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Research Report

Differential activation of object-selective visual areas by passive viewing of pictures and words

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Abstract

Functional imaging has shown that pictures of faces (N. Kanwisher, J. McDermott, M.M. Chun, The fusiform face area: a module in human extrastriate cortex specialized for face perception, J. Neurosci. 17 (1997) 4302–4311) and buildings (R. Epstein, N. Kanwisher, A cortical representation of the local visual environment, Nature 391 (1998) 598–601) activate different regions within the lateral occipital complex (LOC). To investigate effects of stimulus format on activation in these areas, we used event-related fMRI to measure brain activity during the passive viewing of pictures showing buildings and faces, and of words identifying these pictures. Consistent with earlier findings, pictures of faces activated bilateral regions in the lateral fusiform gyri, whereas pictures of buildings activated bilateral regions in the parahippocampal gyri. Analyzing the activation elicited by visually presenting the written names of the pictures, however, we did not find an effect of word meaning on the fMRI signal change in these areas: fMRI signal changes for the names of faces and the names of buildings did not differ in any of the areas selectively activated by the corresponding pictures. In general, both word conditions and non-preferred picture conditions elicited similar signal amplitudes. While presentation of words did not lead to strong activation in object-specific areas, activation for words of both categories was found in the left occipito-temporal cortex, close to the location which has tentatively been called 'visual word form area' (L. Cohen, S. Dehaene, L. Naccache, S. Lehéricy, G. Dehaene-Lambertz, et al., The visual word form are: spatial and temporal characterization of an initial stage of reading in normal subjects and posterior split-brain patients, Brain 123 (2000) 291–307), revealing that words were processed effectively during the experiment. Taken together, these results show that names of pictures do not automatically activate the corresponding object-selective areas.

1. Introduction

Functional imaging studies have shown that regions in the occipito-temporal cortex respond preferentially to pictures of specific types of objects. The most prominent examples for categories that have been reported to elicit object-selective activation are faces and houses or scenes. Specifically, it has been demonstrated that an area in the lateral fusiform gyrus, sometimes called the fusiform face area (FFA; [34]), is activated when subjects view pictures of faces in comparison to viewing scrambled pictures or pictures of other objects. In contrast, pictures of buildings selectively activate a more medial region within the ventral occipital cortex, which has been called the parahippocampal place area (PPA; [15]). This lateral-to-

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medial topography of face vs. house-related peak activations has reliably been reported (e.g., [7,8,15,22,39,41]; see [24] for a recent review). It is highly consistent within individuals [60] and across studies [42].

In the present study, we investigated whether presentation of words leads to an automatic activation of object-category-specific areas in the ventral occipitotemporal cortex. This question is highly relevant for further studies in the field, because in order to separately investigate processing of pictures and words in neuroimaging studies, it is necessary to ensure that evoked responses can be disentangled.

Evidence for activation of perceptual information during word reading comes from behavioral studies showing word-picture priming [21,38,49] and from imaging studies showing similar patterns of activation in the left occipito-temporal cortex for objects and their denotations either during naming and silent reading [4] or during semantic judgment tasks [64]. It has further been shown that semantic processing of written words from different categories (animals and tools) can evoke category-related activation patterns in the fusiform gyri similar to those obtained during viewing and naming of pictures from the same categories [7,51].

In contrast to these studies showing that it is possible to obtain category-specific activation during semantic retrieval, we wanted to know whether presentation of words leads to a rapid, automatic category-specific activation in human LOC. To achieve this goal, we presented pictures of faces and buildings and the corresponding words tachistoscopically in a rapid presentation event-related fMRI paradigm. Furthermore, the primary task of our subjects was a geometrical pattern detection task, for which the identification of the object pictures or words was not necessary. Taken together, the presentation mode and task demands favored shallow processing [12] of face and building stimuli. We expected that under these conditions, activation in ventral occipital complex will be largely bottom-up driven, and top-down effects [37] will be small. Therefore, we expected that pictures of faces and buildings would elicit a lateral to medial category specific activation, replicating previous studies. Corresponding words, on the other hand, were not expected to elicit a comparable category-specific activation in the FFA and PPA. In contrast, we expected a region in the left fusiform gyrus to respond maximally to word stimuli, corresponding to previous reports [10,11]. Word-specific activation in this area has been found even in the absence of conscious processing [13,53]. Such a pattern of results would suggest that (1) written words are initially processed as a distinct category of visual 'objects' (e.g., word forms; [10,11,43], but see [54]), in much the same way as pictures of different object categories such as faces and objects, and (2) that there is no automatic (top-down) activation of category specific visual object processing areas, e.g., via semantic processing.

2. Materials and methods

2.1. Participants

Ten volunteers participated in this study (5 males). All subjects were consistent right handers according to their score in the Edinburgh Handedness Inventory [48]. Subjects' age was in the range of 20–37 years, with a mean age of 26.5 years. All subjects were native speakers of German and had no history of neurological or psychiatric disease. All subjects gave informed written consent according to the guidelines of the Max-Planck-Institute. The fMRI procedures were approved by the University of Leipzig ethics committee.

2.2. Stimuli and procedures

The experimental stimuli consisted of 30 color photographs and 30 black words on a white square that were presented on a grey screen (Fig. 1). For the building category, the pictures showed 15 different types of buildings; for the face category, the pictures showed 15 different human faces from various kinds of nationalities (see Appendix for a complete list of names). All faces were depicted in frontal view with about the same amount of hair and background visible. Pictures of faces were matched to the nationalities based on facial attributes only, such as skin complexion, hair color, eye color, etc. The words were the corresponding descriptions for each picture, i.e., the names of the buildings and the names of the nationalities (e.g., "church" and "Chinese"[1]). The names of the two categories did not differ with respect to frequency taken from the CELEX data base [2], word length, and number of syllables (all $P > 0.05$). Scrambled versions of all picture and word stimuli were generated using Fourier transformations on red, green, and blue components that left the spatial frequency of the picture intact (http://www.princeton.edu/~mpinsk/science.htm).

In addition to passively watching the picture and word stimuli, subjects' had to make a two-choice discrimination judgment based on two target stimuli. Pictures of two circles with a small gap on either the right or the left side were presented simultaneously and subjects had to decide as fast as possible whether the openings were in the same or opposite directions. This task was used to ensure that subjects were fixating during the experiment, because identification of the gaps in both targets at once was only possible when fixating the cross in the middle.

All scans were performed in a single session with an absolute scanning time of about 20 min. Stimuli were presented through LCD goggles (VisuaStim XGA, Reso-

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[1] In the German language, there are different words for adjectives and people belonging to a certain nationality, i.e., they are non-ambiguous.