).

• **The N170 is delayed and enhanced for by inversion for faces**,but not for any other object category tested, confirming previous observations (12).

→ Loss of configural information, either by inversion (12, the present study), feature removal (7), presenta tion of isolated features (4) or induced-analytical strategy (10), may slow down facial processing analysis and delay the N170 component.

• **The N170 does not reflect a face or object structural encoding stage:** it is normal in amplitude and latency in a prosopagnosic patient strongly impaired at tasks involving the extraction of an invariant face (and object) representation.

→ The absence of any *electrophysiological difference* between normal and inverted faces at the level of the N170 in a prosopagnosic patient with no *behavioral inversion effect* supports the relation between the two effects: the behavioral inversion effect takes place very early, at a perceptual encoding stage in which the information necessery to distinguish between faces is encoded (but which occurs prior to face identification).

Conclusions

Our two experiments provid strong evidence against the hypothesis that the N170 reflects a face-specific structural encoding stage.

Neuroimaging experiments indicate that several occipito-temporal areas, particularly in the fusiform gyrus, are involved in face and object processing (1-3), and recent electrophysiological investigations show that the human fusiform gyrus is activated at 170 ms following face presentation (16). In line with these observations, we propose that the N170 may be better understood as an component related to object perception, whose amplitude may be category-related (but not category-specific).

The amplitude and the latency of the N170 are dependent on the extraction of configural information from faces, an ability (impaired with inversion) that seems to be dependent on subject expertise (17,20). The N170 face-inversion effect may be related to the face inversion effect (17,20) as well as the inversion effect in the fusiform face area observed with fMRI (3). Such effects have been associated with object expertise ratherthan face-specificity. The N170 inversion effect might be observed in future studies in experts presented with non-face objects belonging to their domain of expertise.

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