



Perception of direct vs. averted gaze in portrait paintings: An fMRI and eye-tracking study

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ABSTRACT

In this study, we use separate eye-tracking measurements and functional magnetic resonance imaging to investigate the neuronal and behavioral response to painted portraits with direct versus averted gaze. We further explored modulatory effects of several painting characteristics (premodern vs modern period, influence of style and pictorial context). In the fMRI experiment, we show that the direct versus averted gaze elicited increased activation in lingual and inferior occipital and the fusiform face area, as well as in several areas involved in attentional and social cognitive processes, especially the theory of mind: angular gyrus/temporo-parietal junction, inferior frontal gyrus and dorsolateral prefrontal cortex. The additional eye-tracking experiment showed that participants spent more time viewing the portrait's eyes and mouth when the portrait's gaze was directed towards the observer. These results suggest that static and, in some cases, highly stylized depictions of human beings in artistic portraits elicit brain activation commensurate with the experience of being observed by a watchful intelligent being. They thus involve observers in implicit inferences of the painted subject's mental states and emotions. We further confirm the substantial influence of representational medium on brain activity.

1. Introduction

1.1. Gaze in art theory and cognitive neuroscience

Gaze represents an important topic in both art history/visual studies and cognitive neuroscience. Art historians and art critics have written extensively on both various forms of gaze depicted in figural representations in paintings, photography and videoart, as well as on practices of gazing at works of art (e.g. Bryson, 1983; Wollheim, 1987; Belting, 2009). They distinguish various dimensions of depicted gazes (e.g. duration of the gaze, its “power”, or sexual allure) but most of these qualities cannot be easily objectified or studied by empirical methods. One aspect of gaze, however, which features prominently in both art historical accounts and scientific examination is the direction of the gaze.

It is well-established that gaze direction is a critical facial cue, essential for social interaction and cognition (Argyle & Cook, 1976; Frischen, Bayliss, & Tipper, 2007; George & Conty, 2008; Gibson & Pick, 1963; Hamilton, 2016). As an instrument of social

communication, it modifies the perception of emotions and enables decoding of mental states, related to the process of theory-of-mind or mentalizing. Gaze direction is a key element of socially relevant signaling encoded in and decoded from faces. Eye contact, modulates cognitive processing, particularly enabling to read or to see the minds of others in direct mutual interaction (Baron-Cohen, 1995; Nummenmaa & Calder, 2009; Senju & Johnson, 2009; Stawarska, 2006). Depending on the context, it can have various meaning, ranging from an expression of intimacy to that of dominance or hierarchy (George & Conty, 2008). In terms of Bayesian theories of the human brain, humans have prior expectation (priors) that other's gaze is directed toward them (Mareschal, Calder, & Clifford, 2013). Contemporary research thus sheds some light on the practice of visual artists who for centuries intuitively manipulated the direction of the gaze of depicted persons to imbue their works with distinct psychological effects. Eye contact was given prominence in Roman portrait busts, which often express an awareness of the viewer's gaze and initiate – probably for the first time in history of art – direct scopical and thus potentially psychic interaction with beholder

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(Nodelman, 1975). This potential has then been further explored in some of the arguably best Renaissance and modern portraits, where the gaze of the depicted subject returns the gaze of the viewer, or – on the other hand – avoids it in various ways. In summary, artists have been exploring the potential of a painted gaze for centuries, deploying it in specific ways and in conjunction with facial expression, to imbue portraits with distinct meanings and effects and they continue to do so (Kesner, 2011).

Several neuroimaging experiments have explored the neural correlates of direct versus averted gaze. The brain areas that respond differently to eye contact and averted gaze include the posterior superior temporal sulcus (STS) linked to processing of gaze shifts, the amygdala engaged in processing of threatening and ambiguous stimuli, the fusiform gyrus, the orbitofrontal cortex, as well as regions involved in self-related and complex social-cognitive processing and theory of mind/mentalizing (the paracingulate part of medial prefrontal cortex and temporo-parietal junction, TPJ) (for a review see Senju & Johnson, 2009; Nummenmaa & Calder, 2009; Hamilton, 2016). However, many inconsistencies among the findings prompt further research in this area. One of the specific problems concerns the role of specific visual modality, which conveys the face and gaze stimulus.

1.2. Aims and hypotheses

Neuroimaging studies on gaze direction conducted so far have used naturalistic photographs of isolated eyes and eyes in a face, in which the gaze direction is sometimes digitally manipulated (e.g. Kampe, Frith, & Frith, 2003; Mason, Tatkov, & Macrae, 2005; Straube, 2010; Berchio et al., 2016), symbolic line drawings (Friesen & Kingstone, 1998), video clips (Kuzmanovic et al., 2009; Pelphrey, Morris, & McCarthy, 2004), computer-generated agents (Schilbach et al., 2006; Wilms et al., 2010) and, most recently, also live people (Cavallo et al., 2015; Debruille, Brodeur, & Franco Porras, 2012; Myllyneva & Hietanen, 2015a, 2015b; Pönkänen et al., 2011). Different types of stimuli have different levels of ecological validity, social richness and potential to engage an audience effect (Hamilton, 2016; Risko, Laidlaw, Freeth, Foulsham, & Kingstone, 2012). So far, there is only scant evidence of the effect of representational medium in the perception of gaze direction. Several studies using event-related potential (ERP) N170 showed that the physical and structural characteristics (photographs or impoverished line-drawn faces) of the stimulus drive and modulate the response in favor of the photographs (Puce, Smith, & Allison, 2000; Rossi, Parada, Kolchinsky, & Puce, 2014; Rossi, Parada, Latinus, & Puce, 2015). Congruently, a comparison of responses to a directly gazing live person, photograph and dummy showed that ERPs in early windows (125–170 and 170–230 ms) depended on the nature of the stimulus and in N300 were significantly more negative in the case of the dummy (Debruille et al., 2012). However, it is not clear if the findings from these studies are generalizable to brain processing of artistic portraits. Clearly, the problem is (how) the representational medium modifies the neurobiological response to human faces and gazes prompts further investigation.

Our study, consisting of a separate fMRI and eye-tracking experiment, was designed to explore the neuronal and behavioral response to painted portraits with direct versus averted gaze. This study addressed two questions. First, we aimed to identify how the neural and behavioral response to emotional expressive faces in paintings is modulated by the direction of gaze. In other words, we asked if direct (vs. averted) gaze in painterly portraits affects the saliency of the social cognition brain areas. To identify the behavioral influence of the gaze direction in artistic portraits on the beholder's eye movements and visual scanning, we complemented the fMRI study by performing separate eye-tracking measurements. Second, to identify the modulatory effects of painting characteristics on brain activation, we further resampled our artistic portraits series according to three contrasting factors: (i) *period of the painting* (pre-modernist vs. modernist paintings); (ii) *influence of style*

(painterly vs. linear),¹ and (iii) *pictorial context of the portrait* (face only vs. face and torso vs. face, torso and hand gesture).

We hypothesized that firstly; direct vs averted gaze will exert different brain activation similar to previous studies with photographs and videos. Specifically, direct gaze will be linked to activity in the fusiform gyrus and in brain areas processing mentalizing (paracingulate cortex, MPFC and TPJ). The separate eye-tracking experiment addressed the question of the behavioral effect of portrait characteristics. We expected that (i) beholders will spend more time viewing the eyes of the depicted person with direct gaze, than under an averted gaze condition; (ii) the representational medium characterized by the modern and painterly styles (i.e. less realistic) will engage cortical regions responsible for higher level of visual processing more intensively than realistic pictures (typically a linear style of painting). We assumed that this effect stems from the fact that more formalized or stylized/less realistic pictures need more effort (with larger hemodynamic response) to be recognized and processed properly. We further assumed that the specific face-processing brain areas (e.g. the fusiform gyrus) would be activated more intensively when viewing portraits depicting only faces versus portraits also depicting body and hand gestures.

2. Materials and methods

2.1. fMRI experiment

2.1.1. Stimuli

A set of artistic portraits was used as stimuli for the fMRI experiment. The portraits were organized in duplets – each duplet contains two portraits from the same artist, the first portrait being classified as “direct gaze” (the portrayed person gazes directly at the observer), the second one as “averted gaze” (the portrayed person gazes to the side or behind the observer). The direct gaze (or eye contact) group included both images with the face directed forward and faces averted at various degrees. The original set of 110 portraits from 32 artists was first assessed by 11 volunteers in a pilot study validating the set of stimuli. The evaluators were to decide whether the portrayed person was looking directly at them (direct gaze) or not (averted gaze). The portraits with a consensus of a minority of less than seven evaluators were excluded from the final stimuli set together with the paired stimulus (from the same artist). The final set of 72 portraits (36 duplets, 72% with a consensus of at least 10 evaluators) is from 27 artists from various periods and provenances, beginning with Flemish Early Renaissance (Jan van Eyck, Hans Memling, Dieric Bouts, Petrus Christus, anonymous), Italian Renaissance and Mannerism (Domenico Ghirlandaio, Agnolo Bronzino), German Renaissance (Albrecht Dürer, Matthias Grünewald), followed by Baroque paintings (Christian Seybold, Pietro Antonio Rotari), modernism (Paul Cézanne, Oskar Kokoschka, Egon Schiele, Max Beckmann, Christian Schad, Charley Toorop, Paula Modersohn-Becker, Kathe Kollwitz, Vilma Vrbová-Kotrbová, Jan Preisler, Josef Šíma), and postmodern art: pop art with its typical comic book style (Roy Lichtenstein), or new figuration with distorted or

¹ Here we adopted the historical categories of *linear* (or *tactile*) versus *painterly style*, introduced by art historians Heinrich Wölfflin and Alois Riegl. The *linear* style is characterized by sharp definition of the form (e.g. Albrecht Dürer's portraits): the style emphasizes contours, it radically differentiates the figure from the background or each individual shapes between each other. The figure is clearly shaped into a precisely “graspable” plastic shape, which can even induce “the feeling of touch”, according to Wölfflin, such as we somehow touch the precisely sculptured figures with our eyes (Wölfflin, 1950: 21). Conversely, the element of physical touch or grasp is missing in painterly style, which does not differentiate shapes and the figure from the background so clearly, as it is organically interconnected, having its origin in the same material. Instead of precise lines and smooth surfaces, the painterly style makes the medium visible and thus the way the painting has been made (perceptible brushstrokes, blotches etc.; e.g. Oskar Kokoschka). Although it could invoke an intensive effect of plasticity or depth, it disrupts the “graspable feeling” of figures, as Wölfflin suggested (Wölfflin, 1950: 21), therefore paintings rendered in a painterly style engage only vision and lack the intention to grasp the figure.

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