Fusiform Face Area in Chess Expertise

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Abstract

The ability to recognize faces is arguably one of the most important and most practiced skills. The possible functions of the fusiform face area (FFA), generally believed to be responsible for face recognition, also feature these two characteristics. On the one hand, there are claims that the FFA has evolved into a face specific module due to great importance of face processing. On the other, the FFA is seen as a general visual expertise module that distinguishes between individual examples within a single category. The previous studies used experts and novices on stimuli such as cars, birds or butterflies with ambiguous results. Here this research stream is extended to the game of chess, which does not share visible features with faces. The first study shows that chess expertise modulates the FFA activation when complex multi-object chess positions were presented. In contrast, isolated single chess objects did not produce different activation patterns among experts and novices. The second study confirmed that even a couple of isolated objects do not differently engage the FFA among experts and novices. The two studies provide support for the general expertise view of the FFA function, but also extend the scope of our understanding about the function of the FFA. The FFA does not merely distinguish between different exemplars. It also seems to engage into parsing complex multi-object stimuli that contain numerous functional and spatial relations.

Keywords: face perception; expertise; pattern cognition; chess; fMRI.

Introduction

Faces are arguably the most important and most practiced stimuli. We start practicing face perception from our early moments and we are highly dependent on correctly distinguishing individual faces. It is fitting that the proposed functions of the fusiform face area (FFA), possibly the most important brain area in face perception, center on these two characteristics: importance and practice. On the one side, we have researchers who believe the FFA, due to, among other things, its importance in our lives, has evolved into a brain module exclusively specialized for perception of faces (Kanwisher, McDermott, & Chun, 1997; Kanwisher & Yovel, 2006). On the other side, in contrast to this face-specificity hypothesis, we have researchers that advance the claim that the FFA is a general expertise module (Gauthier, Skudlarski, Gore, & Anderson, 2000; Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999). According to the expertise hypothesis, the FFA is responsible for perceptual processes associated with differentiating among different objects within a single category stimulus (e.g., visual individuation), without regard of the type of stimuli. We investigated the expertise hypotheses using the game of chess as a model for visual expertise.

The neural basis of face perception has been extensively investigated (for a review, see Kanwisher & Yovel, 2006). Different category types have been used to investigate the expertise hypothesis, ranging from birds (Gauthier et al., 2000), cars (Gauthier et al., 2000; Gilaie-Dotan, Harel, Bentin, Kanai, & Rees, 2012; Grill-Spector, Knouf, & Kanwisher, 2004; McGugin, Gatenby, Gore, & Gauthier, 2012; Xu, 2005), butterflies (Rhodes, Byatt, Michie, & Puce, 2004), to novel object types (Gauthier et al., 1999). The results are mixed and their interpretation has been the focus of an extensive debate (Bukach, Gauthier, & Tarr, 2006; Nancy Kanwisher & Yovel, 2006; Op de Beeck & Baker, 2010). Among factors complicating the interpretation is the visual similarity between faces and other categories employed – cars, birds, and even butterflies all have face-like features (Kanwisher & Yovel, 2006).

The game of chess offers a way around the resemblance problem. Chess entails both individual objects and complex "chess positions" made out of individual objects. None of chess objects resemble faces and chess positions do not have much in common with face, at least not at the superficial perceptual level. Individual chess objects can be, however, differentiated just like individual faces. Expert chess players have accumulated extensive knowledge about chess objects and are quicker in recognizing them as well as their relations than novice chess players (Bilalić, Kiesel, Pohl, Erb, & Grodd, 2011; Kiesel, Kunde, Pohl, Berner, & Hoffmann, 2009; Saariluoma, 1995). The real (chess) expertise lies, however, in using knowledge to quickly size the gist of chess positions (Bilalić, Langner, Erb, & Grodd, 2010; Bilalić, Turella, Campitelli, Erb, & Grodd, 2012; Gobet & Simon, 1996). This expertise process of automatically parsing complex multi-object environment bears similarity to that found in face perception. Both processes are automatic, quick, and efficient in binding individual features into meaningful units.

These characteristics make chess a suitable domain for investigation of the FFA expertise hypothesis. A recent study showed that expertise in chess is negatively correlated with the performance on face perception (Boggan, Bartlett, & Krawczyk, 2012). One possible interpretation would be that both skills engage similar processes that compete for the resources in the same brain areas. Indeed, we (Bilalić, Langner, Ulrich, & Grodd, 2011) recently showed that chess expertise mediates the activation in the FFA regardless of the task (domain specific or not) as long as the stimuli feature naturalistic chess positions (but see Krawczyk, Boggan, McClelland, & Bartlett, 2011). However, it is unclear how the FFA will behave with individual chess objects instead of multi-object positions. Here I present two studies that test the FFA responses with individual chess objects and complex chess positions. In the first study we presented participants with single isolated chess objects and chess positions during a 1-back task. In the second study we used only a couple of isolated chess objects in chess specific tasks (see Bilalić et al., 2011).

Study 1

Method

The first study involved a 1-back task where participants indicated whether the current stimulus was the same as the previous one.

Participants Table 1 presents the information about the number of experts and novices, their mean age (with SD), and their chess ability score [mean Elo rating with SD; available only for experts] in both studies. All participants were male and right-handed. The sample size is relatively small, but it reflects the rarity of the studied group and is comparable to recent behavioural studies using chess experts (e.g., Bilalić et al., 2008a, 2008b, 2009; Brockmole et al., 2008; Kiesel et al., 2009). The small sample size is offset by the large differences between experts and novices. We also used exclusively male participants as they outnumber female chess players and we were not interested in gender differences. Written informed consent was obtained in line with the study protocol as approved by the Ethics Committee of Tübingen University.

Table 1: Participants – Overview

Study	Group	Age±SD	Elo±SD	*n*
1	Expert	24±8	2116±125	12
	Novice	27±6	----	14
2	Expert	29±7	2130±147	8
	Novice	29±5	----	8

Localizer Participants first passively watched pictures of faces and objects to localize face related areas (for more details, see Bilalic et al., 2011). The area used in further analysis, the right FFA and the right posterior superior temporal sulcus (pSTS) were then identified (contrast faces vs. objects; $p < .0001$ uncorr.) and isolated for the use in Study 1 and 2 – see Figure 1.

Stimuli and procedure The 1-back task in Study 1 featured the following stimuli: faces, isolated chess objects (pieces), and chess positions (see Figure 2). The stimuli of each category were blocked in 12 second units that featured 6 individual stimuli (each stimuli taking 1.75s with a break of 0.25s between them). There were ten blocks of each category spread over two different runs. Baseline (18s of black screen with a cross in the middle) was presented between the blocks of stimuli.

MRI acquisition and data analysis fMRI data were acquired using a 3-T scanner (Siemens Trio) with a 12-channel head coil. All measurements covered the whole brain using a standard echo-planar-imaging (EPI) sequence with the following parameters: TR, 2 s; FOV, 192 x 192; TE, 30 ms; matrix size, 64 x 64; 32 slices with thickness of 3.2 and 0.8 mm gap resulting in voxels with the resolution of 3 x 3 x 3.2 mm3. Finally, anatomical images covering whole brain with 176 sagittal slices were obtained after the functional runs using an MP-RAGE sequence with a voxel resolution of 1 x 1 x 1 mm3 (TR, 2.3 s; TI, 1.1 s; TE, 2.92 ms). SPM software package was used for analysis. All functional data were first preprocessed using standard SPM routines for realignment, coregistration, normalization and smoothing (8mm). Blocks of individual stimulus categories as conditions of interest were then modeled using the standard canonical response function. The ROI analysis was performed on the mean percentage signal change extracted using Marsbar SPM Toolbox from all the voxels within the selected region – FFA and pSTS.

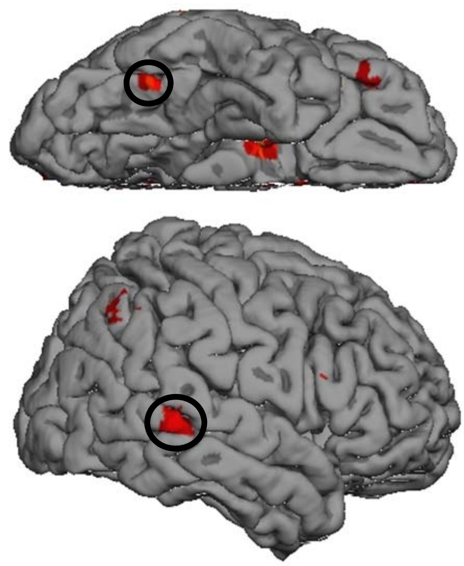

Figure 1: FFA (upper picture – inferior view) and pSTS (lower picture – lateral view) used as regions of interest (ROI) in the studies.

Results and discussion

The faces unsurprisingly activated the FFA more than the two chess categories, but chess positions also elicited more activation than chess objects (ANOVA for main effect of stimulus category – $F(2, 48) = 79$, $p = .001$) – see Figure 2.

There was no overall effect of expertise ($F(1, 24) = 0.3$, *ns.)* but the expertise modulated activation depending on the stimulus category (ANOVA for interaction expertise x stimulus category – $F(2, 48) = 4.5$, $p = .016$). While there were no differences between experts and novices on chess objects and faces, experts' FFA was more activated on the chess positions than the FFA of novices ($t(24) = 2.2$, $p = 0.039$).

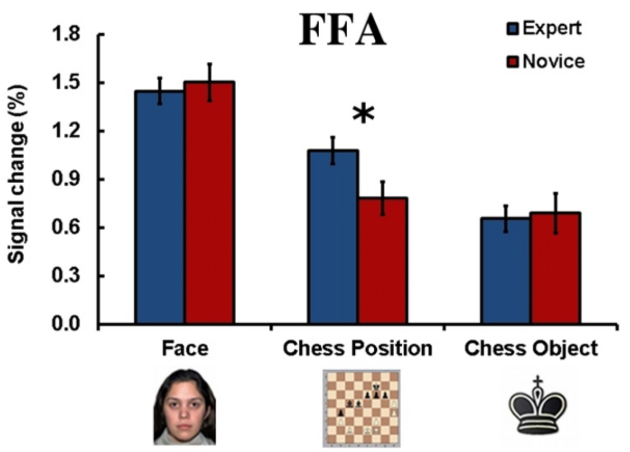

Figure 2: FFA activation pattern among experts (blue) and novices (red) on faces, chess positions, and chess objects in Study 1.

Unlike with the FFA, in the pSTS there were no expertise effects ($F(1, 24) = 1.6$, *ns*) nor there was interaction between expertise and stimulus categories ($F(2, 48) = 0.2$, *ns*) – see Figure 3. Faces again elicited most activation, which resulted in the significant main effect of stimulus categories ($F(2, 48) = 11.6$, $p = .001$).

This is the first time both isolated and complex chess stimuli were used in a single study. The results confirm the previous study on chess expertise (Bilalic et. al., 2011) and its finding of FFA sensitivity to expertise on complex chess positions. Here it is shown that the same pattern of activation does not generalize to single isolated objects. When isolated chess pieces were presented, expertise did not modulate the FFA activity.

Study 2

Method

The second study again used chess stimuli in chess specific tasks but this time they were neither completely isolated – they always featured two objects. The study has been published (Bilalić et al., 2011) but here we use the unpublished ROI analysis on the FFA and pSTS.

Participants Information about participants is presented in Table 1.

Task, stimuli and procedure There were three tasks (Figure 4). In the check task, participants had to indicate if

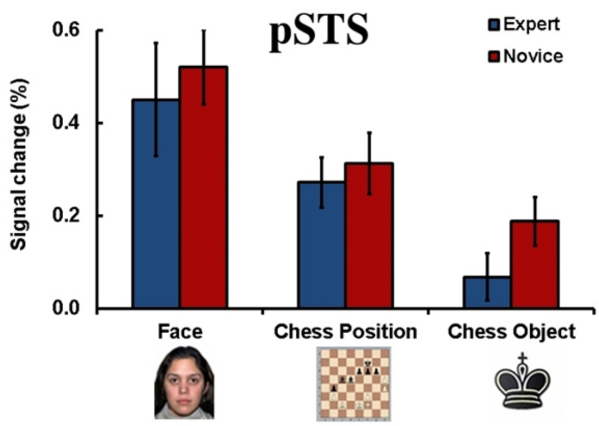

Figure 3: pSTS activation pattern among experts (blue) and novices (red) on faces, chess positions, and chess objects in Study 1.

the white king is given check (one of the most important aspects in the game of chess) by the present black piece. In the identity task, the participants were presented with the same stimuli as in the check task, but this time they had to identify the black piece presented. In the control task, chess pieces were changed for geometrical shapes and the participants had to indicate the identity of the shape (diamond or square). We again used block design (for more details, see (Bilalić et al., 2011) with blocks of 13.5s containing 4 trials.

MRI acquisition and data analysis This part of the study was the same as the previous study, except that this time a different EPI sequence was used: TR, 2.5 s; FOV, 192 x 192; TE, 35 ms; matrix size, 64 x 64; 36 slices with thickness of 3.2 0.8 mm gap resulting in voxels with the resolution of 3 x 3 x 4 mm3. We again specified condition of interest as blocks, convolved it with HRF and analyzed responses in the selected ROIs using MarsBar toolbox.

Results and discussion

Unlike in the previous study, there were no differences among experts and novices in the FFA activity in none of the three tasks (ANOVA for expertise, $F(1, 14) = 0.1$, ns) – see Figure 4. There were no differences between the tasks (ANOVA for task, $F(2, 28) = 1.1$, ns) nor there were differences between the task among the groups (ANOVA for task x expertise interaction, $F(2, 28) = 0.9$, ns).

Similarly, the pSTS also did not produce different responses among experts and novices in all three tasks ($F(1, 14) = 1.8$, ns) and there was no main effect of task ($F(2, 28) = 5.1$, ns) nor interaction with expertise ($F(2, 28) = 0.04$, ns).

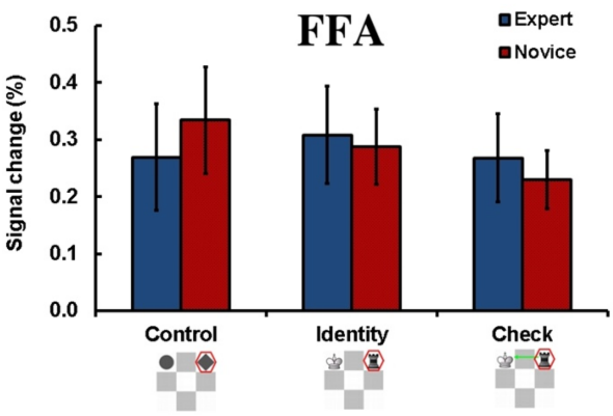

Figure 4: FFA activation pattern among experts (blue) and novices (red) on control task (identifying geometrical shapes), identity task (identifying chess objects), and check task (identifying check relations among objects) in Study 2.

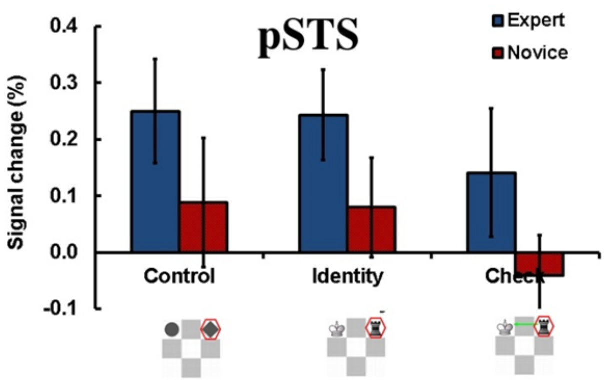

Figure 5: pSTS activation pattern among experts (blue) and novices (red) on control task (identifying geometrical shapes), identity task (identifying chess objects), and check task (identifying check relations among objects) in Study 2.

General Discussion

Our previous study (Bilalić et al., 2011) showed that the FFA is sensitive to expertise as long as chess positions were present, even when the task at hand did not require specific chess activity. Here this result is extended to other kind of chess stimuli – isolated chess objects. Study 1 showed that chess positions, stimuli featuring several chess objects, produced an expertise effect, confirming our previous study. There were no, however differences when isolated chess objects were presented. The lack of expertise modulation with isolated chess objects was further confirmed in Study 2. Even when two objects formed a relation, the FFA was not responding differently in experts and novices.

Chess objects (as featured in Study 1) and chess relations (as featured in Study 2) are main building blocks of chess positions and the very same stimuli that consistently elicit expertise effects in the FFA. It is thus surprising to find a lack of expertise effect in the FFA when it comes to isolated chess objects and their relations. One reason could be that Study 1 did not use explicit individuation between chess objects. Study 2, however, did use the differentiation between chess objects (based on which the tasks could be only done), not to mention that individuation processes are assumed to be implicit and automatic. It is, of course, possible that the lack of expertise effects in the FFA was due to low power of the studies. After all, the studies featured dozen participants in each group at most and the non-significant results should not be confused with a complete absence of effects. It is nevertheless the case that chess positions produced significant expertise effects in FFA in this and previous study, although both studies did not have large samples.

The FFA seems to be the only face area involved in chess perception. Here it was again shown that the pSTS does not differentiate between experts and novices on chess stimuli. As with the previous non-significant effect, one needs to be careful with conclusions. It seems reasonable, however, to conclude that the role of pSTS in chess expertise is arguably not as pronounced as that of FFA.

Although visually different, chess positions are essentially rather similar to faces. They are also made out of different individual parts (chess objects and relations between them). These parts are perceived as such only by beginners. Experienced chess players perceive chess positions rather as meaningful units, not unlike most of us perceive faces. The stored knowledge structures in memory (Gobet & Simon, 1996) that enable them to quickly recognize situations on the board. In that sense, processes involved into parsing chess positions are much closer to those involved in face perception that are the processes involved in recognition of chess individual objects.

The exact role of FFA in chess expertise remains to be determined. Our previous study (Bilalic et al., 2011) demonstrated that experts' FFA reacts to chess positions without regard of the executed task. Even task that were not chess related (e.g., counting the number of all chess objects on the board) elicited expertise effects in the FFA. This indicates that the chess related processes in the FFA are automatic and stimulus, not task, dependent. In contrast, the other chess areas identified in our studies (Bilalić et. al., 2010; 2012), such as a part of the collateral sulcus and retrosplenial cortex, are also sensitive to task demands in addition to stimuli. How these regions are connected and how and to what extend they enable chess expertise remains an important question for future research.

The results also revise the expertise hypothesis by providing evidence against individuation as the primary function of the FFA. Study 1 did not involve explicit individuation as the individual chess objects were only passively observed. Study 2, however, involved explicit identification of a single chess objects (Identity task) and there were still no expertise-modulated response in the FFA. Only chess positions, consisting of numerous chess objects and relations between those objects, produced different activation in the FFA of experts and novices. These results support previous studies demonstrating the importance of holistic parsing of individual parts of faces as the main FFA function (Arcurio, Gold, & James, 2012; Gold, Mundy, & Tjan, 2012), and put under questions is role in individuation.

They also revise the expertise hypothesis by providing evidence that complexity of stimuli and the processes that enable their fast and efficient perception are at the heart of the FFA function, and not only individuation.

These two chess studies, together with the previous work on the similarities between face and chess perception (Bilalić, et al., 2011; Boggan, 2012), underline the suitability of chess as an exploration vehicle in cognitive neuroscience.

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