Neuroanatomical correlates of aesthetic preference for paintings

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A study was conducted to determine the neuroanatomical correlates of aesthetic preference for paintings using fMRI. Subjects were shown representational and abstract paintings in different formats (original, altered, filtered), and instructed to rate them on aesthetic preference. Our primary results demonstrated that activation in right caudate nucleus decreased in response to decreasing preference, and that activation in bilateral occipital gyri, left cingulate sulcus, and bilateral fusiform gyri increased in response to increasing preference. We conclude that the differential patterns of activation observed in the aforementioned structures in response to aesthetic preference are specific examples of their roles in evaluating reward-based stimuli that vary in emotional valence. *NeuroReport* 15:893–897 © 2004 Lippincott Williams & Wilkins.

Key words: Aesthetics; Art; Caudate nucleus; Cingulate; MRI; Preference; Reward; Vision

INTRODUCTION

This study was conducted to determine the neuroanatomical correlates of aesthetic preference for paintings. To date, no neuroimaging work has been done on the topic of aesthetics in art, but there is reason to believe that neuroimaging techniques can be used to study this topic [1]. For example, substantial evidence has accumulated in two areas that are related to aesthetic preference for paintings. The first is the investigation of brain regions that are involved in processing pictures that vary in emotional valence. Findings from this area are relevant to aesthetic preference because people tend to attribute emotional valence to works of art [2]. Results have demonstrated that processing pleasant pictures is distinguished from neutral pictures by activations in the cingulate, left precuneus, right and left insula, right inferior frontal gyrus, visual cortex, and left caudate nucleus [3–5].

A second area of research that is related to aesthetic preference is the assessment of attractiveness in faces. Studies have shown that activations in medial orbitofrontal cortex, left anterior frontal cortex, left frontal-temporal junction, nucleus accumbens, right caudate nucleus, and visual cortex are related to viewing faces of varying degrees of attractiveness [6–8]. Activation in the aforementioned regions has been attributed to the reward properties of faces. In fact, it has been suggested that a system involving orbitofrontal and striatal neurons may be involved in the valuation of rewards irrespective of any particular modality that may give rise to the rewarding stimulus [9,10]. Because the role of the orbitofrontal cortex and the striatum in processing reward-based stimuli is well established [7,9] it appears that aesthetic preference for attractive faces is mediated by their reward value. Given the involvement of structures in frontal, limbic, paralimbic and visual cortex in processing attractive faces and pleasant visual stimuli, we hypothesized that aesthetic preference for paintings would involve some of the same structures.

MATERIALS AND METHODS

Subjects: Twelve right-handed subjects (10 females) with no history of neurological or psychiatric disorders participated in this study. The mean ($\pm$ s.d.) age of the sample was 28 ± 6.13 years and the education 16.4 ± 2.18 years. The study was approved by the Human Participants Review Sub-Committee of York University, and all subjects gave informed consent.

Materials and procedure: Twenty representational and 20 abstract paintings were selected from the archives of http://www.artcyclopedia.com. Graphic manipulation of stimuli was done using Photoshop (Adobe). Stimuli were resized to fit within a 500×500 pixels frame. These resized paintings will be referred to as original paintings (Fig. 1). An object in each original painting was then moved to a different location within the frame using Photoshop [11,12]. The purpose of this manipulation was to test whether compositional rearrangement would have an effect on aesthetic preference. The 40 paintings that were created through this process will be referred to as altered paintings (Fig. 1). Finally, each original painting was subjected to a median noise filter. This process resulted in the random distribution of color levels within a 16-pixel radius. The 40 paintings that were created using this process are referred to as filtered

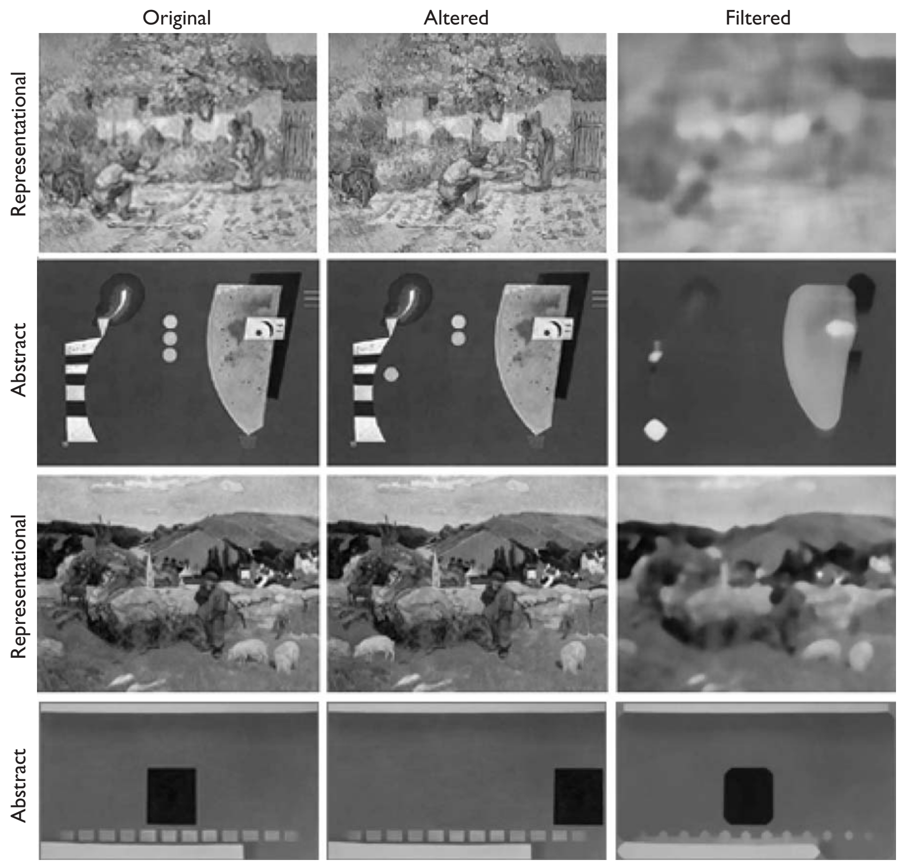

Fig. 1. Examples of stimuli that were used in the study. From top, Van Gogh (First steps), Kandinsky (Sin titulo, 1924), Gauguin (The Swineherd, Brittany), and O'Keeffe (Black door with red).

paintings (Fig. 1). Filtered paintings served as a comparison condition because they retained the overall form of the original paintings while lacking perceptual detail. The above process resulted in the preparation of 120 paintings that varied along the dimensions of Type (representational *vs* abstract) and Format (original *vs* altered *vs* filtered). In the scanner, paintings were presented in an event-related design. The three formats corresponding to each painting appeared in succession. The order in which the three formats (original, altered, filtered) were presented was randomized for each painting. There were no gaps in presentation between paintings. Each painting was presented for 6 s, and subjects were instructed to determine their preference ratings using a 0–4 scale, where 0 indicated very low preference and 4 indicated very high preference. Half the subjects used the right hand and the other half the left hand to enter their responses.

fMRI scanning and analysis: A 4 T magnet (Oxford Magnet Technologies) was used to acquire T1 anatomical volume images (3 × 3 × 5 mm voxels). Twenty-two 5 mm echoplanar images were acquired axially, positioned to cover the whole brain. Data were recorded during a single session, and a total of 240 volumes were acquired with a repetition time (TR) of 3.0 s/vol. The stimuli were presented to the subjects using a LCD projector (NEC MultiSync MT800) with a video resolution of 640 × 480 pixels, and a light output of 370 lumens. Data were analyzed using Statistical Parametric Mapping (SPM2) [13]. All volumes in the session were spatially realigned to the first volume of the session. All structural volumes were then spatially normalized to the Montreal Neurological Institute brain template [14] using non-linear basis functions [15]. The derived volumes were spatially smoothed with a 12 mm FWHM isotropic Gaussian kernel. The resulting time series across each voxel were high-pass filtered with a cutoff of 128 s, using cosine functions to remove session-specific low frequency drifts in blood oxygenation-level dependent (BOLD) signal. Condition effects at each voxel were estimated according to the general linear model and regionally specific effects compared using linear contrasts. Each contrast produced a statistical parametric map of the t statistic for each voxel, which was subsequently transformed to a unit normal z distribution. The activations reported survived a voxel level false-discovery-rate (FDR) correction of $p < 0.05$, and a cluster level correction of $p < 0.05$ using a random effects model.

RESULTS

Behavioral results: Average preference rating across all stimuli was 1.42 ± 1.25. Average preference ratings for representational and abstract paintings in their original formats were 2.32 ± 1.19 and 1.36 ± 1.23, respectively. Although average preference rating across all stimuli was low, the levels reported for representational and abstract

Table 1. Comparisons involving levels of Type and Format.

Comparison	Region of activation	*BA*	*L*	*Z*	*x*	*y*	*z*
Representational–abstract	Ventral occipital pole	18/19	L	4.60	−22	−102	−16
		18/19	R	3.99	20	−100	−14
	Middle temporal gyrus	37/39	R	4.38	44	−60	8
	Precuneus	7	R	3.57	4	−60	42
Original–altered	Lingual gyrus	18	R	4.83	16	−50	6
	Cerebellum		R	4.51	16	−62	−20
Original–filtered	Fusiform gyrus	18/19	R	4.31	42	−74	−16
(Representational original – representational filtered) – (abstract original – abstract filtered)	Lingual gyrus	19	L	4.59	−10	−44	−8
		19	R	4.00	16	−38	−8
	Superior/parietal sulcus	5/7	L	3.90	−14	−48	68
	Middle occipital gyrus	19	R	3.85	32	−90	18

Note. None of the reverse comparisons (abstract – representational, altered – original, filtered – original, filtered – altered, [(abstract original – abstract filtered) – (representational original – representational filtered)]) reached significance. Regions are designated using the MNI coordinates. *BA* indicates Brodmann area. *L* indicates laterality. *Z* indicates z– score.

paintings in their original forms were comparable with those reported elsewhere in the literature [16]. Average response latency was 2351.4 ± 1033.4 ms. There was a significant correlation between preference ratings and response latency ($r = 0.16$, $p < 0.05$). Thus, as preference for a painting increased, subjects viewed it for a longer period prior to rating it. A repeated-measures ANOVA demonstrated that representational paintings (1.73 ± 1.32) were preferred over abstract paintings (1.13 ± 1.14); $F(1,11) = 6.65$, $p < 0.05$). The results also demonstrated that original (1.84 ± 1.30) and altered (1.72 ± 1.26) paintings were preferred over filtered (0.74 ± 0.95) paintings ($F(2,22) = 64.12$, $p < 0.001$). Finally, there was a significant interaction between Type and Format ($F(2,22) = 36.54$, $p < 0.001$), indicating that the drop in preference between original and altered paintings versus filtered paintings was more pronounced for representational than for abstract paintings.

fMRI results: Subjects' preference ratings were analyzed using a mixed-model parametric analysis of fMRI data. Specifically, presentations of paintings were treated as events (coupled with preference ratings as the parameter of interest), and the period following the motor response was entered as an epoch of no interest. Behavioural results demonstrated a positive correlation between preference ratings and viewing time. Therefore, to reveal regions that covaried with preference ratings irrespective of viewing time, viewing time was entered as a covariate of no interest. The results revealed that activity in right caudate nucleus extending to putamen (6, 10, 8, $z = 4.57$) decreased in response to decreasing preference for paintings, while activity in left cingulate sulcus (*BA* 32/10; −16, 48, 0, $z = 4.42$), bilateral occipital gyri (−24, −104, 2, $z = 5.40$ and 24, −104, 2, $z = 5.30$), including bilateral fusiform gyri (*BA* 18; 46, −76, −20, $z = 5.29$, and −46, −76, −20, $z = 3.69$), right fusiform gyrus (*BA* 37/39; 32, −71, −31, $z = 4.70$), and bilateral cerebellum (32, −71, −31, $z = 5.29$, −12, −86, −28, $z = 5.22$, and −26, −94, −24, $z = 5.42$) increased in response to increasing preference for paintings (Fig. 2).

The behavioural results showed that representational paintings were preferred over abstract paintings. A categorical comparison of representational *vs* abstract painting conditions revealed significant activation in bilateral ventral occipital poles (*BA* 18/19; −22, −102, −16, $z = 4.60$ and 20, −100, −14, $z = 3.99$), posterior middle temporal gyrus (*BA* 37/39; 44, −60, 8, $z = 4.38$), and precuneus (*BA* 7; 4, −60, 42, $z = 3.57$; Table 1). The reverse comparison revealed no significant activation.

The literature has shown that original paintings are preferred over their altered counterparts [17], and our data exhibited a similar trend. We therefore undertook direct comparisons of original, altered, and filtered painting conditions. These comparisons demonstrated the involvement of lingual gyrus (*BA* 18; 16, −50, 6, $z = 4.83$) and the cerebellum (16, −62, −20, $z = 4.51$) in original *vs* altered paintings, and the involvement of right fusiform gyrus (*BA* 18/19; 42, −74, −16, $z = 4.31$) in original *vs* filtered paintings (Table 1). The reverse comparisons revealed no significant activation.

Finally, because behavioural data had demonstrated that the drop in preference between original and altered paintings *vs* filtered paintings was more pronounced for representational compared with abstract paintings, we conducted an interaction analysis [(representational original−representational filtered)−(abstract original−abstract filtered)]. The results revealed significant activations in bilateral lingual gyri (*BA* 19; −10, −44, −8, $z = 4.59$ and 16, −38, −8, $z = 4.00$), superior/parietal sulcus (*BA* 5/7; −14, −48, 68, $z = 3.90$), and middle occipital gyrus (*BA* 19; 32, −90, 18, $z = 3.85$; Table 1). The reverse comparison revealed no significant activation.

DISCUSSION

The result of the parametric analysis demonstrated that activations in right caudate nucleus, bilateral occipital gyri, left cingulate sulcus, bilateral fusiform gyri, and the cerebellum are related to preference ratings in different ways (Fig. 2). In particular, activation in right caudate nucleus decreased in response to decreasing preference ratings, with minimal activation for paintings with very low preference ratings (Fig. 2d). In contrast, activation in bilateral occipital gyri (Fig. 2f) and left cingulate sulcus (Fig. 2e) increased in response to increasing preference ratings, with maximal activation for paintings with very high preference ratings. The decrease in activation in right caudate nucleus (extending into putamen) in response to decreasing preference is in line with evidence from two different lines of research. First, imaging data on mood

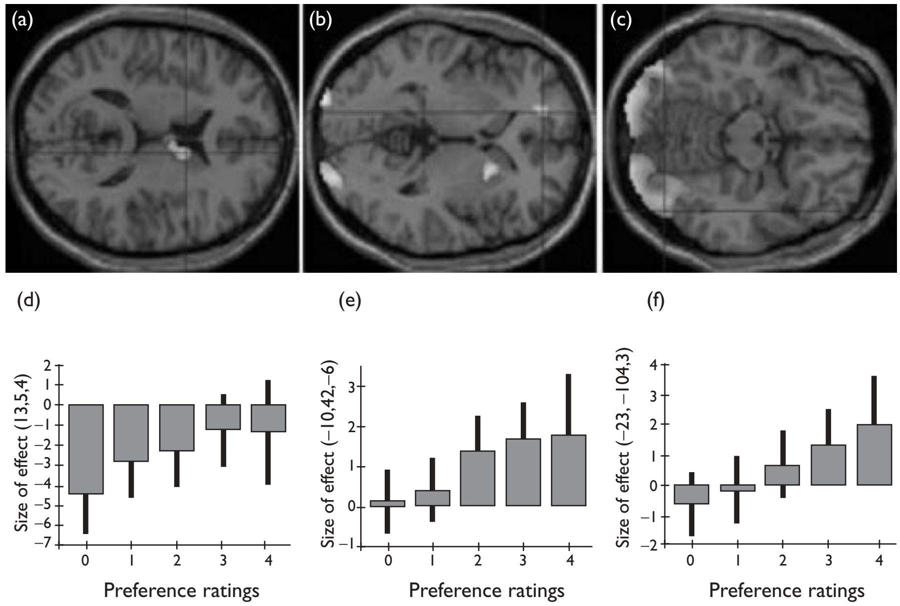

Fig. 2. Activation in (**a**) right caudate nucleus (10, 8, 14, $z = 3.73$), (**b**) left cingulate sulcus (−16, 48, 0, $z = 4.42$), and (**c**) bilateral fusiform gyri (46, −76, −14, $z = 5.23$ and −46, −76, −14, $z = 4.08$) and bilateral occipital gyri (−24, −104, 2, $z = 5.40$ and 24, −104, 2, $z = 5.30$; not shown) is related to preference for paintings. (**d**) Graph shows decreasing activation in right caudate nucleus (10, 6, 4, $z = 4.11$) in response to decreasing preference for a single subject. (**e**) Graph shows increasing activation in left cingulate sulcus (−10, 42, −6, $z = 3.43$) in response to increasing preference for a single subject. (**f**) Graph shows increasing activation in left occipital gyrus (−28, −104, 0, $z = 3.55$) in response to increasing preference for a single subject. SPM rendered into standard stereotactic space and superimposed on to transverse MRI in standard space. Regions are designated using the MNI coordinates.

disorders have demonstrated that activation in caudate nucleus is lower in depressed patients than normal controls [18,19]. One feature of depression is a decrease in the ability to experience pleasure and reward (anhedonia). Second, when subjects were required to make choices that were rewarded or punished monetarily, activation in bilateral caudate nuclei decreased sharply below baseline when the outcome was a punishment [20]. It was also demonstrated that the reduction in activation in the caudate nucleus was linked parametrically to magnitude and valence manipulations [21]. Because the involvement of the striatum in processing emotionally salient and reward-based stimuli is well established [7,9], the current results suggest that the decrease in activation in right caudate nucleus in response to decreasing preference may be a specific example of its general pattern of reduced activation in response to less rewarding stimuli.

The increase in activation in bilateral occipital poles and fusiform gyri in response to increasing preference is in line with findings from several studies that have highlighted the role of primary and associative visual cortex in processing pictures and faces that vary in emotional valence. For example, it has been shown that viewing pleasant versus neutral pictures results in increased regional cerebral blood flow (rCBF) in right primary visual cortex (*BA* 17) [3]. It has also been shown that viewing faces that convey positive emotion results in significant activation in bilateral fusiform gyri [22]. These results suggest that primary and associative visual cortex are involved in the assessment of visual stimuli that vary in emotional valence, although the results could also imply increased visual attention in response to higher preference ratings. The increase in activation in left cingulate sulcus in response to increasing preference adheres to findings from the literature on processing emotionally salient content. For example, rating as opposed to passively viewing pictures that vary in emotional valence was associated with increased activation in anterior cingulate sulcus (*BA* 32) [23]. Attending to subjective emotion in response to picture sets was associated with increased neuronal activity in anterior cingulate cortex (*BA* 32) [24]. The current results add to a body of evidence that implicates the cingulate sulcus in the active evaluation of visual stimuli that vary in emotional valence and reward properties, while also implying increased visual attention in response to higher preference ratings.

Representational paintings were preferred over abstract paintings. A comparison of representational *vs* abstract trials revealed significant activation in ventral occipital poles, posterior middle temporal gyrus (*BA* 37/39), and precuneus (*BA* 7). Because activation in bilateral occipital poles and fusiform gyri increased with increasing preference, the observed differences are probably a reflection of relatively increased activation associated with higher preference for representational paintings. Results from previous studies have shown that the middle temporal gyrus is involved in viewing faces that vary in emotional valence [22]. The current results extend those findings to include visual stimuli other than faces that vary in emotional valence and reward properties.

A comparison of original *vs* altered trials revealed significant activation in right lingual gyrus (*BA* 18). Previous studies have demonstrated that original paintings are preferred over their altered counterparts [17] and a trend in that direction was also apparent in our results. Displacing an object within the frame alters the compositional structure of paintings, and behavioural studies have shown that original paintings are considered to be more balanced and compositionally superior to their altered counterparts

[11,12]. Because the original *vs* altered comparison revealed significant activation in right lingual gyrus whereas the reverse comparison did not, it appears that an element related to the compositional structure of original paintings (e.g. perceived balance) may have resulted in increased activation in original paintings.

The difference in preference between original and filtered paintings was reflected in significant activation in right fusiform gyrus (*BA* 18/19). The right fusiform gyrus has been implicated in processing faces that convey greater emotional expression [22]. It appears that the activation in right fusiform gyrus in the original *vs* filtered comparison may be due to increased emotional or reward properties of original paintings. Behaviourally, the difference between original and filtered paintings was more pronounced for representational compared to abstract paintings. This interaction was reflected by significant activations in bilateral lingual gyri (*BA* 19), superior/parietal sulcus (*BA* 5/7), and middle occipital gyrus (*BA* 19). This reflects a larger difference in preference-related activation in the visual cortex between original and filtered versions of representational compared with abstract paintings. Finally, although altered paintings were preferred over filtered paintings, the altered *vs* filtered comparison did not yield any significant activation. A possible explanation may involve the composition of altered paintings. It is possible that compositional rearrangement may have diminished the compositional quality of altered paintings [11]. If structural composition is related to aesthetic preference, the reduced compositional quality of altered paintings may have reduced the likelihood of detecting a difference between altered and filtered paintings on a neuroanatomical level.

CONCLUSION

This study was conducted to investigate the neuroanatomical correlates of aesthetic preference for paintings. Our primary results demonstrated that activation in right caudate nucleus decreased in response to decreasing preference, and that activation in bilateral occipital gyri, left cingulate sulcus, and bilateral fusiform gyri increased in response to increasing preference. We conclude that the differential patterns of activation observed in right caudate nucleus, bilateral occipital gyri, left cingulate sulcus, and bilateral fusiform gyri in response to preference ratings are specific examples of their roles in evaluating reward-based stimuli that vary in emotional valence.

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