



The neural organization of perception in chess experts

Daniel C. Krawczyk^{a,b,*}, Amy L. Boggan^a, M. Michelle McClelland^a, James C. Bartlett^a

^a Center for BrainHealth® and School of Behavioral and Brain Sciences, The University of Texas at Dallas, Richardson, TX 75083-0688, USA

^b Department of Psychiatry, University of Texas Southwestern Medical Center, Dallas, TX 75390-9070, USA

ARTICLE INFO

Article history:

Received 3 February 2011

Received in revised form 2 May 2011

Accepted 15 May 2011

Keywords:

Perception

Face processing

Chess

Expertise

fMRI

ABSTRACT

The human visual system responds to expertise, and it has been suggested that regions that process faces also process other objects of expertise including chess boards by experts. We tested whether chess and face processing overlap in brain activity using fMRI. Chess experts and novices exhibited face selective areas, but these regions showed no selectivity to chess configurations relative to other stimuli. We next compared neural responses to chess and to scrambled chess displays to isolate areas relevant to expertise. Areas within the posterior cingulate, orbitofrontal cortex, and right temporal cortex were active in this comparison in experts over novices. We also compared chess and face responses within the posterior cingulate and found this area responsive to chess only in experts. These findings indicate that the configurations in chess are not strongly processed by face-selective regions that are selective for faces in individuals who have expertise in both domains. Further, the area most consistently involved in chess did not show overlap with faces. Overall, these results suggest that expert visual processing may be similar at the level of recognition, but need not show the same neural correlates.

© 2011 Elsevier Ireland Ltd. All rights reserved.

Expertise can be developed through extreme levels of practice resulting in behavior considered to be outstanding relative to the general population. Uncommonly effective performance within a domain remains the clearest marker of expertise [10,7]. Recent neuroimaging explorations of expertise using have begun to provide insights into the neural basis of expertise [8,26]. Among expert domains, chess is widely regarded to be one in which a select few experts perform at an exceptional level [6,15]. In the process of becoming outstanding at chess, a Master level player accumulates massive visual experience with chess configurations. This experience confers distinct advantages to experts over novices when encountering situations that commonly appear in games. These expertise effects are limited to game configurations, as the perceptual and memory advantages of experts are greatly reduced when tasks are not chess game specific [10,6]. Meanwhile, the brain organization of perceptual recognition in chess experts has remained unclear.

The perception of faces is a skill at which nearly everyone is considered to be an expert. Face perception has been associated

activation of the fusiform gyrus [18]. More broadly, the fusiform is considered to be a neural marker of visual expertise, as other studies have reported selective fusiform activity when car experts and bird experts perceive cars and birds and when radiologists examine scans [12,27,17]. Such findings have spawned the hypothesis that the fusiform gyrus can support expert processing in a variety of domains. However, cars, birds, and body scans share properties with faces, including similar features, similar configurations, and biological characteristics in the case of birds and radiology scans. Chess allows a critical test for theories of visual expertise, as chess configurations bear little featural or configural resemblance to faces, cars, or birds and also lack biological characteristics. If chess experts process chess patterns similarly to faces, it would challenge the view that common visual or biological characteristics are necessary for different classes of stimuli to be perceived in the same way [9].

The idea that face-selective fusiform cortex can become adapted to process chess patterns is a compelling one, and there have been reports in the expertise literature that the fusiform may be involved in processing chess patterns [21,24,2]. A recent documentary film showed a neuroimaging clip with a chess expert and suggested that the face-selective fusiform can be “hijacked” to process chess patterns [23]. However, there has not yet been a published study comparing expert chess perception to that of faces and other visual categories.

The present study addressed the central question of how large amounts of practice at chess alters the functional organization of the brain. Specifically, we tested whether face selective areas

Abbreviations: FFA, fusiform face area; OFA, occipital face area; MRI, magnetic resonance imaging; MNI, montreal neurological institute; ROI, region of interest; HRF, hemodynamic response function; GLM, general linear model.

* Corresponding author at: Center for BrainHealth® and School of Behavioral and Brain Sciences, The University of Texas at Dallas, Richardson, TX 75083-0688, USA. Tel.: +1 972 883 3234; fax: +1 214 905 3026.

E-mail address: daniel.krawczyk@utdallas.edu (D.C. Krawczyk).

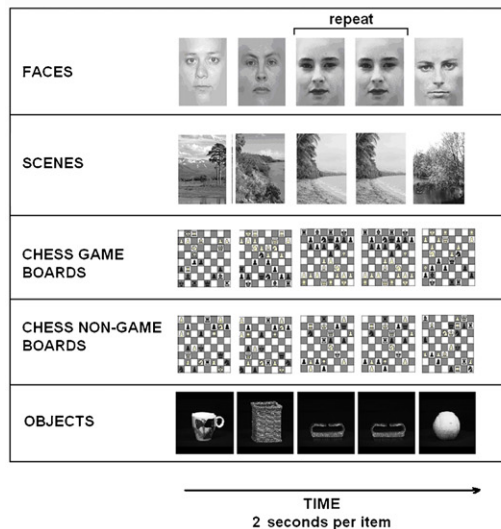
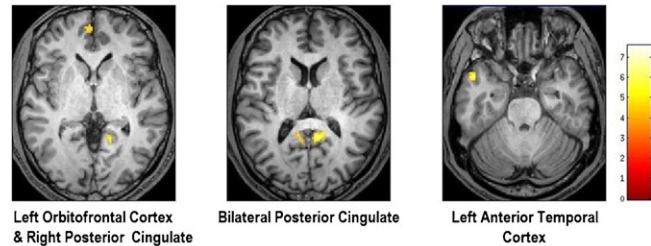
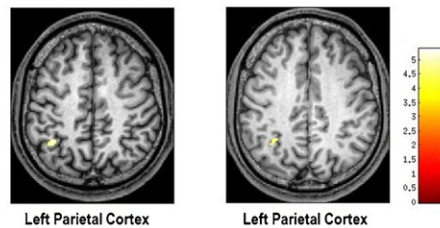
A. fMRI Visual Recognition Conditions**B. Areas showing greater activation for Chess > Random Chess contrast in Experts over Novices****C. Areas showing greater activation for Chess > Random Chess contrast in Novices over Experts**

Fig. 1. (A) Examples of each category shown in the experimental task. Conditions included blocks of chess, random chess, faces, outdoor scenes, and objects. (B) Regions of significant difference within the experts over the novices on the chess > random chess contrast. (C) Regions significantly greater for novices over experts on the chess minus random chess contrast.

become adapted to support chess expertise at an early perceptual level and whether there are other regions that become more active when chess expertise has been achieved. We compared the activation of chess experts and novices when viewing faces, chess boards, and other stimuli to determine whether chess and face perception activate common regions using fMRI.

We included a comparison of chess board recognition to scrambled chess board recognition, as scrambled boards tend to reduce the performance advantage typical of chess experts [10,6]. By including this comparison, we are able to address a secondary question: whether chess expertise is limited to game-specific configurations at the neural level, or whether this expertise extends to non-game configurations using the same spatial and featural information. Furthermore, we were interested in whether such areas would show chess selectivity relative to faces and other visual categories including scenes and objects.

Subjects were twelve healthy, right-handed males. Six were chess experts recruited from the UT Dallas Chess Program, age 20–28 ($M=23$ years). These subjects ranked within the top one percent of tournament players (five International Masters, one Grandmaster). Their expertise was substantiated by their competitive ratings (Elo range = 2447–2583; $M=2515$), years playing ($M=16$ years), and tournament activity ($M=17$ per year). The remaining six subjects were healthy males who were chess novices age 21–27 ($M=25$ years). These subjects reported that they rarely played chess and had not participated in tournaments. This experiment was approved by the Institutional Review Boards of UT Dallas and UT Southwestern Medical Center. Informed consent was obtained in accordance with the 1964 Declaration of Helsinki.

Subjects viewed blocks of items and judged whether each was a repeat or a new image. Stimuli consisted of images of chess boards from games, randomly positioned chess boards that could not occur in real games, objects [14], and outdoor scenes (see Fig. 1A). Images were presented in five runs of 8 blocks, 12 images per block, 2 s per image, and a 5000 ms inter-stimulus interval. We used longer exposure times and inter-stimulus intervals than standardly appear in the face literature to ensure that novices could perform the task given the complexity of chess boards. Images were presented offset from center to the right or left in an alternating sequence to avoid apparent motion effects in the chess conditions between

non-matching items in sequence. Two image repeats occurred per block, and subjects were instructed to press buttons for each repeat. Each block, presented in a pseudo-randomized order, contained one image category or was a fixation block (lasting 30 s).

Images were acquired using a 3T Philips MRI scanner with a gradient echoplanar sequence ($TR=2000$ ms, $TE=28$ ms, flip angle = 20°) sensitive to BOLD contrast. Each volume consisted of tilted axial slices (3 mm thick, 0.5 mm slice gap) that provided nearly whole brain coverage. Anatomical T1-weighted images were acquired in the following space: $TR=2100$ ms, $TE=10$, slice thickness = 4 mm with no gap at a 90° flip angle.

fMRI block design analyses were conducted using multiple regression. Preprocessing was conducted using SPM5 (www.fil.ion.ucl.ac.uk/spm). EPI images were realigned to the first volume and then smoothed (8 mm 3D Gaussian kernel).

Separate regressors were used to model each block, convolved with a canonical hemodynamic response function (HRF), and entered into a modified general linear model (GLM). Parameter estimates were extracted from this analysis for each regressor. At an individual subject level, contrasts between conditions were computed by performing one-sample t -tests on the contrasted images. A faces minus scenes and objects contrast was used to functionally define ventral temporal and occipital regions of interest (ROIs) using a Family-Wise Error (FWE) corrected threshold ($p < .01$). In some instances False Discovery Rate (FDR) ($p < .05$) or uncorrected ($p < .005$) thresholds were used to localize as many of the face regions as possible in each subject (minimum of 10 voxels per cluster). While we did not run an independent face localizer to isolate fusiform face area (FFA) regions, we did not include chess or random chess to localize FFAs, thereby leaving chess as an independent category to be evaluated.

We also isolated chess regions using a chess minus random chess contrast between groups. To carry out a subject-specific ROI analyses, we ran this contrast on each group independently ($p < .001$ uncorrected, 10 voxel cluster minimum). This contrast showed no significant clusters in novices. In experts, this contrast resulted in two clusters within the posterior cingulate (MNI coordinates: $x=32$, $y=10$, $z=12$) and the right insula ($x=12$, $y=-50$, $z=10$). To further isolate chess responses we defined ROIs at the individual level. Five of the experts showed significant activation within the

Download English Version:

<https://daneshyari.com/en/article/6284687>

Download Persian Version:

<https://daneshyari.com/article/6284687>

[Daneshyari.com](https://daneshyari.com)