

Is the N170 ERP Component Face Specific?

Alan Robinson, Department of Cognitive Science, UC San Diego
(robinson@cogsci.ucsd.edu)

Joanna Morris, School of Cognitive Science, Hampshire College
(jmorris@hampshire.edu)

Abstract

Previous ERP studies have suggested the N170 ERP component is specific to the visual processing of faces. We measured ERP responses to the presentation of human heads in increasing lateral rotation, from full frontal views of the face through views of the back of the head. Of interest was if the N170 would still be present when subjects viewed the back of the head, and whether any systematic change would co-occur with rotation.

It was found that all views of the head produced statistically significant N170 responses, but the nature of those components varied. For occipital electrodes there was an increase in latency and a decrease in amplitude as rotation increased, but for parietal electrodes there was no constantly significant effect for rotation. This suggests that the N170 is not always a face specific response, though it is topographically sensitive to the presence of faces.

Background

There is a preponderance of evidence that human visual processing of faces is quantitatively different than for many other types of visual stimuli (Farah, et al., 1998). This evidence comes from both behavioral studies and brain imaging studies. What is not clear, however, is that these differences reflect unique aspects of processing of faces. Faces may be part of a small subset of stimuli that are processed uniquely in order to allow fine-level distinctions (Gauthier, et al., 1999).

Of particular interest to this study is the ERP literature on face processing, which initially suggested that the N170 component was only elicited by viewing human faces. This was taken as supporting evidence that face processing was unique (Bentin et al., 1996). More recent research, however, has shown that a great variety of non-face objects also elicit N170 components (Rossion et. al, 2000) though faces (or parts of faces, such as the eyes in isolation) consistently produce the largest amplitude components.

The presence of an N170 component, therefore, cannot, on its own, be used to support the existence of face specific processing. The question remains, however, if there are aspects of the N170 that are face specific. So far it has been shown that:

- Faces produce the largest amplitude N170 components, particularly for left temporal electrodes.
- Inverted faces produce higher latency and higher amplitude N170s; inverted non-face stimuli do not produce this effect (Rossion et. al, 2000).

Our Study

In this study we examined the N170 response to the lateral rotation of human heads. It is necessarily true that views of faces are also views of heads, so it is possible that the N170 is a response to detecting a head, and does not reflect face processing at all. Alternatively, showing different views of the face might elicit different N170 components, revealing an additional face-specific aspect of the N170 response. Our study addresses these hypotheses by measuring if either latency or amplitude co-vary with degrees of head rotation, and if views of the back of the head produce N170s.

Stimuli and Procedures

Subjects: 16 subjects successfully completed all trials and their data were included in the analysis. All subjects were run on the same stimuli, but the order of the stimuli was randomized for each subject.

ERP Recording: The EEG was recorded from 32 scalp sites according to the international 10-20 system using Ag/AgCl electrodes mounted in an electrode cap (QuikCap™ from NeuroSoft, Inc.) with respect to a linked mastoid reference. A common average reference was later computed offline. Horizontal and vertical eye movements were recorded using electrodes placed at the outer canthi and above and below the left eye. EEG and EOG were continuously acquired at a rate of 500Hz. Epochs were created from the continuous EEG beginning 200 ms before stimulus onset and ending 1000ms after stimulus presentation. The DC offset of individual sweeps were removed using an automatic baseline correction algorithm. DC levels were estimated using the pre-stimulus interval of the epoch. Epochs with eye movement artifacts greater than $\pm 50\mu\text{V}$ were removed from analysis.

Stimuli: ERPs were recorded for six conditions:

- Human heads presented at 0, 45, 90, 135, and 180 degrees of rotation.
- Circularly cropped pictures of cars.

Face stimuli were scaled such that the distance from the top of the head to the chin was constant, no matter what the view. Four unique heads were used, two male, two female. Head images were generated via computer models to ensure the angles of rotation were consistent between heads.

Presentation: Stimuli were displayed on a Macintosh computer with a 15" monitor at a distance of 2 feet, using SuperLab (version 2.0) Subjects each saw 1000 images of human heads, total, plus 120 non-head images (cars). Each picture was preceded by a fixation point at the center of the screen. A random ISI between 1.3 seconds and 2.0 seconds was imposed between presentations of each picture. Subjects were instructed to press a button each time they saw a car, ensuring they continued to focus on each picture throughout the experiment.

Component Analysis

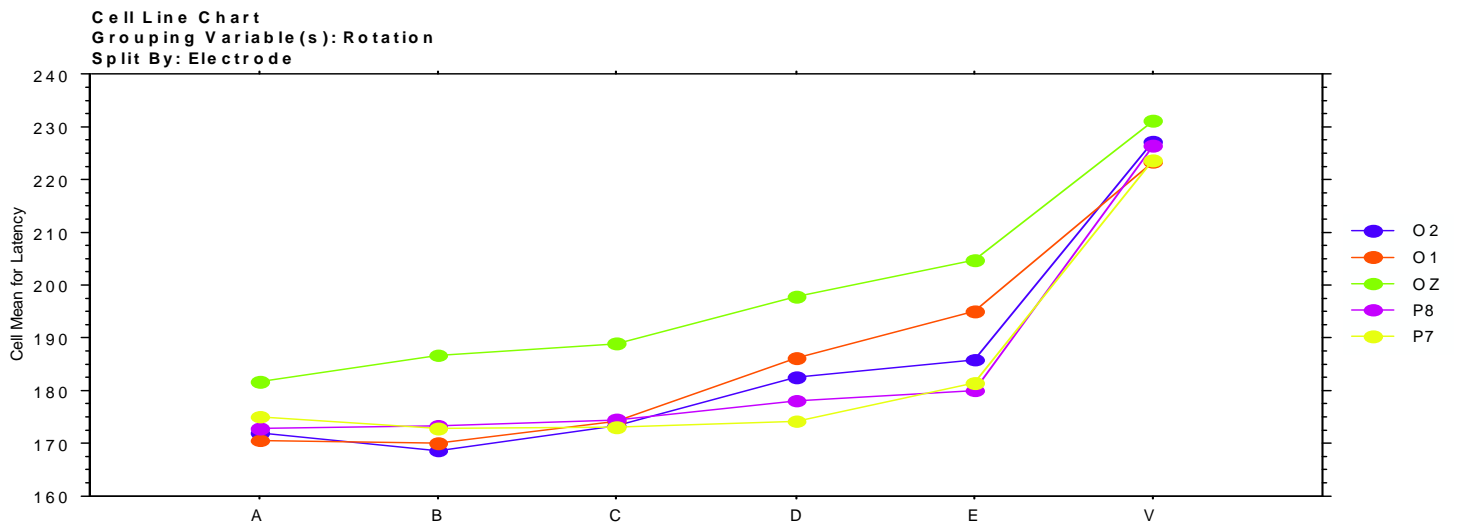
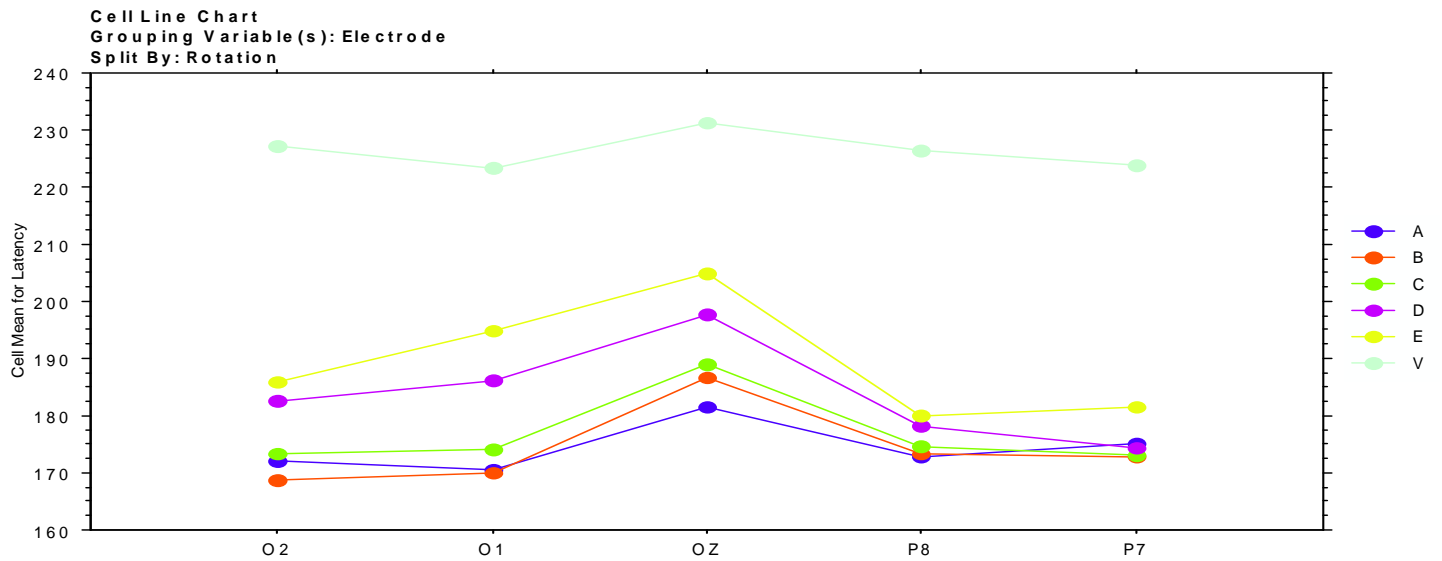
For each condition the amplitude and latency of N170 components were calculated from averaged epochs for electrodes O1, O2, OZ, P7 and P8. Components were extracted automatically by finding the most negative amplitude between 150 and 250 ms after stimulus presentation. Repeated measures ANOVA were performed separately for amplitude and latency.

Results

In the following graphs and tables, O1, O2, and OZ refer to the occipital electrodes. P7 and P8 refer to the parietal electrodes. Condition A refers to views of faces at 0° of rotation, condition B refers to faces at 45°, and so on to condition E which refers to views of faces at 180° (that is, the back of the head). Condition V refers to views of vehicles. Full discussion of the results follows the graphs and tables.

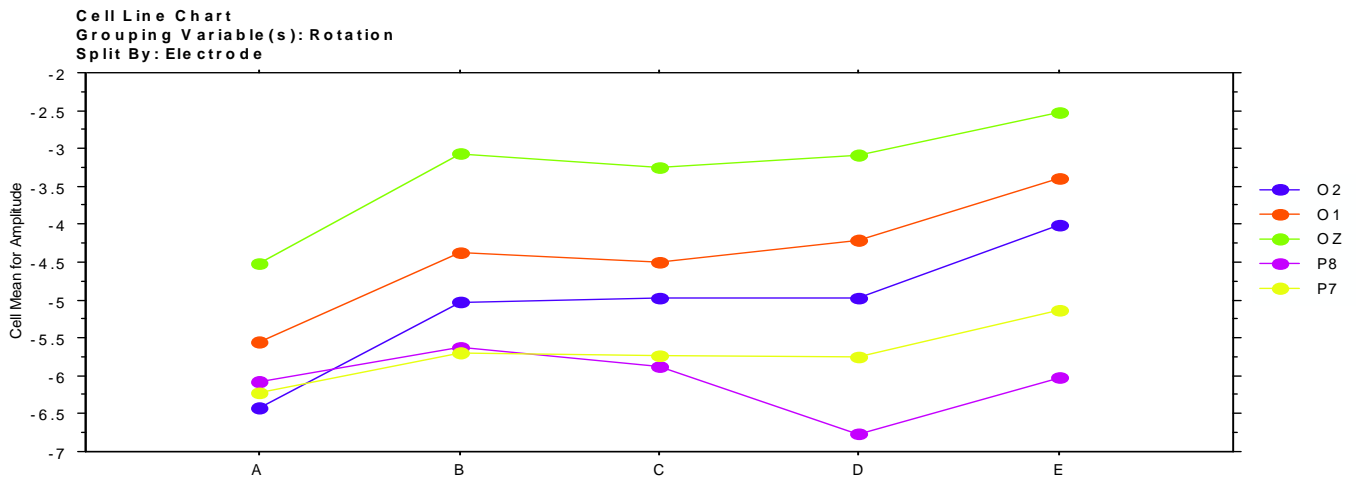
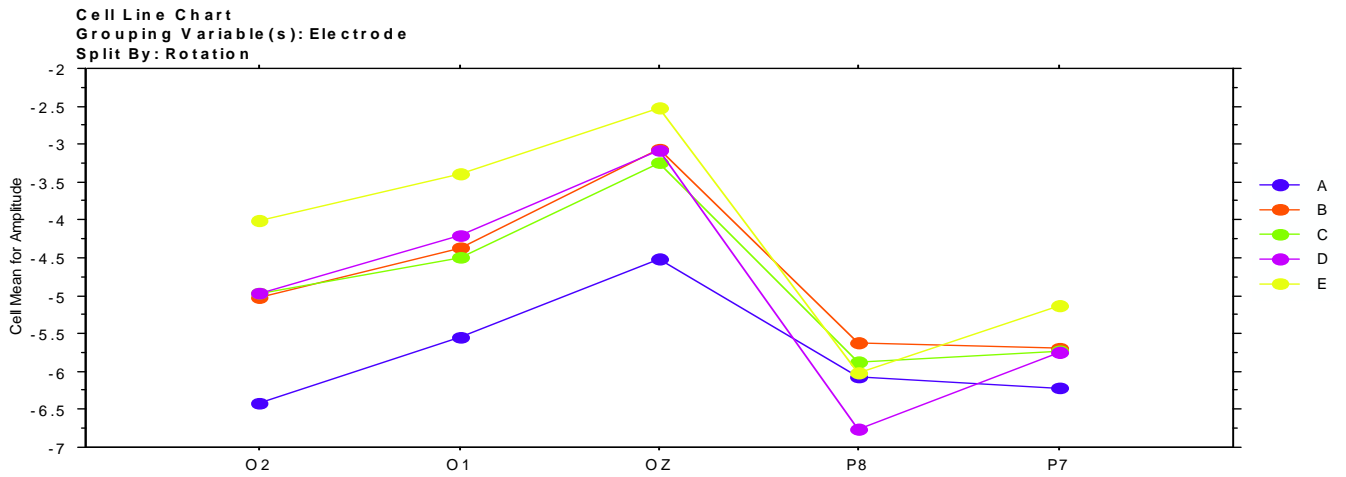
ANOVA Table for Latency

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Subject	15	65990.470	4399.365				
Rotation	4	14115.440	3528.860	19.123	<.0001	76.492	1.000
Rotation * Subject	60	11072.080	184.535				
Electrode	4	15612.140	3903.035	5.880	.0005	23.519	.982
Electrode * Subject	60	39828.180	663.803				
Rotation * Electrode	16	3946.160	246.635	2.020	.0127	32.313	.969
Rotation * Electrode * Subject	240	29309.520	122.123				

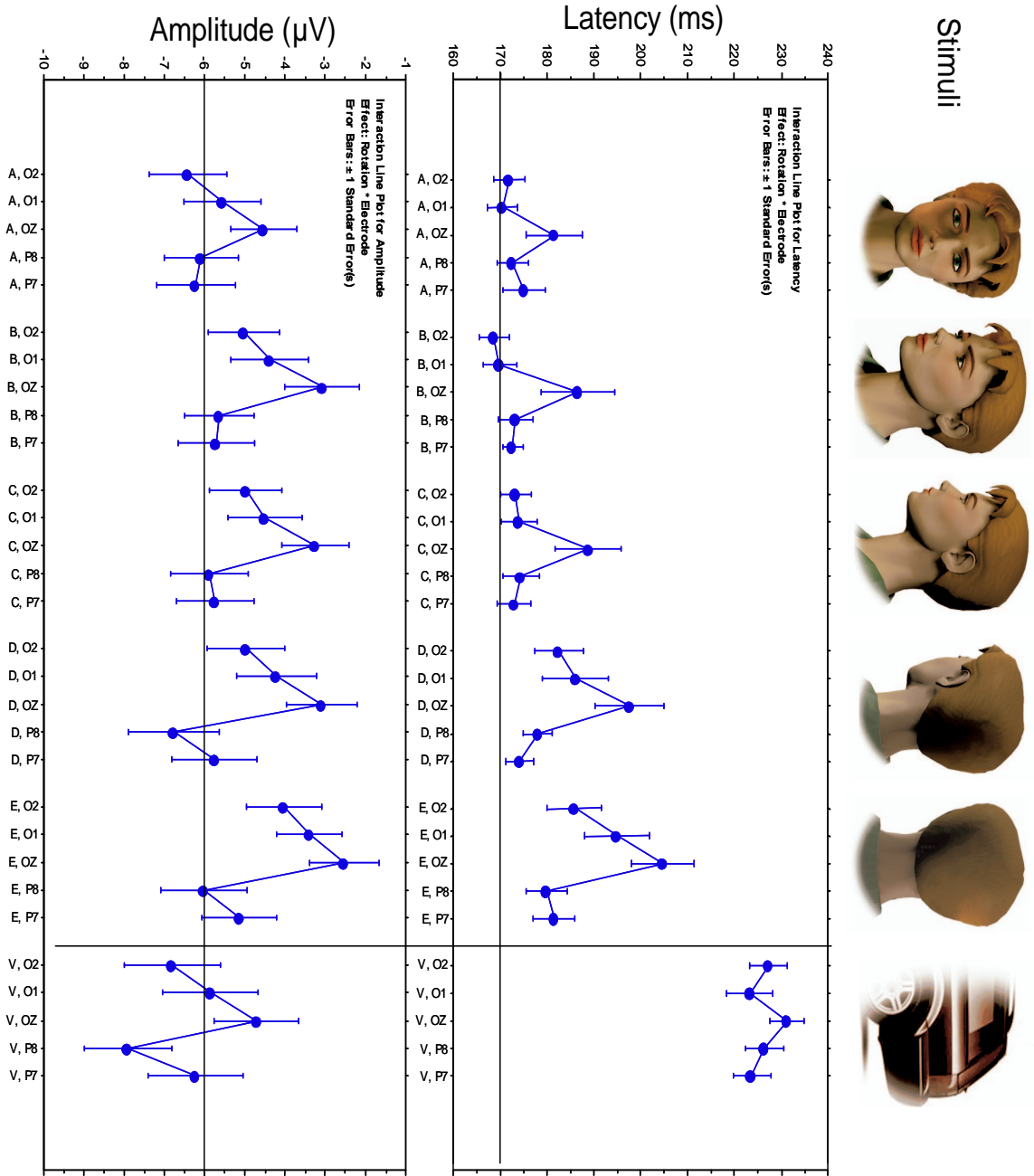


ANOVA Table for Amplitude

	DF	Sum of Squares	Mean Square	F-Value	P-Value	Lambda	Power
Subject	15	4338.837	289.256				
Rotation	4	98.076	24.519	12.987	<.0001	51.947	1.000
Rotation * Subject	60	113.281	1.888				
Electrode	4	391.722	97.930	8.364	<.0001	33.457	.999
Electrode * Subject	60	702.492	11.708				
Rotation * Electrode	16	43.454	2.716	3.989	<.0001	63.826	1.000
Rotation * Electrode * Subject	240	163.396	.681				



Combined summary of results



Results - Latency

Vehicles alone among the stimuli did not produce a negative deflection in the ERP waveform in the 170ms region.

We found a main effect of head rotation; as the face disappeared the latency of the average N170 component increased. This change was most pronounced for occipital electrodes (O1, O2, OZ), with parietal (P8, P7) latencies changing much less, and less consistently in co-variation with head rotation.

We compared latency for front and back views (0° and 180° rotations) of the head, using paired *t*-tests. For the 180° rotation, all occipital sites showed a significantly delayed N170 component. The N170 at the parietal electrodes, though delayed, showed much smaller effects of rotation, which were not always statistically significant (see following table depicting latency change from 0 to 180 degrees):

Electrode	Mean difference	P value	Bonferroni corrected P (x 5)
O2	14ms	0.004	0.02
O1	24ms	0.001	0.006
OZ	23ms	0.002	0.002
P8	7ms	0.036	0.18
P7	6ms	0.003	0.016

Results – Amplitude

We found a main effect of head rotation; with increased rotation the magnitude of the average N170 amplitude decreased. Following a similar pattern to the latency results, this change was most pronounced for occipital electrodes (O1, O2, OZ), with parietal electrodes (P8, P7) changing much less, and less consistently in co-variation with head rotation.

We compared response amplitude for front and back views of the head, using paired *t*-tests. For the 180° rotation, all occipital sites showed a significantly decreased N170 component. The N170 at the parietal electrodes, though slightly reduced in amplitude, showed much smaller effects of rotation, which were not statistically significant (see following table depicting amplitude change from 0 to 180 degrees):

Electrode	Mean difference	P value	Bonferroni corrected P (x 5)
O2	2.4 μ v	0.0003	0.0015
O1	2.2 μ v	0.0001	0.0005
OZ	2.0 μ v	0.0001	0.0005
P8	0.06 μ v	0.98	1+
P7	1.1 μ v	0.018	0.092

Conclusion

Our findings present clear evidence to suggest that the N170 does not respond to specific facial features as has been suggested by the "eye" or "gaze direction" detector hypothesis (Bentin, Allison, Puce, Perez & McCarthy, 1996; Puce, Smith & Allison, 2000) as heads rotated 180° with no visible facial features elicited a definite, albeit delayed and attenuated, N170.

We observed differences between the parietal and the occipital electrodes in terms of their N170 response to the different degrees of rotation—occipital electrodes showed delayed, attenuated responses with increasing rotation, while the parietal electrodes tended to be much less affected by rotation. We have formulated two hypotheses to explain these results.

One is that the N170 at the occipital electrodes may index a process that attempts to recognize a specific face and hence requires the presence of facial features to accomplish this task, whereas parietal activity reflects processing that merely recognizes a face/head as a category exemplar.

The other hypothesis is that the occipital electrodes might respond to the presence of facial features, an absolute cue to the presence of a face, while the parietal electrodes may respond to the probability of a face being present, taking into account a host of contextual cues including, but not limited to facial features. If other cues, e.g. the high frequency of face stimuli as opposed to other non-face stimuli such as cars appearing in an experimental context, suggest that a given object is a face, then one might expect an N170 even in the absence of facial features. We are currently testing this theory by running subjects in an experiment in which they will be exposed to only backs of heads among other non-face stimuli. In this case, one would expect a low amplitude and a long latency for the N170 in response to the back of a head for both the occipital and the parietal leads.

References

- Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy G. (1995) Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience*. Vol 8(6), 551-565.
- Farah, M. J., Wilson, Kevin D., Drain, M., Tanaka, J. N.(1998) What is "special" about face perception? *Psychological Review*. 105(3), pp. 482-498
- Gauthier, I., Tarr, M. J., Anderson, A. W., Skudlarski, P., & Gore, J. C. (1999). Activation of the middle fusiform "face area" increases with expertise in recognizing novel objects. *Nature Neuroscience*, 2(6), pp 568-573
- Puce, A., Smith, A., & Allison, T. (2000). ERPs evoked by viewing facial movements. *Cognitive Neuropsychology. Special Issue: The cognitive neuroscience of face processing*, 17(1-3), pp. 221-239
- Rossion, B., Gauthier, I., Tarr, M. J., Despland, P., Bruyer, R, Linotte, S., & Crommelinck, M. (2000). The N170 occipito-temporal component is delayed and enhanced to inverted faces but not to inverted objects: An electrophysiological account of face-specific processes in the human brain. *Neuroreport*, 11(1), 69-74.