·Original Article·

# Functional MRI mapping of category-specific sites associated with naming of famous faces, animals and man-made objects

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**Abstract: Objective** Category-specific recognition and naming deficits have been observed in a variety of patient populations. However, the category-specific cortices for naming famous faces, animals and man-made objects remain controversial. The present study aimed to study the specific areas involved in naming pictures of these 3 categories using functional magnetic resonance imaging. **Methods** Functional images were analyzed using statistical parametric mapping and the 3 different contrasts were evaluated using *t* statistics by comparing the naming tasks to their baselines. The contrast images were entered into a random-effects group level analysis. The results were reported in Montreal Neurological Institute coordinates, and anatomical regions were identified using an automated anatomical labeling method with XJview 8. **Results** Naming famous faces caused more activation in the bilateral head of the hippocampus and amygdala with significant left dominance. Bilateral activation of pars triangularis and pars opercularis in the naming of famous faces was also revealed. Naming animals evoked greater responses in the left supplementary motor area, while naming man-made objects evoked more in the left premotor area, left pars orbitalis and right supplementary motor area. The extent of bilateral fusiform gyri activation by naming man-made objects was much larger than that by naming of famous faces or animals. Even in the overlapping sites of activation, some differences among the categories were found for activation in the fusiform gyri. **Conclusion** The cortices involved in the naming process vary with the naming of famous faces, animals and man-made objects. This finding suggests that different categories of pictures should be used during intra-operative language mapping to generate a broader map of language function, in order to minimize the incidence of false-negative stimulation and permanent post-operative deficits.

**Keywords:** brain mapping; category-specific naming; famous face; animal; man-made object

## 1 Introduction

The goal of surgery in the treatment of intrinsic cerebral tumors is to maximally resect the neurologically permissible tumor volume, and to spare areas associated with the control of motor functions, senses, language and memory, as well as other cognitive functions[1-5]. Intra-operative direct electrical stimulation of the central nervous system provides a real-time, reliable, precise and safe method of functional mapping useful for all operations on lesions located in these areas[6-12]. This technique minimizes definitive post-operative neurological deficits while concurrently

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improving the quality of resection. Therefore, it is regarded as the "gold standard" in defining cortical and subcortical pathways[11,13]. However, this technique may also result in false positives and false negatives, even when properly used. Consequently, false positives may lead to a premature interruption of the resection, whereas false negatives may result in permanent neurological sequelae[1,14,15].

There are several causes for false negatives, such as an extremely low intensity of stimulation, a short duration of stimulation, and the stimulation being performed during a transient post-epileptic refractory phase, which may lead to erroneous "negative mapping". Nevertheless, such errors can be avoided by strictly following the practical rules of stimulation[14,15]. Another cause of false negatives is an inappropriate intra-operative task for functional mapping. Counting, reading and naming are the most-used intra-operative tasks for mapping language. Among them, naming is the basic task used in mapping procedures because it is a core component of language abilities and is supposed to be a reliable method for identifying essential language sites[16]. In the task, patients are asked to name a set of line drawings of objects when the stimulation probes are placed at a cortical site. The pictures shown intra-operatively include those of animals, birds, fruits, vegetables, and man-made objects, which are blended in one naming task[5,7,8].

Naming is considered to be one of the most complicated functions of the human brain. Cortical sites for naming may vary among categories[17,18]. Category-specific recognition and naming deficits have been observed in a variety of patient populations. The most common dissociation is impairment in recognizing living versus non-living objects. This double dissociation provides compelling evidence that the neural processes related to recognizing different classes of objects are organized categorically in the human brain[19-22]. In addition, patients with brain lesions may show selective impairment of face recognition versus the recognition of objects, and the opposite pattern has also been described. The double dissociation implies that different brain regions are recruited for the recognition of faces and other types of visual objects[22-26].

A similar dissociation has emerged from brain imaging studies. Chouinard *et al.*[17] reported category-specific neural processing for naming pictures of animals and naming pictures of tools. In this study, naming animals evoked greater responses in the left ventral prefrontal cortex, the left anterior cingulate cortex, and a number of visual areas in the occipital lobe. In contrast, naming tools evoked greater responses in the left middle temporal gyrus, the medial portion of the fusiform in both hemispheres, motor areas in the left frontal lobe, and sensory areas in the anterior portion of the left parietal lobe.

However, the category-specific cortices for naming famous faces, animals, and man-made objects are still in debate. Studies based on lesion analysis and functional neuroimaging have both highlighted the importance of the temporal lobes in the recognition and naming of several object categories[27]. Lesions in the left anterior temporal lobes are often associated with category-specific naming deficits involving unique objects such as famous faces or landmarks, while more posterior left temporal lobe lesions are associated with impaired naming of man-made objects[28,29].

In a recent study by Giussan *et al.*[30] involving intra-operative electrical stimulation of the cortex during awake surgery on brain tumors, face-naming areas in addition to those in the temporal lobe were discovered, mainly in 2 regions: the left frontal part of the superior, middle, and inferior frontal gyri, and the anterior part of the superior and middle temporal gyri.

Given the evidence for category-specific agnosia in neurological patients and the existence of category-specific naming sites by intra-operative direct cortical stimulation, naming of famous faces, animals and man-made objects may exhibit different patterns of activity in the brain. In the present study, functional magnetic resonance mapping of areas evoked during naming of famous faces, animals and man-made objects was conducted using 3 tasks in a Latin square design to avoid fatigue and other interfering factors. The aim of this study was to test the hypothesis of dissociation of category-specific naming areas in the cerebral cortex.

## 2 Methods

**2.1 Subjects** Twenty-one Chinese volunteers including 11 males and 10 females [mean age (33.0 ± 3.3) years, ranging 24–47 years] participated in this study. All subjects were right-handed as assessed by the Edinburgh handedness inventory and received reimbursement for expenses incurred. All participants had normal or corrected-to-normal vision and reported no history of neurological illness or drug abuse. The mini-mental state examination scores for all subjects were normal to 30 points. None had any overt brain abnormalities as shown by structural magnetic resonance imaging (MRI). The study procedures were approved by the Medical Ethics Committee of Liuhuaqiao Hospital, Guangzhou, China. Written informed consent was given by all subjects.

**2.2 Stimuli for functional MRI (fMRI) study** The pictures were projected onto a screen from behind the MRI scanner, and the subject viewed them via a mirror positioned above the head coil. To avoid movement artifacts, the participants were instructed to "name" or "speak" silently. Subjects were asked to keep their eyes straight ahead during the rest condition without moving during the experiment. Before the initiation of scanning sessions, the subjects performed a practice block in front of a computer to ensure that they had understood the instructions.

Black-and-white pictures of different categories (famous faces, animals and man-made objects) and category-specific controls (right side up or upside down pictures of an unknown person's face, animal or arrow) were presented on a white background. Pictures for the naming task were selected 24 h before scanning. Pictures in the famous face category were obtained from the internet and consisted of photographs of 30 male and 22 female celebrities (mostly actors/actresses, athletes and politicians) and those of animals and man-made objects were from the pictures of Snodgrass. The face unfamiliar to all the subjects was that of a student in Beijing Normal University. The unfamiliar animal was a skunk, which is unknown to most Chinese people, including all the subjects in this study. The man-made object control was a schematic drawn arrow. Pictures were presented in a block-design fashion. Subjects participated in 3 sessions, and each session was composed of one prelude block and 6 naming blocks each followed by a baseline block (6 in total), in a Latin square design (Fig. 1). Each block contained 6 pictures and lasted 18 s except for the prelude block, which had 8 pictures and lasted 24 s. Each stimulus was presented for 3 s. The subjects were asked whether the pictures were familiar to them or not so that the pictures used for the tasks were similarly familiar

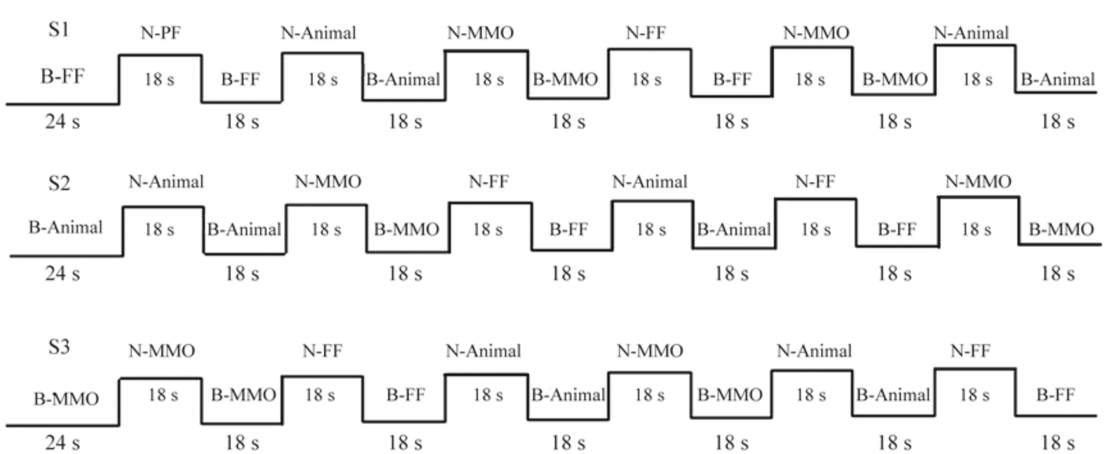


**Fig. 1 The experiment was composed of 3 sessions, each consisting of one prelude block and 6 naming blocks each followed by one baseline block, presented in a Latin square design. Each block contained 6 pictures and lasted 18 s except the prelude block which had 8 pictures and lasted 24 s. The baseline block contained pictures of unfamiliar faces, animals, or arrows, presented right side up or upside down, and subjects were asked to read "up" or "down" silently. FF, famous face; MMO, man-made object; B, baseline; N, silent naming.**

among the 3 categories. The subjects were asked to silently "name" famous faces, animals or man-made objects, as well as the unfamiliar controls (pictures of unfamiliar faces, animals or arrows presented right side up or upside down, where the subjects were asked to respond with ‘‘up’’ or ‘‘down’’).

**2.3 Data acquisition and analysis** MR images were acquired using a Siemens 1.5 T scanner with a 12-channel coil (www.siemens.de). A single-shot gradient-echo echo-planar imaging sequence was used to acquire the functional imaging data [time of repetition (TR) = 2000 ms, echo delay time (TE) = 37 ms, field of view (FOV): 240 × 240 $mm^2$, flip angle = 90°). Twenty-eight oblique axial slices were obtained by interleaved acquisition in bottom-to-top order containing both cerebellum and cerebrum. The base resolution matrix was 64 × 64, and the slice thickness was 4 mm with a 1-mm gap. The MR scanner had 4 s for uniform magnetization before scanning, so only 118 images were acquired in one session. A high-resolution T1 image (MP-RAGE sequence) of 112 slices was additionally acquired for anatomical labeling (TR = 1320 ms, TE = 3.93 ms, FOV = 250 × 250 $mm^2$, flip angle = 150°).

Functional images were analyzed using statistical parametric mapping (SPM8 software; Wellcome Department of Cognitive Neurology, London, UK, http://www.fil.ion. ucl.ac.uk/spm/). The first 10 volumes of the functional images obtained when the preclude baseline tasks were represented, were discarded in order to eliminate T1 saturation effects. Analysis started with the slice timing procedure followed by realignment of all images to the first volume to correct for head motion, and were corrected for movement by susceptibility artifacts. All images were spatially normalized to the stereotactic space of the Montreal Neurological Institute (MNI) template image (2-mm isotropic voxels) provided by SPM8, and smoothed with a Gaussian kernel of 8 mm. Statistical parametric maps were calculated using the general linear model. Regressors for the 3 naming conditions and for the baseline conditions were entered into the design matrix and convolved with a canonical hemodynamic response function. Data were high-pass filtered to eliminate low-frequency components (a cut-off value of 128 s was used) to reduce the effect of slow drifts.

Three different contrasts were evaluated using *t* statistics by comparing the naming tasks to their baselines. The 3 group contrast images were each entered into a random-effects group level analysis. The results are reported in MNI coordinates as given by SPM8, using a cluster of at least 10 contiguous voxels ($P < 0.001$, uncorrected; or $P < 0.05$, corrected for family-wise error, FWE). Anatomical regions were identified using the automated anatomical labeling method in XJview 8 (Xu Cui, Human Neuroimaging Lab, Baylor College of Medicine; http://www.alivelearn.net/xjview/). The laterality index (LI) was calculated as described by Ruff *et al.*[31]: LI = (L–R)/(L+R), where L represents the activated voxels in the left side of a certain area and R is for the right side. The LI ranged from -1 (completely right-lateralized) to +1 (completely left-lateralized). Bilateral activation was defined in the range -0.2 to 0.2.

## 3 Results

**3.1 Naming of famous faces** The results obtained by using a cluster of at least 10 contiguous voxels ($P < 0.001$, uncorrected), showed that the cortical areas activated while silently naming famous faces compared to the baseline tasks were the bilateral fusiform gyri, bilateral pars triangularis, pars opercularis and the anterior insular cortex with left dominance, the left supplementary motor area and anterior cingulate gyrus, bilateral head of the hippocampus with left dominance and the right caudate nucleus (Fig. 2, Table 1).

**3.2 Naming of animals** Similarly, the results showed greater activation for naming animals relative to baseline tasks in the left supplementary motor area, bilateral fusiform gyri, left pars triangularis and anterior insular cortex, left superior temporal pole and left middle occipital gyrus (Fig. 2, Table 1).

**3.3 Naming of man-made objects** Naming man-made objects compared to baseline tasks displayed greater activation in the bilateral fusiform gyri, left pars triangularis, pars orbitalis and premotor area, right pars triangularis and pars opercularis, left anterior cingulate gyrus, right supplementary motor area and left superior occipital gyrus (Fig. 2, Table 1).

**3.4 Common and category-specific areas associated with naming of pictures in the 3 categories** A network of cortical areas was activated for all 3 picture categories. These areas were bilateral occipitotemporal regions including the fusiform gyrus and pars triangularis of the left inferior frontal gyrus. However, there were minor differences in the common activation areas among the 3 categories. For example, the extent of activation of the bilateral fusiform gyri and the pars triangularis by naming man-made objects was much greater than by naming famous faces or animals. When corrected with FWE, the activated voxels of the pars triangularis and premotor area by naming man-made objects was 173 voxels, compared with 70 by naming animals and 11 by naming famous faces. In addition, the sites in the bilateral fusiform gyri activated by naming famous faces were more posterior than those by the other 2 categories (Figs. 2, 3; Tables 1, 2).

Naming famous faces exclusively recruited areas in the bilateral anterior temporal lobes (including the head

**Table 1. Extent and intensity of activation when silently naming 3 categories of pictures, compared with baseline tasks of speaking without naming (uncorrected, *P* < 0.001). Activation of the cerebellum and brain stem were excluded.**

| Anatomical region | Cluster size | MNI coordinates | | | T value |
|---|---|---|---|---|---|
| | | x | y | z | |
| Famous faces | | | | | |
| L. Fusiform | 1058 | -40 | -50 | -22 | 9.72 |
| R. Fusiform | 1121 | 38 | -62 | -24 | 8.45 |
| R. Inferior frontal gyrus, opercularis and triangularis | 577 | 44 | 12 | 34 | 6.97 |
| L. Inferior frontal gyrus, opercularis, triangularis and insula | 1169 | -38 | 12 | 28 | 6.37 |
| R. Insula | 197 | 32 | 26 | -2 | 5.56 |
| R. Caudate nucleus | 36 | 12 | 14 | 10 | 4.40 |
| L. Supplementary motor area and anterior cingulum | 326 | 0 | 14 | 60 | 5.62 |
| L. Head of hippocampus | 558 | -18 | -10 | -14 | 6.55 |
| R. Head of hippocampus | 133 | 28 | -10 | -16 | 4.76 |
| Animals | | | | | |
| L. Supplementary motor area | 703 | -4 | 22 | 50 | 14.87 |
| L. Fusiform | 1292 | -42 | -62 | -16 | 8.09 |
| R. Fusiform | 1069 | 40 | -40 | -22 | 10.22 |
| L. Inferior frontal gyrus, triangularis and L. insula | 903 | -48 | 16 | 30 | 8.20 |
| L. Middle frontal gyrus | 56 | -40 | 48 | 14 | 5.88 |
| L. Head of hippocampus | 77 | -26 | -8 | -14 | 4.77 |
| Man-made objects | | | | | |
| R. Fusiform | 1686 | 34 | -34 | -26 | 13.59 |
| L. Fusiform | 2002 | -36 | -44 | -24 | 11.37 |
| L. Inferior frontal gyrus, triangularis, premotor area | 899 | -48 | 16 | 28 | 9.09 |
| L. Inferior frontal gyrus, orbitalis | 27 | -38 | 34 | -16 | 5.99 |
| R. Inferior frontal gyrus, triangularis and opercularis | 147 | 52 | 32 | 16 | 5.81 |
| L. Anterior cingulum | 80 | 0 | 6 | 30 | 6.49 |
| R. Supplementary motor area | 232 | 4 | 14 | 56 | 6.30 |
| R. Superior occipital gyrus | 98 | 28 | -76 | 34 | 5.19 |

L: left; R: right. MNI: Montreal Neurological Institute.

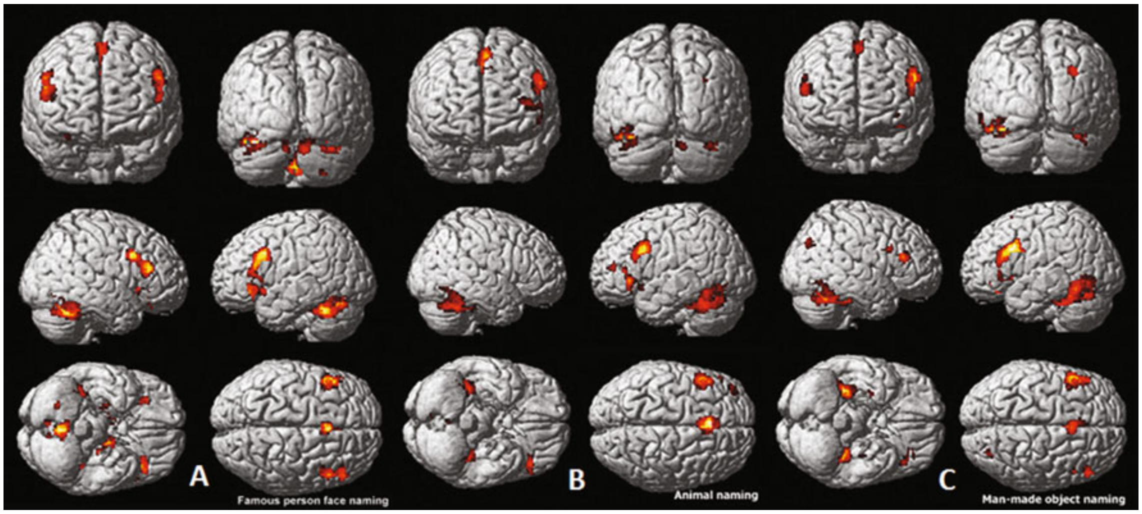


**Fig. 2 Cortical areas activated by naming of famous faces (A), animals (B), and man-made objects (C). Results are shown at a significance level of *P* < 0.001, uncorrected.**

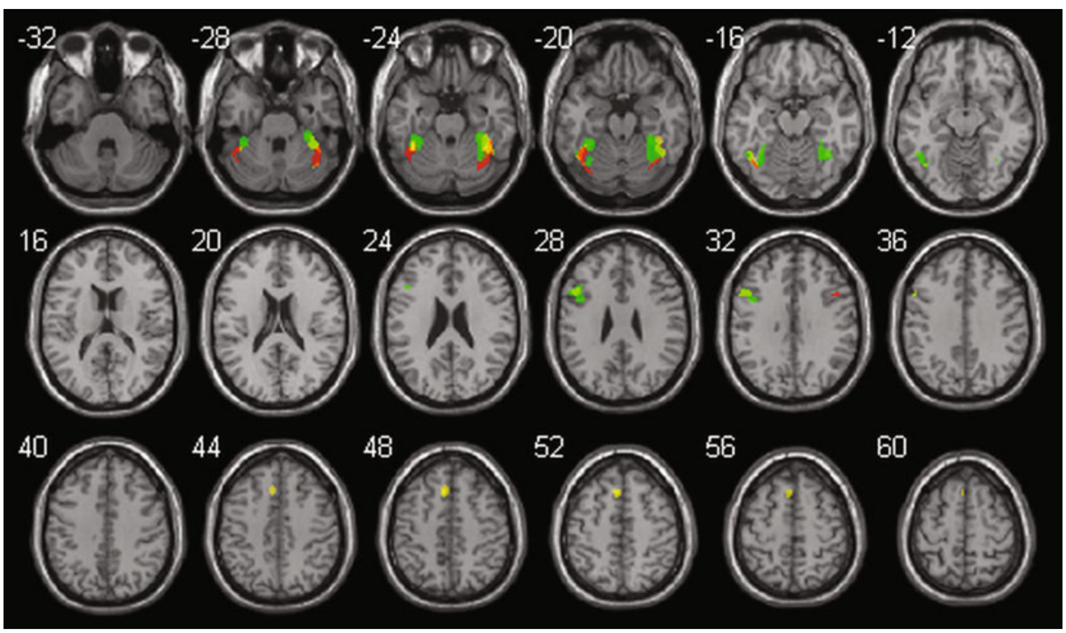


**Fig. 3 Mixed overlapped cortical areas invoked by naming of famous faces (red), animals (yellow), and man-made objects (green). Results are shown at a significance level of *P* < 0.05, corrected for family-wise error.**

of the hippocampus and some of its neighbors, such as the amygdaloid nucleus) with significant left dominance and activated right caudate nucleus. Although the left head of the hippocampus was also activated by naming animals, the clusters of activation were only 77 voxels compared with 558 activated by naming famous faces. Bilateral pars triangularis and pars opercularis of the inferior frontal gyrus were involved in the naming of famous faces. The LI results for the inferior frontal gyrus were 0.20 for naming famous faces, 1.00 for animals, and 0.73 for man-

**Table 2. Extent and intensity of activation when naming the 3 categories compared with their baseline tasks. Corrected for family-wise error (FWE), *P* < 0.05.**

| Anatomical region | Cluster size | MNI coordinates | | | P (FWE) | T value |
|---|---|---|---|---|---|---|
| | | x | y | z | | |
| Famous faces | | | | | | |
| L. Fusiform | 237 | -40 | -50 | -22 | 0.000 | 9.72 |
| R. Fusiform | 195 | 38 | -62 | -24 | 0.002 | 8.45 |
| R. Inferior frontal gyrus, opercularis | 11 | 44 | 12 | 34 | 0.020 | 6.97 |
| Animals | | | | | | |
| L. Supplementary motor area | 159 | -4 | 22 | 50 | 0.000 | 14.87 |
| R. Fusiform | 181 | 40 | -40 | -22 | 0.000 | 10.22 |
| L. Inferior frontal gyrus, triangularis | 70 | -48 | 16 | 30 | 0.003 | 8.20 |
| L. Fusiform | 135 | -42 | -62 | -16 | 0.004 | 8.09 |
| Man-made objects | | | | | | |
| R. Fusiform | 595 | 34 | -34 | -26 | 0.000 | 13.59 |
| L. Fusiform | 502 | -36 | -44 | -24 | 0.000 | 11.37 |
| L. Inferior frontal gyrus, triangularis, premotor area | 173 | -48 | 16 | 28 | 0.001 | 9.09 |

L: left; R: right. MNI: Montreal Neurological Institute.

made objects ($P < 0.001$, uncorrected; Fig. 2, Table 1).

Naming animals evoked greater responses in the left supplementary area and left middle frontal gyrus. The activated clusters in the supplementary motor area and anterior cingulum were 703 voxels for naming animals, whereas naming famous faces corresponded to 326 voxels and naming of man-made objects was 312 voxels. Furthermore, naming of animals had much greater left dominance (Fig. 2, Table 1).

The cerebral areas specific for man-made objects involved more of the left premotor area, pars orbitalis of the left inferior frontal gyrus, right supplementary motor area and right superior occipital gyrus. The extent of activation of the bilateral fusiform gyri by naming man-made objects was much greater than that by naming famous faces or animals. The activated clusters (corrected with FWE, $P < 0.05$) were 502 voxels on the left and 595 on the right for naming man-made objects, 237 voxels on the left and 195 on the right for naming famous faces, and 135 voxels on the left and 181 on the right for naming animals (Figs. 2, 3; Tables 1, 2).

## 4 Discussion

In the present study, the intra-operative naming task was used to design a simple naming task for fMRI detection of category-specific naming areas. SPM8 analysis was used to identify the network of brain regions associated with naming famous faces, animals and man-made objects. Besides, common brain regions activated by naming of these categories, as well as the specific regions activated by each category, were analyzed.

**4.1 Common areas activated by the 3 categories** We found that the common brain regions activated by naming the 3 picture categories were the bilateral occipitotemporal region, including the fusiform gyrus and pars triangularis of the left inferior frontal gyrus. The fusiform gyrus, also known as the occipitotemporal gyrus, is an extremely long convolution that extends lengthwise over the inferior aspect of the temporal and the occipital lobes. While dispute still exists over the precise functions of this area, the current consensus includes face and body recognition, within-category identification (including faces and other categories), processing of color information, word recognition and number recognition[32-36]. Grill-Spector *et al.*[37] have stated that the fusiform face area is involved in both the detection and identification of faces, while it has little involvement in within-category identification of non-face objects. Moreover, the brain areas involved in other within-category identification of non-face objects are thought to be located in the medial fusiform gyrus, inferotemporal gyrus and parahippocampal area, which are outside the fusiform face area. It has been demonstrated that even in the fusiform gyrus, naming of different categories activates different areas, which has been confirmed by neuropsychological behavior experiments[36,39] and our functional MR study.

The pars triangularis is a region of Broca's area in the left inferior frontal gyrus, and contributes to speech, semantic encoding and cognitive control of memory. Significant increases in pars triangularis activity as well as some of its neighbors during naming procedures have been reported[17,39-41]. Not surprisingly, the pars triangularis was activated in all 3 naming tasks.

**4.2 Category-specific naming for famous faces** The ability to recognize and name known faces is crucial for creating and maintaining social relationships. The face-naming process begins with face recognition, which is a specialized form of visual recognition and relies on cortical areas separate from those for object recognition[26,42]. While some functional neuroradiological studies (including positron emission tomography and fMRI) have shown that face recognition specifically activates the inferior occipital gyrus and the lateral part of the middle fusiform gyrus mainly in the right hemisphere, other researchers have emphasized that more evenly distributed bilateral neural system activity may be involved in face recognition[46,47]. Here, the bilateral activation of pars triangularis and pars opercularis by naming famous faces was also confirmed. The LI of the inferior frontal gyrus was 0.20 for naming famous faces, 1.00 for animals, and 0.73 for man-made objects. This is because our tasks involved both face recognition and naming.

Although face recognition preferentially relies on the right hemisphere, studies have shown that face naming is a function of the left hemisphere[30,48]. Specific language sites for face naming have been identified in the left premotor and prefrontal cortex[49-51]. In other studies, patients with lesions in the anterior region of the left temporal lobe failed to retrieve the correct names of famous persons when seeing their faces[50-52]. The involvement of the left temporal pole in face naming has also been found by using functional neuroimaging[42]. In this study, we found that naming famous faces recruited the bilateral anterior temporal lobes (including the head of the hippocampus and some of its neighbors, such as the amygdaloid nucleus) with significant left dominance. As commonly accepted, the hippocampus plays roles in memory and the naming of famous faces relies more on memory than does naming animals or man-made objects. This may explain the significant activation of the bilateral head of the hippocampus during the naming of famous faces.

**4.3 Category-specific naming for animals** The ability of rapid recognition of animals has survival value in avoiding predators and finding food. A separate neural system for analyzing visual information of animals would allow more efficient recognition of one animal over another[17,53]. This could explain why naming animals evoked visual areas in the ventral stream, which differed from those evoked by naming other categories of objects. However, most of the clusters in the fusiform gyri activated by naming animals overlapped with those activated by naming famous faces. This could be explained by the fact that animals also have faces or that the fusiform facial areas respond to animal faces, both deserving further investigation[37].

Because of the emotional component linked to animals, a neural system dedicated to animal recognition would be associated with the limbic system. This could explain why areas in the left supplement motor area (SMA) and anterior cingulate gyrus are more responsive to naming animals than to naming famous persons or tools[17,54,55]. The SMA is implicated in the planning of motor actions and bimanual control. The stronger anatomo-functional connections of the SMA with regions of the limbic system than the premotor area, suggest that the SMA may participate in the control of movements triggered by visual stimuli with emotional content. Functions such as error detection, anticipation of tasks, motivation, and modulation of emotional responses can be attributed to the anterior cingulate cortex[53,56]. This may also explain why naming animals evoked more in the left supplementary motor area and the left anterior cingulum.

### 4.4 Category-specific naming for man-made objects

Man-made objects typically consist of a special category of objects associated with specific functions and hand postures. It is proposed that the retrieval of information related to their use might aid in their recognition and naming[17,57]. A meta-analysis revealed that naming tools engages not only visual areas in the ventral stream but also the left ventral premotor area, the left post-central gyrus, and the left anterior superior parietal lobule[16]. These latter areas are known to contribute to the control of hand movements during grasping.

In this study, the man-made object-specific cerebral areas were found to involve the pars orbitalis of the left inferior frontal gyrus, right supplementary motor area, right superior occipital gyrus and left premotor area. The extent of activation of bilateral fusiform gyri by naming man-made objects was much greater than that by naming famous faces or animals.

It remains still unclear as to why these areas are activated during tool naming. One possible explanation is that there might be a link between object recognition and the actions required to interact with them[17,58]. A class of neurons in the ventral premotor cortex discharges simultaneously when monkeys view and grasp the same object. However, grasping objects requires shaping of the hand to match the three-dimensional structure of the object. This behavior requires a transformation from the visual representation of the object's geometrical properties to the motor commands acting on the muscles of the hand. It is thought that ventral premotor neurons provide a vocabulary of programs for constructing motor grasps[59,60].

It should be noted that functional neuroimaging measures only correlations between cerebral activity and behavior[17,39,57], that is, an "activated" area may actually not be essential for completing a specific task. Therefore, it is impossible for us to know from our fMRI study whether the areas that we report do play a critical role in the recognition of that class. Given the category-specific recognition and naming deficits found in a variety of patients, and the existence of category-specific naming sites detected during intra-operative cortical direct electrical stimulation, the cortical regions involved in naming may vary among the 3 studied categories.

## 5 Conclusion

As expected, we found different patterns of activity in the brain in response to naming famous faces, naming animals and naming man-made objects. Naming famous faces induced more activation in the bilateral head of the hippocampus and amygdala with significant left dominance and in the right caudate nucleus. Bilateral activation of pars triangularis and pars opercularis in the naming of famous faces was also confirmed in our study. Naming animals evoked greater responses in the left supplementary motor area and left middle frontal gyrus, while naming man-made objects evoked more activity in the left premotor area, left pars orbitalis, right supplementary motor area and right superior occipital gyrus. The extent of activation of the bilateral fusiform gyri by naming man-made objects was much larger than that by naming famous faces or animals. Even in the overlapping activation sites, there were some differences in the activation areas in the fusiform gyri among different categories. In general, our study revealed that the cortical areas involved in naming varied among naming famous faces, animals and man-made objects. These results suggest that various picture categories should be presented during intra-operative language mapping to gain a broader map of language function, thus minimizing the incidence of false-negative stimulations and permanent post-operative deficits.

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# 名人面孔、动物和人造物类别特异性命名区脑定位的功能磁共振研究

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**摘要：目的** 在一些疾病中，病人会出现类别特异性的识别和命名障碍，但有关名人面孔、动物和人造物三种不同类型命名任务的脑定位研究仍存在争议。本研究旨在利用功能磁共振(fMRI)研究这三种不同类型命名任务的脑激活特点。**方法** 采用SPM8软件进行脑功能图像分析，命名任务与基线任务采用*t*检验统计，然后进行群组分析，结果用MNI坐标表示，解剖位置用XJview 8自动标记。**结果** 名人面孔命名区主要位于双侧前颞叶包括海马和杏仁核，且存在左侧优势，同时还激活双侧颞下回三角部和盖部；命名动物主要激活左侧辅助运动区；而命名人造物主要激活左侧运动前区和右侧辅助运动区，三种任务均有双侧梭状回激活，但命名人造物激活区范围比其余两种任务都大。**结论** 人、动物和人造物三种不同类型命名任务的脑定位存在差异，这提示在术中定位功能区过程中，需要选择不同类型的命名任务，以减少阴性刺激和术后永久性功能障碍的发生率。

**关键词：**脑定位；类别特异性命名；名人面孔；动物；人造物