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The M170 is selective for faces, not for expertise[☆]

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Abstract

Are the mechanisms for face perception selectively involved in processing faces per se, or do they also participate in the processing of any class of visual stimuli that share the same basic configuration and for which the observer has gained substantial visual expertise? Here we tested the effects of visual expertise on the face-selective "M170", a magnetoencephalography (MEG) response component that occurs 170 ms after stimulus onset and is involved in the identification of individual faces. In Experiment 1, cars did not elicit a higher M170 response (relative to control objects) in car experts compared to controls subjects. In Experiment 2, the M170 amplitude was correlated with successful face identification, but not with successful car identification in car experts. These results indicate that the early face processing mechanisms marked by the M170 are involved in the identification of faces in particular, not in the identification of any objects of expertise.

Keywords: Visual expertise; Face perception; MEG; Vision; Learning

Many researchers agree that that the mechanisms involved in face processing are "special", but few agree on what exactly these mechanisms are specialized for (Bentin & Carmel, 2002; Carmel & Bentin, 2002; Kanwisher, 2000; Liu & Chaudhuri, 2003; Rossion, Curran, & Gauthier, 2002a; Tarr & Gauthier, 2000). According to the *Face Specificity Hypothesis*, cognitive and neural machinery exists that is selectively involved in the perception of faces per se. According to the *Expertise Hypothesis*, however, those mechanisms that appear to be selectively involved in face perception are in fact engaged more generally in the identification of any class of visual stimuli that share the same basic configuration and for which the subject has gained substantial visual expertise (Diamond & Carey, 1986; Gauthier, Skudlarski, Gore & Anderson, 2000). Note that these hypotheses concern the functional specificity of face processing mechanisms in adults, not the origin of those mechanisms in development. Because domain-specific mechanisms can in principle arise from experience-based self-organization (Jacobs, 1999), without any specific genetic blueprint for the mechanism in question, the question of adult functional specificity is orthogonal to the question of developmental origins. Here we used the face-selective M170 response recorded with magnetoencephalography (MEG) to test two predictions of the *Expertise Hypothesis*: (1) That the amplitude of the face-selective M170 response to visually presented cars will be elevated (relative to other objects) in car experts compared to nonexpert control subjects, and (2) that the amplitude of the M170 will be correlated with successful car identification in car experts.

Unlike fMRI measures of visual expertise (Gauthier et al., 2000; Xu, 2004), which sum activity over many stages of processing (both those involved in visual recognition, and those occurring subsequently), event-related potentials (ERPs) and

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MEG have very high temporal resolution and can be used to selectively query processes occurring at specific latencies after stimulus presentation. Prior work with MEG and ERPs has characterized a response component called the N170 (or M170 in MEG) that occurs around 170 ms after stimulus onset, and is about twice as large for face stimuli as for a variety of control nonface stimuli such as hands, houses or animals (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Jeffreys, 1996; Liu, Higuchi, Marantz, & Kanwisher, 2000; Sams, Hietanen, Hari, Ilmoniemi, & Lounasmaa, 1997; see also Bentin & Golland, 2002). The face-selective M170 has also been directly linked to face identification (Liu, Harris & Kanwisher, 2002): A trial-by-trial correlation was found between M170 amplitude and success on a face (but not house) identification task. The relatively early latency of the M170 combined with the evidence linking it to face identification make this response component an ideal marker for testing the expertise hypothesis.

Three prior studies have reported effects of expertise on the N170 response recorded with ERPs (Gauthier, Curran, Curby, & Collins, 2003; Rossion, Gauthier, Goffaux, Tarr & Crommelinck, 2002b; Tanaka & Curran, 2001). Tanaka and Curran (2001) reported that the N170 response to birds and dogs was higher in experts than novice subjects. However, the sensors that showed this expertise effect were not tested for face selectivity. As the authors themselves noted, “the N170 for objects of expertise may be distributed slightly more superiorly and posteriorly than the N170 for faces (p. 45)”. Thus, this paper may show a *dissociation*, not an *association*, between the processing of faces and of objects of expertise. Moreover, birds and dogs have faces. Showing an expertise effects with ‘facelike’ stimuli can simply reflect the ability of face mechanisms to be recruited for facelike stimuli after training; such effects do not address the ability of face mechanisms to be recruited for the processing of non-facelike stimuli after acquisition of visual expertise.

Rossion et al. (2002b) tested faces and greebles, and found that after extensive training, the N170 latency delay for inverted versus upright greebles was comparable to the inverted versus upright latency delay observed for faces. Rossion et al. also observed a small N170 amplitude modulation in greebles after training, similar to those reported by Tanaka and Curran (2001). However, the expertise effect observed in the N170 latency for greebles after training was much stronger over the left than the right hemisphere. This finding is not consistent with prior ERP (Gauthier, Tarr, Anderson, Skudlarski & Gore, 1999) and fMRI (Gauthier et al., 2000; Xu, 2004) studies, which show that expertise effects are either found exclusively in the right hemisphere or are bilateral. Moreover, greebles resemble faces in their structure, and indeed Rossion et al.’s own data suggest that they are processed as faces even before training: The N170 amplitude to these stimuli was 84% as high as for faces, whereas prior studies have reported no N170 response for nonfaces (Bentin et al., 1996). These data indicate that either the sensors examined were not very face-selective, or even before training greebles evoked some of the same mechanisms used in face processing (which may be later enhanced during expertise training). Either situation renders this study unhelpful in testing the critical prediction of the expertise hypothesis: That face-specific mechanisms can be strongly engaged by stimuli that do not resemble faces after extensive experience with those stimuli.

Table 1
Information on the participants for the present study

	N	Age (S.E.)	Years of car expertise	Car match d' (S.E.)	
				Upright	Inverted
Car experts	9	31.6 (3.1)	23.8 (3.5)	2.87 (0.26)	2.00 (0.22)
Controls	9	29.2 (2.2)	–	1.16 (0.13)	0.72 (0.15)

Gauthier et al. (2003) studied holistic processing of faces and cars in novices and car experts. They found that car perception interfered with concurrent face perception in car experts using both behavioral and ERP measures, and that the amount of interference was correlated with the degree of car expertise in the car experts. However, as in Tanaka and Curran (2001) and Rossion et al. (2002b), face-selective sensors were not independently localized in Gauthier et al. (2003). In fact, the N170 response they reported was not much higher for faces than that for cars even in novices (Fig. 3a of Gauthier et al., 2003), raising the question of whether the sensors examined by Gauthier et al. were face selective. Given the lack of evidence for face selectivity at these sensors, data collected from them cannot test the hypothesis that face-selective mechanisms are engaged by objects of expertise. In addition, although Gauthier et al. reported a strong correlation between the amount of car interference on face perception and the degree of behavioral car expertise, if we examine the amount of car interference on face perception by subject group, there was actually no difference between experts and the controls (if anything, the effect was in the opposite direction as predicted by the expertise hypothesis, see Table 1, Gauthier et al., 2003). This inconsistency raises serious questions about the behavioral results reported by Gauthier et al.

To summarize, of the three prior ERP studies of expertise, two used face-like stimuli, which cannot test the Expertise Hypothesis (which holds that face-specific mechanisms can become engaged on stimuli that do not resemble faces after experience with these stimuli). In addition, none of the three prior studies provide evidence that the sensors that show the putative expertise effects are also face-selective. This is an important shortcoming, because only a subset of the scalp locations over occipitotemporal cortex that produce N170 and M170 responses are face-selective, and it is only these face-selective responses that are relevant for testing the expertise hypothesis. Thus, past ERP studies have not shown that face selective mechanisms are also engaged by objects of expertise. For a critical review of these and other studies often cited as evidence for the expertise hypothesis, see McKone and Kanwisher (in press).

In the two experiments that we report here, we first localized face-selective "sensors of interest" (SOIs) in the occipitotemporal cortex in each subject individually (see Section 1). Next, we measured the amplitude of the M170 response to new stimulus conditions in these face-selective sensors in both car experts and control subjects. In Experiment 1, both car experts and control subjects passively viewed profile views of faces, cars, and shoes. In Experiment 2, the car experts identified partially phase-scrambled face and car stimuli. These stimuli were designed to bring performance to threshold, enabling us to measure the trial-by-trial correlation between the M170 amplitude and successful identification of faces and of cars.

Because prior work has established a trial-by-trial correlation between the M170 and face identification performance, but not house identification performance (Liu et al., 2002), the M170 is the ideal marker for testing between the *Expertise* and *Face Specificity Hypotheses*. The *Expertise Hypothesis* predicts that the amplitude of the M170 will be higher for cars (relative to control objects) in car experts than in control subjects. This hypothesis also predicts that the M170 response to car stimuli will be higher on trials in which the subject correctly identifies the cars than on trials in which they do not, just as Liu et al. (2002) found for faces. Note that this is a critical test of the expertise hypothesis, because it asks whether any expertise effects measured neurally are related to behavioral performance. If the M170 reflects processing critical to the identification of objects of expertise, then it should be not only higher in amplitude overall for objects of expertise, but also correlated trial by trial with identification of objects of expertise (as it is with identification of faces). The *Face Specificity Hypothesis* predicts that the amplitude of the face-selective M170 in car experts will be no higher for cars than for control objects, and no higher for correct compared to incorrect car identification trials.

Consistent with the *Face Specificity Hypothesis*, in Experiment 1 we found that cars did not elicit a higher M170 response (relative to control objects) in car experts compared to control subjects. In Experiment 2 we found that while the amplitude of the M170 was correlated with successful face identification as reported in a previous study (Liu et al., 2002), it was not correlated with successful car identification in car experts. Together, these results indicate that early face processing mechanisms are involved in the identification of faces in particular, not in the identification of any objects of expertise.

1. Materials and methods

1.1. Subjects

Nine car experts (age 21–50, all males, eight right-handed and one left-handed) and nine controls (age 22–43, five females and four males, all right-handed) were recruited. The car experts were recruited from the BMW Club of Boston. The controls were recruited from the MIT campus. Subjects were paid for taking part in the experiment. All subjects participated in Experiment 1. Eight of the nine car experts participated in Experiment 2. Informed consent was obtained from all subjects and the study was approved by MIT committee on the Use of Humans as Experimental Subjects.

All participants took a car discrimination test to quantify their expertise for cars (Gauthier et al., 2000). In this test, the subjects judged whether pairs of car images presented sequentially either both upright or both inverted were the same model (they could be from different years).

1.2. Stimuli and procedure

For the localizer scan, images of front-view faces, houses, and hands were used. There were 50 different images for each category and 100 trials were presented for each category. Each image subtended 5.7° × 5.7° of visual angle and was presented at the center of gaze for a duration of 200 ms. The inter-stimulus intervals (ISIs) were randomized from 600 to 1000 ms (800 ms on average). Subjects fixated on a black dot continuously present in the center, and passively viewed stimuli displayed in a pseudorandom order. *t*-Tests were then conducted between face trials and hand and house trials at each time point and at each of the 96 sensors for each subject. Sensors where the M170 evoked by faces was significantly larger than that by houses and hands ($P < 0.05$) for at least five consecutive time points within a time window (typical width <50 ms) centered at its peak response for that subject were defined as Sensors of Interest (SOI). All critical claims in this paper were based on the analysis of the pooled response across these sensors (which were selected based on the independent dataset of the localizer experiment). This sensor-of-interest approach increased our statistical power by constraining our hypotheses in advance, analogous to the region of interest (ROI) approach used in fMRI. Because statistical tests were conducted on only one region or set of sensors (averaged together and treated as a single value), instead of conducting a test separately for each sensor, there was only one statistical test conducted for each hypothesis. Hence, there was no need to correct for multiple spatial/temporal hypotheses.

In Experiment 1, images of profile view faces, side view cars and side view shoes were used. All the faces were male Caucasian faces; all the car images were from cars made approximately between 1990 and 2002, and all the shoe images were of men's sneakers made approximately between 2000 and 2002. There were 50 different exemplars of each stimulus category and 200 trials were presented for each category. Subjects passively viewed images displayed on a screen with trials from different categories presented in a pseudorandom order. Each image was presented for 200 ms, and the mean ISI was 800 ms (ranging from 600 to 1000 ms).

In Experiment 2, the front and profile views of five male Caucasian faces, and the side and 3/4 views of five hatchback cars were used. The images were phase-scrambled following

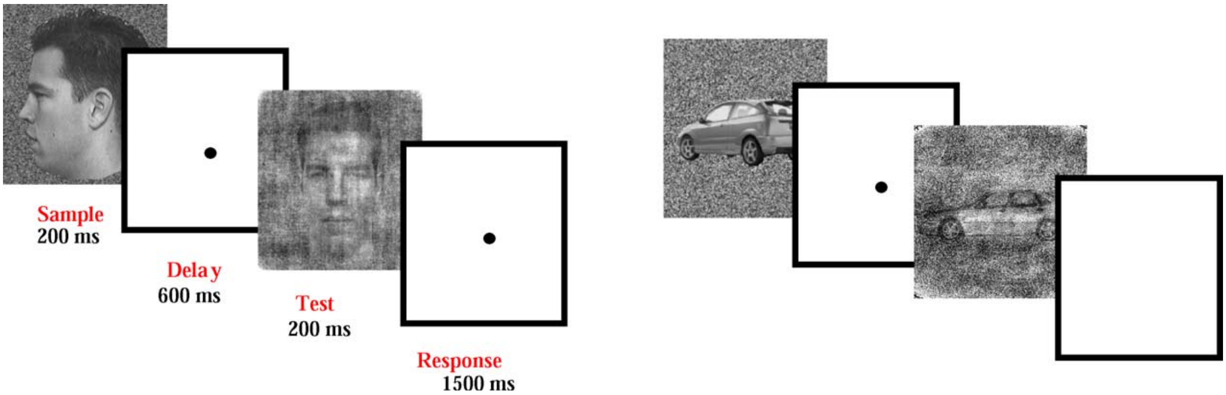


Fig. 1. Example stimuli and sequence of events in each trial in Experiment 2. Subjects were asked to indicate whether the sample and the test stimuli were different views of the same person or the same car by pressing a response button.

a procedure used previously (see Liu et al., 2002, based on the "Rise" method in Sadr & Sinha, 2001), ensuring that all images were equated for spatial frequency, luminance and contrast. Subjects were first instructed to match each front view face and side view car with its profile or 3/4 view respectively outside the MEG scanner until they reached 100% accuracy for six consecutive trials of the same image pair (<10 min). A psychophysical staircase adjustment session was then conducted in the MEG scanner (about 30 min) before the MEG recordings. For each trial, the first image (a nonscrambled image of either a face profile or a 3/4 view car) was presented for 200 ms, followed by a 600 ms blank, and then the probe image (a phase-scrambled front view face or a phase-scrambled side view car) was presented for 200 ms (see Fig. 1 for an example). Subjects had 1500 ms before the presentation of the next trial to judge whether the two images were from the same individual or car. By measuring response accuracy, we constructed five threshold front-view face stimuli and five threshold side-view car stimuli individually for each subject. In the MEG recording session, subjects performed the same identity-matching task except that the phase coherence of probe images were not changed based on the subjects' responses, but pre-assigned from the previous psychophysical session. There were a total of 130 trials for each category. More details of the experimental procedure may be found in Liu et al. (2002).

1.3. MEG recordings and data processing

Continuous magnetic brain activity was recorded from a 96-channel whole-head system with SQUID-based first-order gradiometer sensors (Kanazawa Institute of Technology MEG system at the KIT/MIT MEG Joint Research Lab at MIT). A schematic illustration of the MEG sensor locations is shown in Fig. 2. An active magnetic shielding system (designed by Vacuumschmelze, Hanau, Germany) and a continuously adjusted least-squares method (CALM) noise reduction device were used to increase signal/noise ratio.

The MEG responses were sampled at 500 Hz and filtered with a frequency bandpass of 1–100 Hz and a 60 Hz notch. The recordings were further processed off-line with a digital 3 Hz highpass filter and smoothed by a 17-point Hanning window filter, and the baseline shift of individual trials was removed by subtracting the mean magnetic field level of the pre-stimulus interval of the epoch (from −100 to 0 ms) on each trail from the value of all time points in that trial. Trials were discarded whenever the MEG signals exceeded 3000 ft/cm (for most subjects, fewer than 5% trials were rejected) (Picton, 2000). The peak amplitudes (maximum deflection) and peak latencies of specific MEG components within bounding intervals were calculated for each stimulus type in each hemisphere for each subject. In Experiment 1, these values were normalized to match the amplitude of the face response across subjects before averaging across subjects. (The pattern of the data and the statistical results were very similar when the data were analyzed without such normalization.) In both experiments the sign of the amplitude of the right hemisphere M170 response was reversed to match polarities across hemispheres before averaging over hemispheres (Liu et al., 2002).

2. Results

We tested nine car experts and nine control subjects in Experiment 1, and eight of the nine car experts in Experiment 2. The results from the car discrimination test (to quantify the car expertise of the subjects) are shown in Table 1. Performance was better in car experts than controls, $F(1,16) = 31.90$, $P < 0.001$, and better with upright than inverted cars, $F(1,16) = 56.68$, $P < 0.001$. Subject group and car orientation also interacted significantly ($F(1,16) = 6.39$, $P < 0.05$). This interaction, however, was absent when performance was measured in % correct (as in Diamond & Carey, 1986): Experts, up-90%, inv.-82%; controls, up-71%, inv.-63%.

2.1. Localizer scan

All subjects passively viewed images of front-view faces, houses, and hands presented in a random order. Following

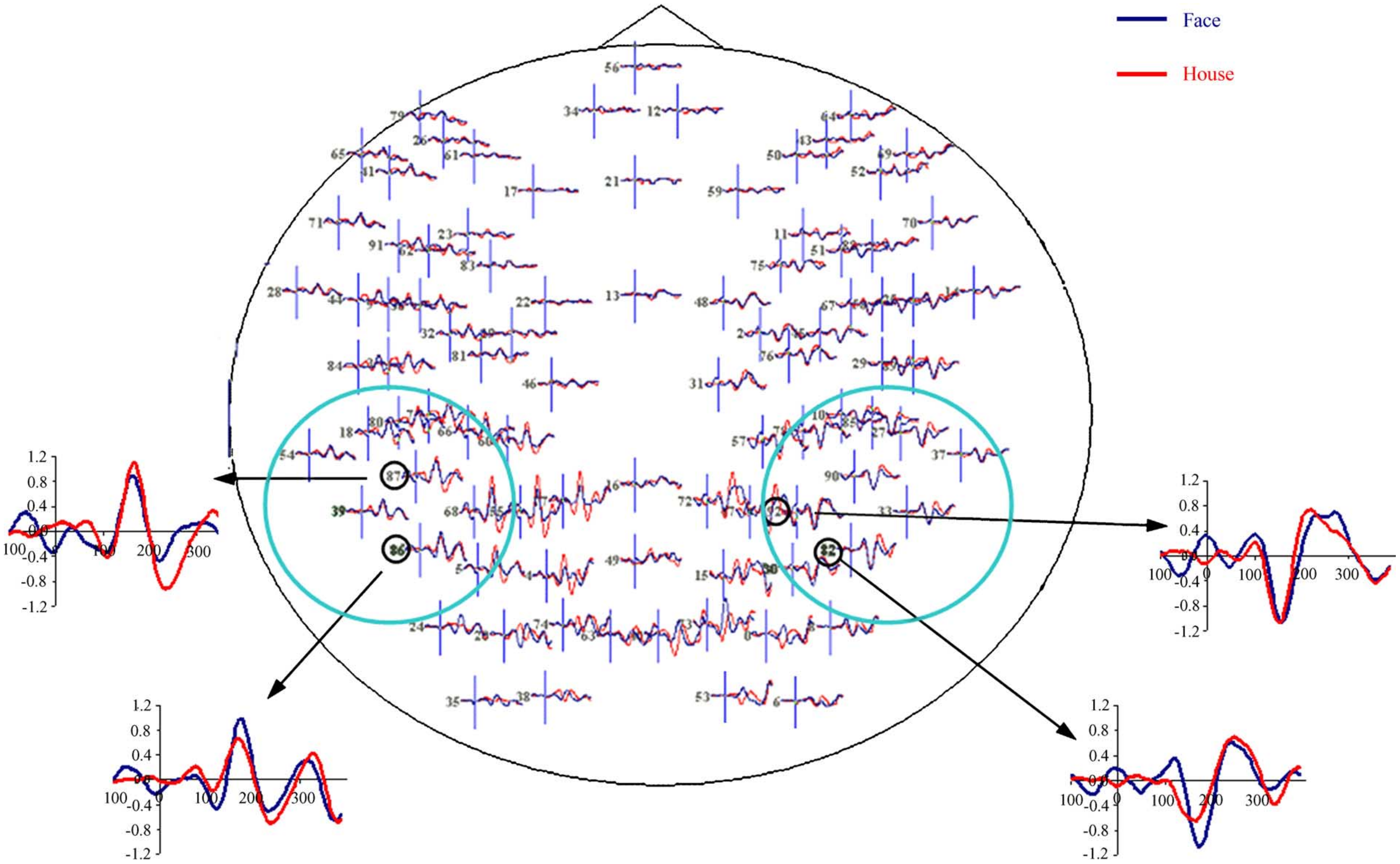
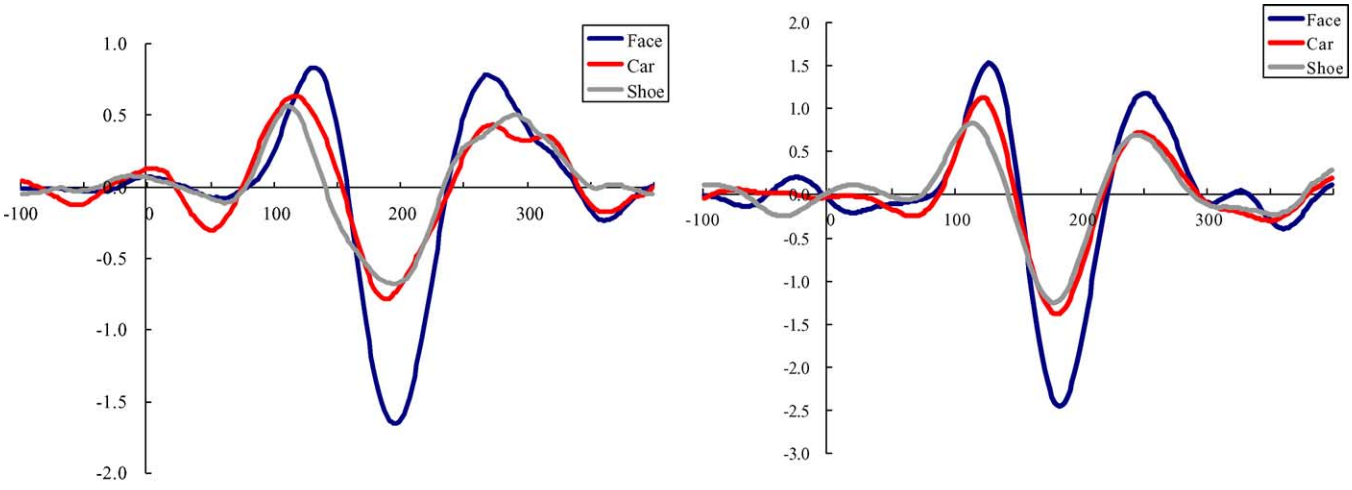


Fig. 2. Examples of MEG sensors showing the response to faces and houses in one subject. Sensors that showed significantly higher responses for faces than houses (e.g. sensors 86 and 30 in this subject) were located over occipitotemporal cortex, approximately corresponding to PO7/8 and P7/8 in a 10-10 EEG system. Note that some sensors showed an M170 response that was not face selective (e.g., sensor number 92), and other sensors even showed a preference for houses over faces (e.g., sensor 87).

Table 2
The face-select M170 amplitude ($\times 10^{-13}$ T) to faces, cars and shoes from each subject (non-normalized) in Experiment 1

Experts	Face		Car		Shoe		Controls	Face		Car		Shoe	
	Right	Left	Right	Left	Right	Left		Right	Left	Right	Left	Right	Left
1	3.75	2.28	1.69	1.41	1.58	1.20	1	1.60	1.46	0.80	0.52	0.88	0.92
2	1.09	0.86	0.37	0.56	0.53	0.62	2	2.69	4.46	1.58	2.40	1.20	2.32
3	1.66	1.72	0.77	1.25	0.97	1.01	3	1.64	3.87	1.17	1.98	0.63	2.71
4	0.74	1.72	0.68	0.83	0.83	1.06	4	1.85	1.54	1.54	1.02	1.19	0.96
5	1.68	1.07	0.93	1.23	0.77	0.78	5	2.63	5.12	1.61	2.98	1.10	3.07
6	1.67	1.43	1.09	0.79	1.07	0.78	6	2.31	2.44	1.48	1.76	1.49	1.25
7	2.62	3.16	1.79	2.15	1.59	1.99	7	1.97	3.62	1.67	2.72	0.96	2.26
8	2.24	1.95	1.56	1.52	0.82	1.01	8	1.98	1.94	0.50	1.32	0.60	1.13
9	3.04	3.02	1.92	2.15	1.69	1.98	9	3.36	3.53	2.26	3.18	3.04	2.55



(A) Car Experts

(B) Controls

Fig. 3. The raw time course of SOI responses averaged over car experts (A) and controls (B).

a procedure used previously (Liu et al., 2002), we located SOIs over the occipitotemporal region that had a significantly higher response to faces than to hands or houses ($P < 0.05$) in each subject (see Fig. 2 for an example). On average, we found six SOIs in each subject in the left hemisphere and seven in the right, and neither the main effect of subject group nor hemisphere nor their interaction produced significant effects on the number of SOIs identified ($P > 0.05$).

2.2. *Experiment 1*

In this experiment all subjects passively viewed profile views of faces and side views of cars and shoes presented in a pseudorandom order. We first asked whether the face-selective M170 response to cars is affected by expertise for cars. The raw data from each subject are presented in Table 2 and the means are plotted in Fig. 3. Overall the amplitude of the M170 response trended toward being higher in controls than in car experts, $F(1,16) = 3.03$, $P = 0.10$. To remove any bias against an expertise effect that may result from the overall lower M170 responses in experts than controls, we normalized the amplitude of the M170 response to each subject's face response (i.e., face response was "1"). All the statistical results reported below were very similar for the normalized and the non-normalized data.

Fig. 4 shows the normalized amplitude of the M170 response to each condition for car experts and control subjects. There was an overall main effect of stimulus type, due to a higher response to faces than to cars and shoes, $F(2,32) = 120.52$, $P < 0.001$; a pairwise analysis also found a trend of a higher M170 amplitude for cars than shoes, $F(1,16) = 3.31$, $P < 0.10$. However, the critical interaction of subject group by stimulus type (cars versus shoes) was not even close to significant ($F(2,32) = 1.33$, $P > 0.28$). Separate analyses of the right and left hemispheres alone also failed to find an interaction between subject group and stimulus type (cars versus shoes) in either hemisphere, $F < 1$. The 3-way interaction of hemisphere, subject group, and stimulus type, was not significant either ($F(2,32) = 1.04$, $P > 0.30$).

The mean M170 latency (in ms) and SD for faces, cars, and shoes were as follows: for car experts, 195 (15), 193

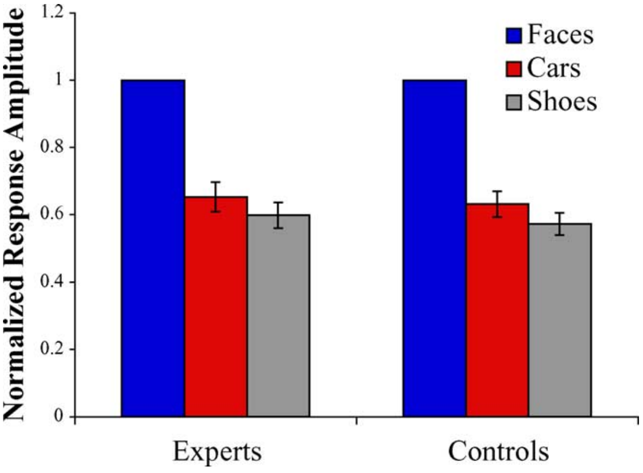


Fig. 4. The face-selective M170 results of Experiment 1 with mean amplitude of the M170 response normalized for each subject to the face response amplitude and then averaged over all face selective sensors. No significant interaction of stimulus type (cars vs. shoes) and subject group (experts vs. controls) was found, indicating the absence of an car expertise effect on the M170 response to cars.

(17), 193 (20); and for controls, 189 (15), 187 (18), 182 (16), respectively.[1] The interaction of subject group and stimulus type (cars versus shoes) was not significant, $F \ll 1$. The above data thus provide no evidence for the *Expertise Hypothesis*.

We also examined the response in the most face-selective sensors in each hemisphere from each participant and repeated the above analyses. The most face-selective sensors (1 per subject per hemisphere) were chosen based on the criteria that they had the highest ratio of face M170 amplitude to house M170 amplitude (they usually also had the strongest significance levels for the t-test comparing the M170 amplitude for faces versus houses). These sensors were usually located at the center of the SOI cluster. Although the overall M170 amplitude was higher, virtually the same response pattern was observed. Again, there was no interaction between the level of car expertise (car experts versus controls) and stimulus category (cars versus shoes), $F < 1$.

Several further efforts to find effects of expertise were also unsuccessful. First, we found no correlation across the 18 subjects between the M170 response to cars minus shoes normalized by the face response, i.e. (cars − shoes)/faces, and car expertise d' obtained from the behavioral test (Fig. 5; for the left hemisphere, $r = 0.29$, $P = 0.24$, and for the right hemisphere, $r = 0.08$, $P = 0.76$. Note that the $r = 0.29$ correlation in the left hemisphere was mainly driven by the data point on the upper right corner. When this data point was removed, the correlation value became: $r = 0.09$ and $P = 0.74$). Next, we examined the MEG response components before and after the M170 (i.e., the M100 & P2) in the face-selective sensors and repeated all the above analyses, again failing to find any expertise effects, all $F < 1$. Last, we examined MEG responses recorded from each sensor individually. We conducted t-tests between faces and shoes (Fig. 6, top) and between cars and shoes (Fig. 6, bottom) at each MEG sensor at each time point independently. By interpolating the t values between sensors, we obtained statistical maps for each latency. Once again, we failed to observe expertise effects. Fig. 6 shows the statistical map for the car expert with the highest behavioral car expertise.

Thus, expertise for cars does not increase the amplitude of the face-selective M170 response to cars. This finding is consistent with the *Face Specificity Hypothesis*, but not the *Expertise Hypothesis*.

2.3. Experiment 2

It is possible that although expertise for cars does not increase the overall amplitude of the face-selective M170 response under the passive viewing condition in Experiment 1, the magnitude of this M170 response to cars may nonetheless be correlated trial-by-trial with successful car identification in car experts. Experiment 2 tested this possibility.

In this experiment, we used front and profile views of five male Caucasian faces, and side and 3/4 views of five hatchback cars. Following the procedure of Liu et al. (2002), we first constructed five threshold front-view face stimuli and 5 threshold side-view car stimuli individually for each subject (see Section 1). The average thresholds (percentage of phase coherence) over all subjects were 50.1 and 45.7% for face and car identification, respectively. The difference in thresholds between the two was not significant, $t(7) < 1$.

During MEG recording, subjects performed identity-matching task (Fig. 1). The mean behavioral accuracy of identifying faces and cars (guessing corrected) were 55.4% and 50.5%, respectively. The difference between the two was not significant, $t(7) < 1$. To obtain the MEG correlates of successful identification, we compared the amplitude of the M170 response in the face-selective SOIs defined in our localizer scan to the same test image when the subject correctly identified it versus when he incorrectly identified it.

The raw data from each subject are shown in Table 3 and the averaged results are shown in Fig. 7. The M170 amplitude in the face-selective SOIs was significantly higher for correct than incorrect face identification trials, $F(1,7) = 36.59$, $P < 0.002$, replicating earlier findings (Liu et al., 2002). The M170 amplitude in these car experts, however, was not significantly higher for correct than incorrect trials in the car identification task, $F(1,7) = 1.38$, $P > 0.25$. The interaction between stimulus category (faces versus cars) and correct versus incorrect identification was significant, $F(1,7) = 11.1$, $P < 0.05$. These results argue against a role for the face-selective M170 in car identification in car experts.

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[1] In the ERP literature the reported latency of the N170 response to faces has generally ranged from 156 ms to 189 ms (156 in Rossion et al., 1999; 162 ms in Taylor, McCarthy, Saliba, & Degiovanni, 1999; 172 ms in Bentin et al., 1996; 189 ms in George, Evans, Fiori, Davidoff, & Renault, 1996). For example, George et al. (1996) reported the N170 peak latency to be 189 ms, which was very close to the latency we found in the present study.

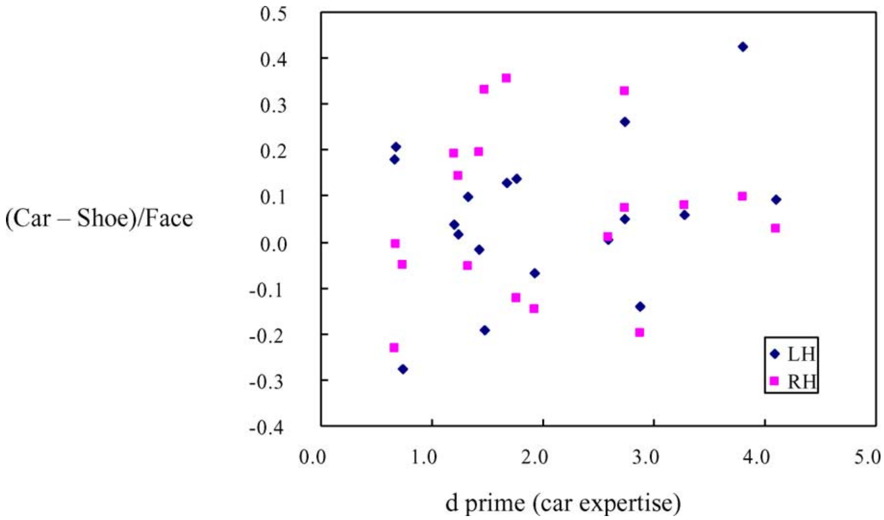

Fig. 5. The amplitude of the face-selective M170 response to cars (normalized as labeled) for each subject plotted against that subject's behavioral car expertise (d'). There was no significant correlation between M170 amplitude for cars and car expertise. LH: left hemisphere, RH: right hemisphere.

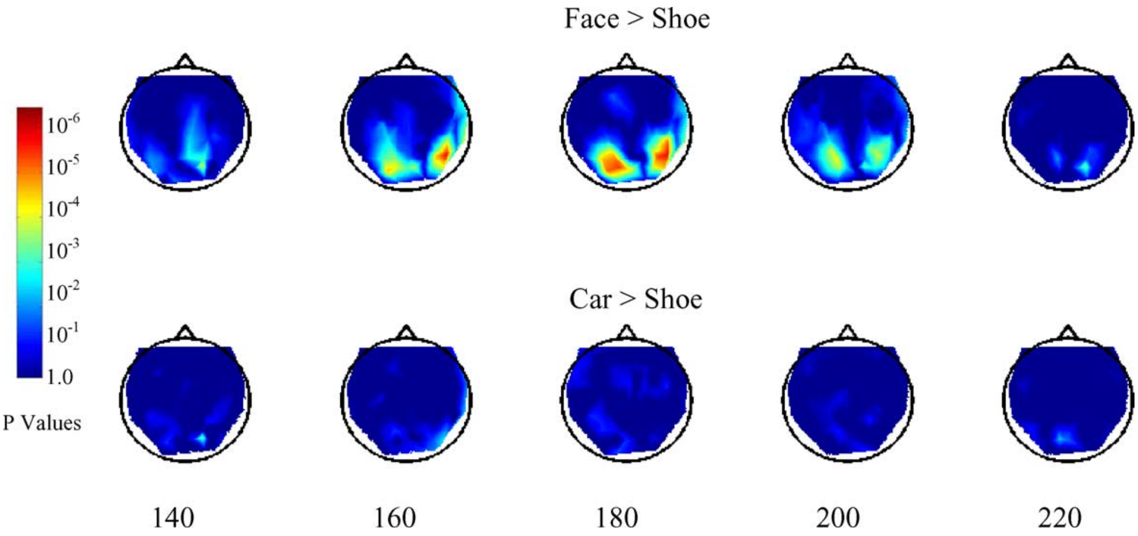

Fig. 6. Statistical maps comparing the response to faces vs. shoes (top) and cars vs. shoes(bottom) in the car expert with the highest behavioral car expertise d'. Sensors in the occipital-temporal area showed strong selectivity for faces compared to shoes, peaking at 180 ms in this subject. Selectivity for cars over shoes, however, was absent.

Table 3
The face-select M170 amplitude ($\times 10^{-13}$ T) for successfully and unsuccessfully identified faces and cars in each of the car experts

Car experts	Face		Car	
	Success	Failure	Success	Failure
1	1.22	0.74	1.59	2.01
2	0.79	0.36	0.43	0.42
3	2.20	2.02	1.14	1.31
4	1.01	0.66	0.68	1.00
5	1.01	0.77	1.22	1.02
6	0.83	0.66	0.39	0.40
7	1.63	1.49	1.16	1.00
8	1.16	0.96	1.09	1.27

3. Discussion

In this study, we tested whether the face-selective M170 reflects a genuinely face-selective process, or one involved more generally in identification of any objects of expertise that share the same basic configuration. We tested car experts who had many years of experience in identifying cars. In Experiment 1, we found that cars did not elicit a higher M170 response (relative to control objects) in face-selective sensors in car experts than in control subjects. Further, we found no correlation between the amplitude of the face-selective M170 response to cars and the level of behavioral expertise for cars. In Experiment 2, while the amplitude of the face-selective

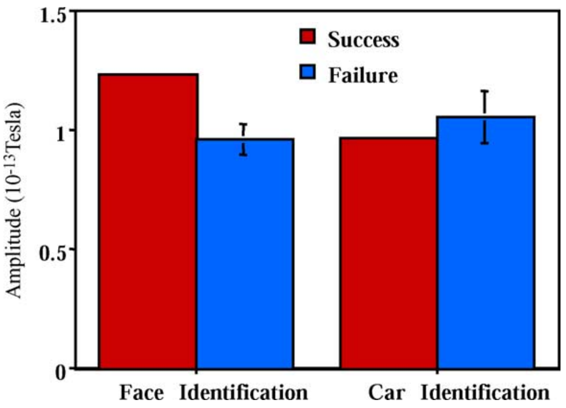

Fig. 7. Results of Experiment 2. In car experts, the face-selective M170 amplitude was significantly higher for trials in which subjects successfully identified the faces than for trials in which they failed to do so. This correlation of M170 amplitude and behavioral response, however, was not found for car identification. These results again indicate an absence of the expertise effect in car experts.

M170 was correlated with successful face identification, it was not correlated with successful car identification in car experts. Together, these results indicate that the M170 response is selective for faces, not for any objects of expertise. These results are therefore consistent with the *Face Specificity Hypothesis* and not the *Expertise Hypothesis*.

The results of the three prior ERP studies of expertise (Gauthier et al., 2003; Rossion et al., 2002b; Tanaka & Curran, 2001) do not contradict our conclusion. Evidence for the expertise hypothesis must show that the same neural response is both (i) selective for faces, and (ii) sensitive to expertise on nonfaces. None of the prior ERP studies meets the first criterion, and two of the three fail the second criterion (the bird and dog stimuli used in Tanaka & Curran, 2001, have faces, and the novel object "Greebles" used in Rossion et al., 2002a,b, have a facelike configuration).

In contrast, in our study, we observed strong face selectivity in our SOIs, both in the amplitude of responses and in the correlation between those responses and face identification performance. Yet the same SOIs showed neither of these effects for cars in car experts. Thus, the processes reflected in the face-selective M170 recorded here are clearly face specific and not expertise specific.

How can the evidence against the *Expertise Hypothesis* reported here be reconciled with the prior findings from fMRI of slightly higher FFA responses for objects of expertise (Gauthier et al., 2000; Xu, 2004)? One possibility is that the FFA is not the source of the M170, and the former is affected by expertise but the latter is not. This possibility would entail some effect of expertise in the FFA, but would indicate that a different and truly face-specific processing mechanism (marked by the M170) nonetheless exists. Another possibility is that the FFA is indeed the neural source of the M170 (Halgren et al., 2000), but the effect of expertise occurs at latencies later than 170 ms. Consistent with this hypothesis, when processing was curtailed by a mask in one recent study (Grill-Spector, Knouf & Kanwisher, 2004), face specificity was still observed in the FFA but expertise effects were not. Although we found no evidence for such later effects of expertise in the present experiments, it is possible that they occurred but were invisible to MEG either because they were not sufficiently time-locked to stimulus onset or because they originated in cortical tissue oriented parallel to the MEG sensors (Hamalainen, Hari, Ilmoniemi, Knuutila & Lounasmaa, 1993). Although the explanation of the prior fMRI findings is not yet clear, those findings in no way contradict the present results.

In sum, the M170 face-selective response reflects a process specific to the identification of faces, not a more general mechanism engaged in the identification of any objects of visual expertise that share the same basic configuration.

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