

Enhancement of Motorcycle Conspicuity Using Brain Activities Induced by the Facial Image Stimuli

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ABSTRACT

Humans have a special ability for recognizing the face. We have proposed a new motorcycle design technique to enhance search performance using this ability. This technique uses shape recognition and light positioning.

Some experiments were carried out to measure brain activity while showing facial image stimuli. Results showed significant activity in the lateral fusiform gyrus (FFA). This implies that the brain analyzes our facial image stimuli as a human face.

1. Introduction

Extraction and analysis of figures for fatal motorcycle accidents (in which automobiles are the principal party) from the Annual Traffic Accident Statistical Database, 1998 Edition⁽¹⁾, showed that failure by drivers of automobiles to notice motorcycles was, together with the misperception of approach speed, a primary factor in accidents (Fig. 1).

Enhancing the visibility of motorcycles should be effective in helping prevent the failure of noticing motorcycles. There is concern, however, that the growing use of headlights during the daytime by trucks and buses will result in a relative lowering of motorcycle visibility. The formulation of rules for the daytime use of headlights by motorcycles is thus being promoted in different countries as a way of dealing with that situation.

Meanwhile, reports from research on the brain in recent years indicate that there are parts of the brain (neurons) that react very sensitively to specific patterns. Reports on "hand neurons"⁽²⁾ in macaques in 1968 were followed by reports on "face neurons" in 1981⁽³⁾.

This present research proposes a means for raising the visibility of motorcycles by making use of the human capability to process

facial images. It also demonstrates, using brain measurements, that it is possible to quantitatively compare human psychological perceptions of facial qualities.

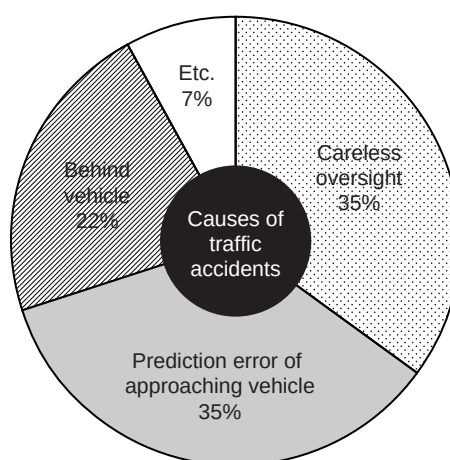


Fig. 1 Analysis of traffic accidents

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2. Proposition

2.1. Human Capability for Facial Image Processing

The technology for noninvasive brain measurement by means of functional Magnetic Resonance Imaging (fMRI) has made advances. This has made it possible to observe brain activity without harming the person being studied, and it has been found that there is a part of the brain in human beings, as in macaques, that handles the processing of facial images. The latest research has confirmed that the face area of the fusiform gyrus (Fusiform Face Area, FFA) in the temporal lobe, and the face area of the inferior occipital gyrus (Occipital Face Area, OFA), have high receptivity to facial images⁽⁴⁾⁻⁽⁶⁾.

These parts of the brain also demonstrate a capability to search for facial images. The human being is easily able, for example, to find the faces in scenes such as seen in Fig. 2. Lewis and others have reported that the facial image pops out from groups of different patterns when a human being is searching for it⁽⁷⁾.

It should be noted that these human capabilities are possessed by human beings without any particular training. Exercise of these capabilities does not require the imposition of any particular psychological burden.

2.2. Motorcycle Design Proposal

Bruce and others showed images of faces and of faces with different parts removed, such as eyes, mouth, and so on, to macaques, and recorded the neuron activity in their inferior temporal lobes⁽³⁾. The results show that a significant decrease in neuron activity was observed with images that had the eyes or mouth concealed. It has been reported that, when measuring human brains by means of fMRI, FFA activity becomes more intense when the facial images being shown are expressing emotion (joy, anger, sadness, pleasure, etc.)⁽⁸⁾. According to experiments by Fox and others⁽⁹⁾, who measured differences in face searching efficiency by differences in facial expression, searches for angry faces were faster than searches for faces with other expressions. These findings were used to create a design that would stimulate the human brain more



Fig. 2 Hidden face images



Fig. 3 Design proposal

efficiently, such as the proposed motorcycle design shown in Fig. 3. This design was configured on the front cowl of the Honda ASV test vehicle. Lamp shapes that would add emphasized facial shapes were devised, with the main lamp forming the mouth, and the directional indicators and position lamps forming the eyes.

The concept is that motorcycles designed in this way might be easier to recognize in a complex traffic environment by means of the human capability for sophisticated facial pattern processing. If so, this might also be expected to raise motorcycle visibility relative to automobiles.

3. Experiments

3.1. Purpose of Experiments

The purpose of the brain measurement experiments was to utilize fMRI to:

- (1) Compare activated regions of the brain to confirm whether the proposed design stimulates the facial image processing part of the brain in the same way that a human face does; and
- (2) Measure brain activity to perform a quantitative comparison of the facial qualities of the proposed design, and of human faces and ordinary motorcycle designs.

3.2. fMRI

Functional MRI (fMRI) is unlike the anatomical MRI, which measures the living structure, and instead measures brain activity and function. It can make measurements noninvasively, so less burden is placed on experimental subjects, even in repeated experiments.

3.3. Experimental Subjects

The subjects for these experiments were six healthy men and women recruited within the company. The measurements were conducted on these experimental subjects (5 men, 1 woman, ages ranging from 20s to 40s).

The experimental subjects were given full explanations of the purpose of the experiments and of ethical and safety aspects. They then gave their informed consent to the experiments, and signed releases accordingly, before the experiment proceeded.

3.4. Overview of Experiments

For these experiments, the subjects were placed in an MRI apparatus (Fig. 4), laying on their backs and holding a pushbutton, by which to make their responses. The stimulating image would be displayed upon a screen placed in the device, reflected in a mirror. The task of the experimental subjects was to look at a series of



Fig. 4 MRI apparatus

images and indicate by pushbutton responses whether each image matched the immediately preceding image or not (1-Back Task).

The angular field of view of the stimulus image, as shown in Fig. 5, was 13° horizontal and 10° vertical, and the image size was 650 x 500 pixels.

3.5. Images Used in the Experiments

The experiments made use of six categories (Fig. 6). Each category was made up of 20 different grayscale images (256 gradations).

1. FBK (facial motorcycle designs)
2. BK (normal motorcycle designs)
3. NFBK (non facial motorcycle designs)
4. HF (human faces)
5. NHF (faces in outline only)
6. OBJ (objects unrelated to faces)

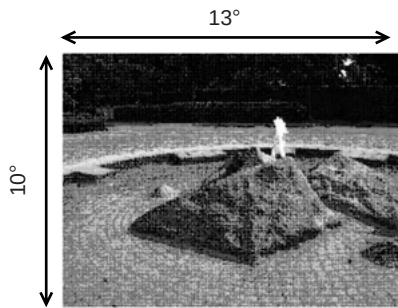


Fig. 5 Stimulation size

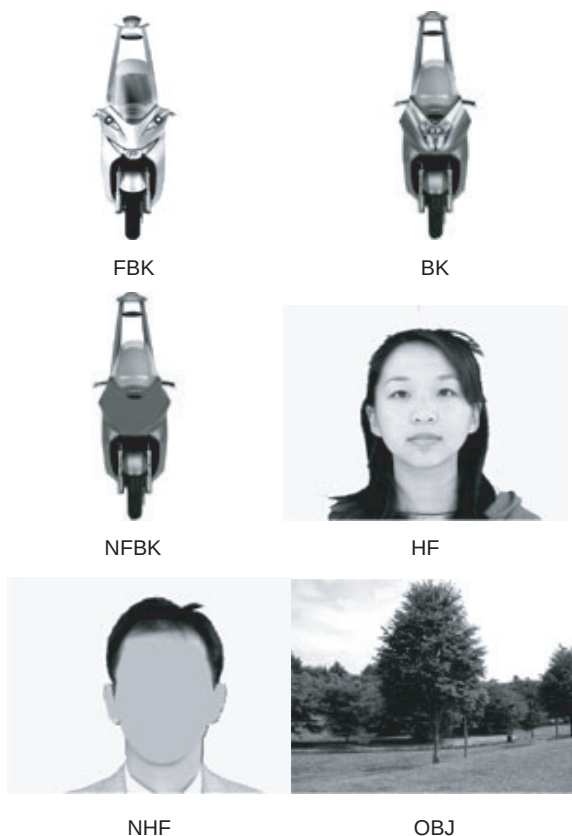


Fig. 6 Examples of stimuli

3.6. Experimental Design

The design used in the present experiments was a block-type task design, which follows a basic experimental protocol for measuring brain activity by means of fMRI. This is considered to produce highly reliable results, even with a relatively small number of experimental subjects.

The tasks were divided among six sessions. Each session was approximately four minutes long. Considering the effects of the order of stimuli, the six categories were presented in a random order during that period. At the beginning and end of each session, and in between categories, a fixation image (a white cross shape on a black background) was shown (Fig. 7).

The stimuli in a session were made up of the basic stimulus image, which lasted one second (a category image for 725 ms and a fixation point for 275 ms) (Fig. 8).

The stimuli in each category were made up of 16 basic stimulus images. In order to keep the experimental subjects aware and hold their attention on the stimulus images, the same image would be randomly repeated in series, and the subjects were assigned the task of indicating by pushbutton responses whether each image matched the immediately preceding image or not (1-Back Task) (Fig. 9).

Each experimental subject went through six-session experiments, two times. The net time taken for each experiment (of six sessions) was approximately 23 minutes (Fig. 10). With preparation included, the time taken was approximately 40 minutes.

3.7. fMRI Imaging and Analytical Method

The equipment used was a MAGNEX ECLIPSE 1.5T Power Drive 250 scanner, manufactured by Shimadzu-Marconi, at the ATR Brain Activity Imaging Center (BAIC).

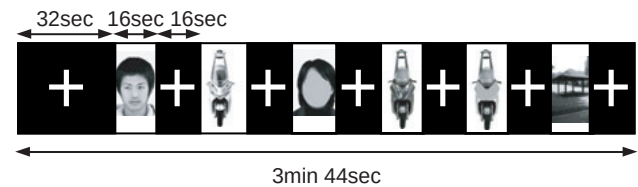


Fig. 7 Session of stimuli

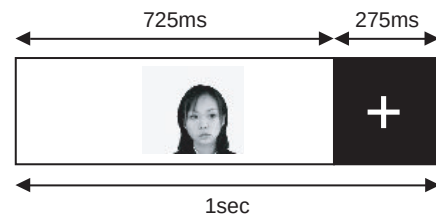


Fig. 8 Element of stimulus

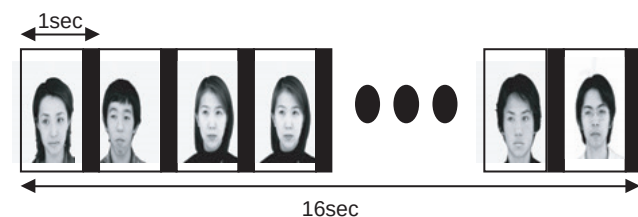


Fig. 9 Category of stimuli

For the present experiments, it was necessary first of all to determine which part of the brain was activated by the given stimulus images. Therefore, the imaging parameters were set to scan the entire human brain (Table 1).

Six experimental subjects did not form a large enough group for the analysis of total group tendencies in these experiments. Therefore, analysis was done for each individual subject.

The analysis was performed using Statistical Parametric Mapping (SPM2), from the Wellcome Institute of Cognitive Neurology, London, UK⁽¹⁰⁾. This is a standard software package for statistical analysis of fMRI data. The analytical process was composed of a part in which the fMRI data is pre-processed in a series of steps, and a part in which hypotheses as to whether brain activity is significant or not are tested statistically.

Pre-processing involved: Realignment, in which position changes caused by head movement were corrected; normalization, which is linear and non-linear conversion to a standard brain; and smoothing, which is 10-mm half-bandwidth Gaussian filtering.

In the part of the analysis that statistically tested hypotheses, the risk rate of testing T was considered to be of $P < 0.05$ (FWE corrected). Active parts were confirmed by conversion of Voxel coordinates (X, Y, Z) to Talairach coordinates (X', Y', Z') and checking against the atlas of Talairach and Tournoux⁽¹⁰⁾. The conversion formula was as follows:

$$\begin{aligned} \text{For } Z \geq 0 \\ X' &= 0.9900 X \\ Y' &= 0.9688 Y + 0.0460 Z \\ Z' &= -0.0485 Y + 0.9189 Z \end{aligned}$$

$$\begin{aligned} \text{For } Z < 0 \\ X' &= 0.9900 X \\ Y' &= 0.9688 Y + 0.0420 Z \\ Z' &= -0.0485 Y + 0.8390 Z \end{aligned}$$

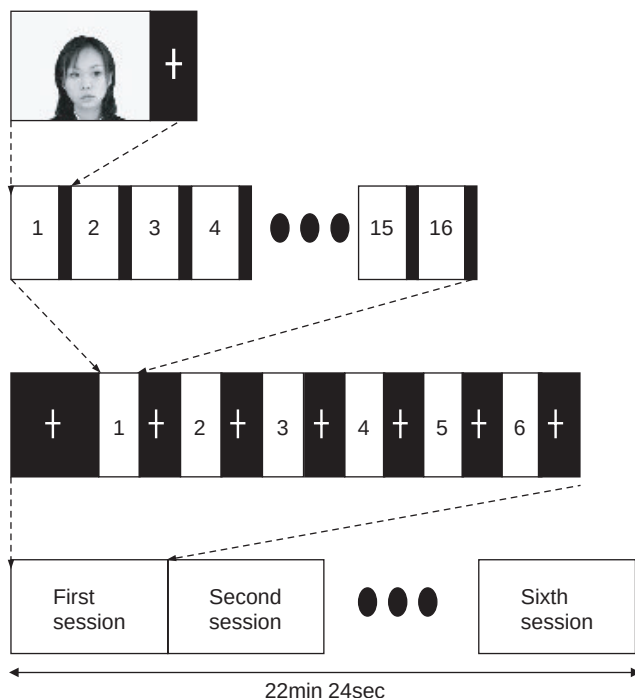


Fig. 10 Experimental design

Table 1 Parameters of fMRI

TR	4 000 ms
TE	50 ms
Flip angle	90°
FOV	192 mm
Slice thickness	3 mm (1 mm gap)
MATRIX size	64 × 64
Slice number	30

The parts of the brain confirmed were the FFA and OFA, which process facial images. Those locations are shown below:

Fusiform Face Area (FFA)

— The middle lateral fusiform gyrus

— Brodmann Area 37 (BA 37)

Occipital Face Area (OFA):

— Inferior occipital gyrus

— Brodmann Area 19 (BA 19)

In order to analyze the amount of brain activity, values conforming to the Blood Oxygen Level Dependent (BOLD) Signal Change were used (calculated from contrast estimates and 90% C.I. in SPM2). BOLD Signal Change values indirectly show changes in nervous metabolism and brain blood flow that accompany brain activity. They show the rate of change of oxygen consumption in the blood⁽¹²⁾.

4. Results and Discussion

4.1. Confirmation of Activated Parts of the Brain

Brain function images (hereafter, contrast images) obtained through analysis are given in Figs. 11 and 12 as representative examples of individual analysis. Figure 11 is a contrast image of HF and OBJ, and Fig. 12 of FBK and OBJ. Activation of the FFA was confirmed at the locations marked with black circles.

Table 2 shows the coordinates for FFA activation (Talairach coordinates), the risk rate (Voxel level) for testing, and the size of the area (Cluster level).

In addition, contrast between FBK and OBJ in OFA activation on the right side was confirmed in three experimental subjects (Subject B, Subject C, and Subject D) (Table 3).

These results yielded data suggesting that FBK and HF are processed generally by the same brain activity in four of the six experimental subjects. Statistically significant differences in activation were not confirmed in the remaining two experimental subjects.

Statistically significant activation of FFA and OFA was not observed in the contrast images for BK and OBJ, and for NFBK and OBJ, in any of the experimental subjects.

4.2. Analysis of the Amount of Brain Activity

The amount of brain activity across the six categories for the four experimental subjects in whom FFA and OFA activation was confirmed, as described in section 4.1, was analyzed and the results

Table 2 Right fusiform face area activated (SubjectA) activated (SubjectA)

Contrast	Subject	Talairach coordinates			Voxel-level	Cluster-level
		X'	Y'	Z'	$P_{FWE-CONT}$	K_E
HF-OBJ	A	48	-57	-11	0.000	25
FBK-OBJ	A	50	-57	-11	0.001	15

Table 3 Right occipital face area activated (SubjectB, SubjectC, Subject D)

Contrast	Subject	Talairach coordinates			Voxel-level	Cluster-level
		X'	Y'	Z'	$P_{FWE-CONT}$	K_E
FBK-OBJ	B	42	-72	-11	0.023	3
	C	55	-67	-13	0.031	3
	D	44	-66	-7	0.013	6

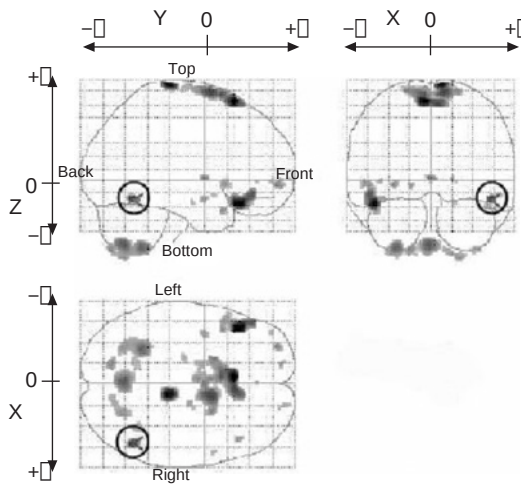


Fig. 11 Contrast image (Subject A: HF - OBJ)

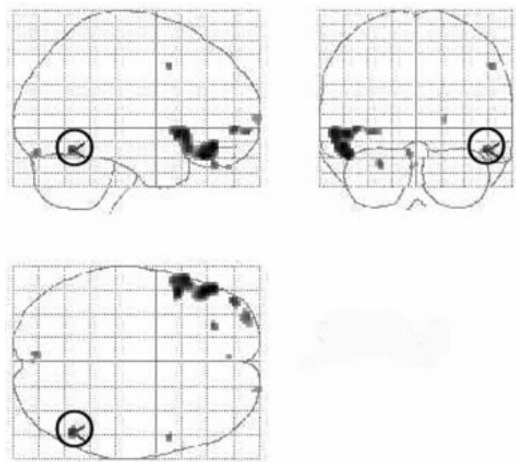


Fig. 12 Contrast image (Subject A: FBK-OBJ)

are shown here (Fig. 13, Fig. 14, Fig. 15, Fig. 16). The error bars in each graph show the Standard Error (SE).

The four experimental subjects all showed about the same level of activity for FBK as for HF. The level of activity tended to be lower for BK and NFBK than for FBK. In all four experimental subjects, the amounts of activity were in this order: HF > FBK >

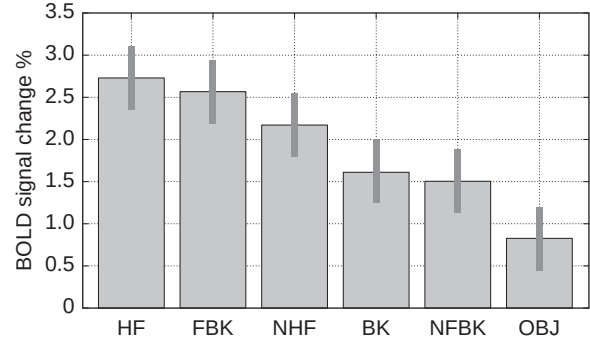


Fig. 13 BOLD signal change (Subject A)

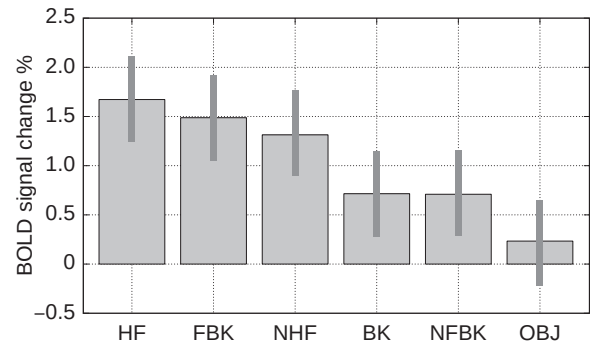


Fig. 14 BOLD signal change (Subject B)

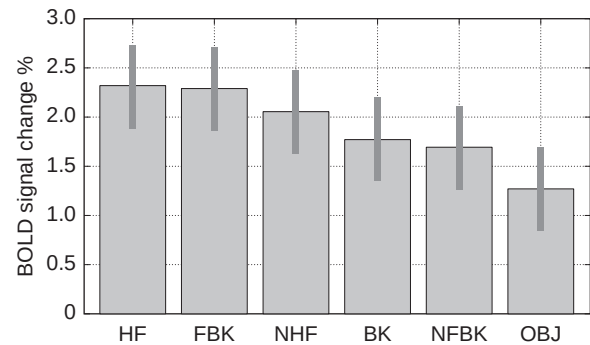


Fig. 15 BOLD signal change (Subject C)

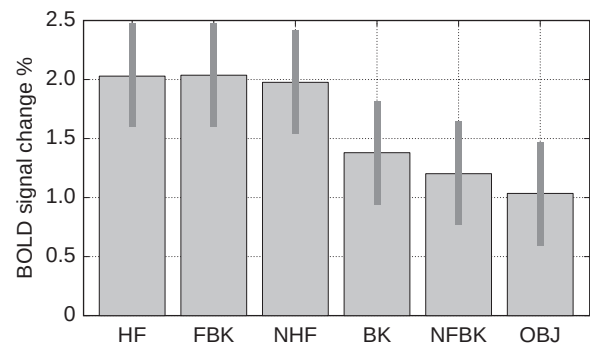


Fig. 16 BOLD signal change (Subject D)

NHF > BK > NFBK > OBJ.

The above results demonstrate experimentally that the FBK design presented here stimulates the same level of brain activity as a human face. This suggests that the BOLD Signal Change values for FFA and OFA, which were employed as quantitative indicators of brain activity for these experiments, could possibly be used as evaluation indices for facial qualities.

5. Conclusion

Styling design technology that enhances motorcycle visibility by making use of the human ability to process facial images was proposed. In order to evaluate its effect, measurements of brain activity were made by means of fMRI. As a result, it was confirmed that the proposed design stimulates the part of the brain that processes facial images, just as the human face does. This provided experimental demonstration of new possibilities for enhanced visibility. These experiments also demonstrated the possibility of quantitative comparison of facial qualities, as sensed psychologically by humans. Efforts will be made to make measurements of more experimental subjects in the future, in order to verify the validity of this proposal, and to take steps toward verification of its effectiveness with actual vehicles in actual traffic environments.

The facial data in this paper are used by permission of Softopia Japan, Research and Development Division, HOIP Laboratory. It is strictly prohibited to copy, use, or distribute the facial data without permission.

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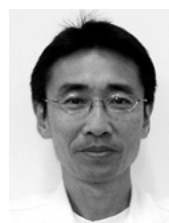
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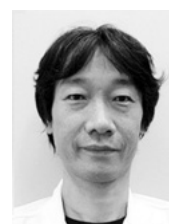
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