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The Influence of Pupil Alignment on Spectator Address in Manet's Portraiture

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Abstract

Participants judged 94 portraits painted by Édouard Manet (70), Gustave Courbet (12) and Henri Fantin-Latour (12) for horizontal and vertical pupil misalignment and gaze ambiguity (Experiment 1) and focal point of gaze (Experiment 2). Eye movements were also measured as participants considered the extent to which sitters in the same portraits acknowledged viewers (spectators; Experiment 3). The results showed Manet portraits to be frequently painted with misaligned pupils that are associated with gaze ambiguity, especially when misaligned on the vertical axis. This ambiguity of gaze was associated with the average focal point of gaze as being judged further up and to the left of the centre for ambiguous relative to non-ambiguous portraits. These decisions in relation to portraits displaying ambiguous gaze were associated with increased eye-movements to the eye region relative to those portraits not displaying ambiguity. Finally, ratings of acknowledgement taken in Experiment 3 correlated with those of gaze ambiguity taken in Experiment 1. The results are interpreted in terms of the role of eye gaze in influencing spectatorship of portraits and, specifically, Fried's theory of the 'double relation' (Fried 1980; Fried 1996) between painting and spectator in the paintings of Manet.

The Influence of Pupil Alignment on Spectator Address in Manet's Portraiture

Art theoretical accounts of Édouard Manet's paintings highlight his radical approach to addressing spectators. Manet largely painted figures from life, whether the picture was a simple portrait or complex narrative composition. In addressing spectators, Manet's paintings place specific importance on the gaze that his sitters present to spectators. In his portraits, the sitter's gaze often seems to deflect the spectator rather than help communicate the sitter's character. The gaze of Manet's figures has been variously described as "blank'" "distracted", "inexpressive" and "unreadable" As Fried (1996) puts it, a "psychological connection with the viewer is something that Manet is usually at pains to avoid" (p.333).

Our goal is to reveal how Manet used gaze in his portraiture. Manet's approach to the way his portraits addressed spectators was radical, the character of which has been described by Fried as "facingness", an innovative conflation of the "absorptive" and the "theatrical". An absorptive mode of address occurs when the subject of paintings seems involved in their own experience and draws the spectator in to the work. In contrast, a theatrical mode presents the subject to the spectator, acknowledging their presence and coming out to meet them. Manet's paintings, in these terms, simultaneously acknowledge the fact of the spectator while retaining aspects of the absorptive mode, setting up what Fried (1996) referred to as a "double relation" to the spectator. The term double relation refers to the lack of clear position that the painting affords us as spectators: we are somehow acknowledged by the sitter but not directly addressed by them. In the face of this ambiguity we become aware not just of the painting's subject but also of the act of spectatorship itself. Within the

conventions of portraiture, while absorptive approaches are certainly possible, the portrait is "essentially confrontational…almost *alive*, in its mode of address" (Fried, 1996, p. 235). In Manet's case, the lack of direct confrontation has been variously noted as, for example, resulting from the sense that the figures are turned in upon themselves, temporarily preoccupied, "they are absent from the world" (Wollheim quoted in Fried, 1996, p.344). The effect of Manet's mode of address has been described as "something like cognitive or musical dissonance", intended as a challenge, turned "towards the beholder with a strange, flamboyant indifference to that beholder" (Pippin, 2014, p.48).

Recently, we investigated the double relation in Manet's seminal work *A Bar at the Folies-Bergère* (Harland, Liversedge, Gillett, Mann, Kass, Godwin, & Donnelly, 2014). *A Bar at the Folies-Bergère* is a complex painting and is thought of as Manet's valedictory masterpiece. The spatial arrangement of people and objects in the painting question the possibility that it can have been painted from a single viewpoint, and certainly not from the single viewpoint that is adopted by any spectator. Through these visual complexities, the painting challenges how a spectator might consider the image and how they might become aware of their own role within the act of spectatorship.

By recording and analyzing the eye movements of novices and experts, Harland et al. (2014) showed the visual puzzle of *A Bar at the Folies-Bergère* is a puzzle only for art experts. That is to say, novices were largely unaware of, and their patterns of visual inspection were unaffected by, the visual complexities of the painting. A lack of sensitivity to spatial incongruities in visual images is a well-known attribute of psychological studies of human vision. Human vision is poor at detecting impossibility in images (Cowie, Mitchell, & Reinhardt-Rutland,

1993) even quite major changes across pairs of images (Rensink, O'Regan & Clark, 1997). Given these insensitivities of the human visual system to impossibility and difference, the fact that novices were insensitive to Manet's manipulation of space and spatial relationships between objects, and objects and people, is, perhaps, unsurprising. In contrast there was evidence in the verbal descriptions of the painting given by novices that they grasped the impact of the averted gaze of the central figure for their spectatorship of the painting.

In this study we extend our consideration of the issue of the importance of gaze in the spectatorship of Manet's portraits. We hypothesize that Manet, more so than other artists, often induces a sense of "facingness" in his portraits by careful construction of gaze[1]. A cursory examination of Manet's portraiture

[1] Depictions of pupil misalignment also occur in the paintings of Bronzino from the late 1530s. Bronzino explored this in portraits of many of his sitters, notably Cosimo de' Medici. Several reasons have been proposed for his use of a "double gaze" (Verstegen, 2011) including the search for a new and distinctive style and an engagement with the "paragone", a prominent debate of the day around which was superior as an art form, painting or sculpture. Verstegen makes a case for the latter, arguing that Bronzino took up Leonardo's challenge that "a picture can never contain in itself both aspects" by "causing the sitter's eyes to alternate their gaze, in effect providing more than one glance, as in sculpture" (Verstegen, 2011, p.30). It is also noted that the gaze in Bronzino's paintings is a device to interrupt our contact with the sitter, a gaze that is disconcerting and impenetrable. In this sense, the effect is aligned with what we find in Manet, though there is an appreciable difference in the tone of Manet's work. Manet's

reveals that he frequently misaligned pupils in his sitters, rather than simply averted their gaze. One possible explanation for the high instance of pupil misalignment could lie in Manet's painting technique. While Manet painted from close observation he was also well known to seek "freshness" as a result of speed of paint application, hence could have accepted "inaccuracies" in favor of immediacy of expression. However, this is not likely to account for the sheer volume of pupil misalignments across his oeuvre. Moreover there are instances of works that have a more "controlled" application method which still show this type of gaze (e.g. *The Conservatory*, 1879). This painting is a primary example of the equivocal attentiveness of Manet figures. As Crary describes it, Manet shows the two eyes of the male figure as notably asymmetrical, creating "a disunified field, with two disparate optical axes" (Crary, 2001, p.104).[2]

It seems pupil misalignment, for Manet, was considered and deliberate, and was designed to produce a desired effect. The impression is that the figures depicted are disengaged, not just from the spectator but from the world that they inhabit (an impression that is frequently linked by writings relating to the end of

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work reflects on social conditions in which the sense of disengagement in the sitter is internalized or alienated.

[2] He goes on to link the nonconvergent gaze to a 'disunified perception' in some of the scientific work of the day. This included Mach's lectures in the 1860's on the binocular field and the statement: 'every observer is composed of two observers' and Helmholtz's extensively discussed studies of strabismus which associated the ophthalmological condition (incorrectly) with nervous disorders and 'psychological processes of dissolution and dissociation' (Crary, 2001:104).

the 19th Century, to the alienating impact upon people of modern urban life in that period.) As Fried points out, this disengaged gaze was commented upon by critics of the day, including Chesneau who in 1863 called it "looking without seeing" (Fried, 1996, p.4). We would be more confident of this conclusion if it could be established that Manet painted misalignment in a structured sense, according to a set of principles or effects and it is evidence for this that we seek in the present study. Considering portraits as painted on a two-dimensional plane, ambiguity of gaze is often delivered through the misalignment of pupils.

We presume that the focal point of gaze equates to the computation of the intersection of the lines of sight (surface normals) projecting from the fixation point to the centre of the fovea of each eye, passing through the centres of each eye's components (including the pupil) (Howard & Rogers, 1995). Whatever the exact mathematics, gaze is computed automatically by specialized brain regions (Baron-Cohen, 1995). It acts as a cue to state of mind and often provides a cue to shifts of attention. (e.g. Frischen, Bayliss & Tipper, 2007). Furthermore, when the lines of sight of each eye are angled such that they do not intersect then ambiguity of gaze results. Note that in such a situation it is not the case that a focal point to gaze cannot be determined by spectators. Focal point of gaze might be computed according to a simplified calculation. Spectators may assume that the visual experience of the individual represented in the portrait is delivered by one eye alone, whilst input from the other eye is suppressed. In this case, while gaze estimation is possible it will carry uncertainty from the perspective of the spectator. Pupils can appear aligned such that the eyes appear to be fixated on some point in 3D space, or pupils can appear misaligned on the horizontal or vertical axes such that there is uncertainty as to eyes that do not readily appear

to be fixated on a single point in 3D space. Our primary hypothesis was that if Manet's use of visual misalignment was purposeful then systematicity should be evident and quantifiable. Alternatively, if gaze misalignment is random then systematicity should not be observed. Additionally, we predicted that if systematicity in gaze misalignment is present in Manet's portraits then its effect should be evident in ratings of gaze ambiguity, the determination of gaze focal position, and in eye movements made in resolving the focal position of gaze during spectatorship of the portraits.

Experiment 1

In Experiment 1 we sought evidence of Manet having a structured approach to gaze misalignment. Misalignment of gaze can be along horizontal and/or vertical axes. Participants made binary decisions of misalignment on horizontal and vertical axes, and provided an overall rating of gaze ambiguity. The goal was to explore whether horizontal and vertical misalignment was related to perceived gaze ambiguity.

Method

Participants

A first group of participants (Group A) was made up of 10 novice undergraduate students (mean age 21 years, range 19 – 24 years). A second group of participants (Group B) was made up of 20 novice undergraduate students (12 female, mean age 24 years, 4 months, range 19-33 years).

Apparatus and Stimuli

Stimuli for Group A were image files for the full set of Manet's portraits painted throughout his working life (1860-1882). Portraits were excluded if they were not oil paintings, if it was unclear which individual was central to the

image, or if only a single pupil was visible for the key individual in the picture. The final image set comprised of seventy images. High-resolution electronic copies of the portraits were gathered from Google. See Figure 1 for an example image.

Participants in Group B also saw an additional twenty-four portraits, twelve each painted by Henri Fantin-Latour and Gustav Courbet (henceforth "Other" artists). These artists were contemporaries of Manet both in place and time. Their portraits form a control set for baseline measurements for determining pupil misalignment and gaze ambiguity. The Fantin-Latour and Courbet images were subject to the same selection criteria as the Manet images. The twelve Fantin-Latour portraits are the full corpus of his portrait work once the inclusion criteria were applied. To match these twelve portraits by Fantin-Latour, we selected the same number of portraits by Courbet. In the case of Courbet, the best known of his portraits that matched the inclusion criteria have been included (see Table 1 for a full listing of the final set of portraits).

Participants saw paintings presented on a Dell Latitude laptop with screen size 30 cm x 17.5 cm. Participants were seated at a distance of approximately 50 cm giving an approximate visual angle of 33.40° by 19.85° for the screen. Screen resolution was 1366 x 768 with a refresh rate of 60 Hz. The set of 94 portraits that were used were shown at a consistent height of 14.70 cm centered on the screen giving an approximate visual angle of 16.73° for each portrait height. The width of the pictures shown on the screen varied between 8.40 and 22 cm for the Manet set giving approximate visual angle widths between 9.60° and 24.82°. The width of the pictures shown varied between

10.60 and 19.30 cm for the Other set giving approximate visual angle widths between 12.10° and 21.85°.

Figure 1 about here

Procedure

Participants were presented with portraits in a random order on a computer screen and were asked to make three judgments in relation to each image. Using a head-centered frame of reference, they were asked three questions: (1) Are the pupils aligned or misaligned on the horizontal axis?; (2) Are the pupils aligned or misaligned on the vertical axis?; (3) How ambiguous is the gaze on a scale of 0 (no ambiguity) to 5 (totally ambiguous)? The task was explained to each participant using a set of standardized instructions. These standardized instructions were as follows: "Eyes are typically aligned to fixate an object or face. This is evident when the pupils are aligned so that they focus on a single point in space. Humans are very good at knowing where others are looking, regardless of whether they are the subject of that gaze or the gaze is directed at another point. Sometimes the two eyes do not align to allow us to confirm a single point of fixation. When this is the case, the shared focal point of the two eyes is difficult to determine. We refer to this difficulty as an ambiguity of gaze. You are asked to categorize whether the primary figure in each of the paintings presented has a pattern of gaze where the eyes are aligned or are not aligned. Sometimes a failure to align occurs because the pupils do not align on the horizontal axis (e.g. one pupil points further left than expected given the other pupil). Sometimes they fail to align on the vertical axis (e.g. one pupil points further up than the other). We are interested in exploring the gaze in a

series of portraits, with reference to the primary figure in each painting (ignore any other figures in the scene). You will be asked to answer three questions for each portrait and respond using the number keys on the keyboard."

The participants answered the three questions for each image in the order presented above. A different random order of images was used for each participant. Participants were allowed to provide an additional commentary for each image that explained their judgment but these are not considered further here. Participants in Group A rated 70 portraits whereas participants in Group B rated 94 portraits.

Results

The data from participants in Groups A and B did not differ in any respect (comparing groups on the Manet portraits alone showed no differences in the probability of horizontal or vertical misalignment (a 2 x 2 Fisher Exact test, two-tailed test, p = .697, or rated ambiguity t_{69} = .145, two-tailed test)). As a consequence, all data were treated together. This meant that we had data from 34 participants for ratings in relation to Manet and from 24 participants in relation to Other artists. For each portrait, we summed the data to establish the probability, across participants, of perceiving misalignment on horizontal and vertical axes. A mean ambiguity score was also calculated, across participants, for each portrait and these were compared for the portraits by Manet and for the Other artists. In both cases there was a higher probability of perceiving misalignment on the horizontal than vertical dimension (two-tailed test t_{69}=3.14, and t_{23} = 1.88 for portraits by Manet and the Other artists, p =.002 and .072 , Cohen's d = .49 and .4 respectively).

The probabilities for perceiving horizontal and vertical misalignments were used as predictors for the ratings of gaze ambiguity for the Manet and Other portraits, in a multiple regression analysis (using the Enter method) with the dependent variable of mean gaze ambiguity. The Variance Inflation Factor (VIF) score for the multiple regression analyses was 1.05, indicating collinearity was not a problem in the analyses.

In the multiple regression analysis, both predictors were entered simultaneously. The resulting model was highly significant (adj $r^2 = 0.474$, $F(2,67) = 32.51$, $p < .001$). Within the model, the standardized beta coefficient for the horizontal dimension was .287. The standardized beta coefficient for the vertical dimension was .579 (both $p < .001$). The increased standardized beta coefficients for the vertical over horizontal dimensions indicate misalignment on the vertical axis to be most strongly linked to ambiguity of gaze. Descriptive statistics from these data are presented in Table 1.

The aggregated data shown in Table 1 can be used to address our initial question of the frequency with which Manet painted portraits with ambiguous gaze compared to other artists. This question cannot be meaningfully answered by reporting mean ambiguity ratings, as the corpus of all artists will contain some unambiguous portraits and some ambiguous portraits. The issue is the relative frequency with which this ambiguity occurred for Manet versus Other artists. To explore this hypothesis, the six point rating scale was collapsed to form three categories of ambiguity: none-weak (scores of 0 - 1.66), moderate (scores of 1.67 - 3.33), high (scores of 3.34 - 5) and mean ratings categorized accordingly. The mean categorizations are shown in Table 1. As no portrait led to a mean ambiguity rating above 3.34, a 2 x 2 Fisher's Exact Test was performed

on the data with strength of ambiguity on one dimension and artist (Manet vs Other Artist) on the other. The result was highly significant (two-tailed test, p = .008). Of the seventy portraits painted by Manet that were viewed by participants, 14 were judged unambiguous and 56 ambiguous. In contrast, of the twenty-four portraits painted by the Other artists, 12 were judged unambiguous and 12 ambiguous. The significance of this effect is attributable to the greater likelihood of moderate gaze ambiguity in the portraits of Manet relative to Other artists.

Table 1 about here

Discussion

The results of Experiment 1 show ambiguity of gaze is most frequently associated with misalignment on the horizontal axis, but most strongly associated with misalignment on the vertical axis. One tentative explanation of why pupil misalignment of gaze along the vertical axis should be so strongly associated with inducing gaze ambiguity is that our binocular system is set to make horizontal vergence movements but not vertical disconjugate movements (Jainta, Blythe, Nikolova, Jones & Liversedge, 2015). As a consequence, perceivers will have observed individuals with different states of horizontal disconjugacy, but very little experience of observing individuals with differing states of vertical disconjugacy. For this reason, vertical pupil misalignment may be more strongly associated with gaze ambiguity than horizontal pupil misalignment.

Furthermore, the data show Manet was more likely than otherwise comparable artists to paint portraits with heightened ambiguity of gaze. Considered alongside the relationship between misalignment on the vertical and gaze ambiguity, there is support for the statement that Manet use of pupil misalignment was associated with spectator perception of gaze ambiguity. This finding is the first strand of support for the hypotheses noted at the end of the Introduction.

In Experiment 1 we asked for a judgment of perceived gaze ambiguity. This is the relevant question to ask of spectators and their experience of gaze. The results of Experiment 1 did not require some correct determination of ocular physiology (cf, Livingstone & Conway, 2004; Marmor, Shaikh, Livingstone, & Conway, 2005), nor did they require some accurate determination of focal point of gaze (e.g. West & van Veen, 2007). Both are known to be very difficult to estimate and to be prone to significant uncertainty (Marmor & Ravin, 2009; Todorov, 2006). Nevertheless, to provide an estimate of how gaze ambiguity impacted on the focal point of gaze, in Experiment 2, we adapted the methodology of West and van Veen (2007) to assess participant estimates of the focal point of the gaze of sitters in the set of portraits shown in Experiments 1.

Experiment 2

Portraits that gaze outwards (theatrical portraits) will tend to be interpreted as having a focal point of gaze towards spectators (The Mona Lisa effect; Bruce & Young, 1998). An interesting question is what happens to spectator's perception of gaze for portraits with increased gaze ambiguity? At least two possible results might emerge. First, and considering only the influence of pupil position, gaze position may be uncertain but taken as an average of the

estimate from both pupils. Second, when pupil alignment is judged ambiguous, gaze position may be determined as resulting from a simplified calculation based on single eyes. Such a simplified calculation is likely to lead to focal point of gaze being shifted away from spectators along both vertical and horizontal axes and, across participants, to make estimates of gaze more variable. The increased variability resulting from estimating gaze from single eyes only and differences in the determination of the choice of single eyes. In Experiment 2, we first explore whether there is evidence that variance in judgments of eye gaze increases with gaze ambiguity, or whether gaze is judged as being shifted further from the center as ambiguity increases.

Method

Participants

Fifteen undergraduate and postgraduate students (mean age = 22 years; range =19-32 years; 6 males) acted as participants. The participants had no specific knowledge of art theory or history and were naïve to the purposes of the experiment.

Apparatus and Stimuli

Paintings were presented on ProNitron 19/600 CRT monitor with screen size 36.80 cm x 27.70 cm. Screen resolution was 1024 x 768 with a refresh rate of 60 Hz. However, the screen was raised so that its center aligned with that of the center of a (100 cm x 49.50 cm) clear Perspex sheet placed 22 cm in front of the monitor screen, with a chin rest a further 28 cm from the Perspex sheet, giving a viewing distance of 50 cm and a visual angle of 40.41° x 30.97° for the screen. The Perspex screen was marked in to a grid with 1.50 cm squares. Participants were instructed to keep the center of the Perspex screen aligned

with the center of the computer monitor by keeping center markings on the top and side edge of the monitor in line with the central horizontal and vertical lines on the Perspex which were marked in red rather than black as for the red of the grid. Judgments of screen and monitor alignment were made binocularly. Head position was maintained using the chin rest. The set of 94 portraits used in Experiment 1 were shown at a consistent height of 22.20 cm centered on the screen giving a visual angle of 25.03° for each portrait height. The width of the pictures shown on the screen varied between 12.60 and 33 cm for the Manet set giving visual angle widths between 14.36° and 36.53°. The width of the pictures shown varied between 16 and 29 cm for the Other set giving visual angle widths between 18.18° and 32.34°.

Procedure

Participants were presented with portraits in a random order on a computer screen. Their task was to estimate where the focal point of gaze of the main sitter in the portrait met the Perspex grid and to indicate this using their index finger. The task was performed binocularly without making head movements. Each portrait was presented until the participant had made their estimation of gaze location. The gaze estimations were hand scored by the experimenter. The experimenter then clicked to display the next portrait. Participants were offered breaks throughout the task.

Results

The mean judgments (with standard errors) of focal point across conditions are shown in Figure 2). The standard errors (computed for each portrait, and across participants) and deviation of judgments from the center of

the Perspex screen (the center of the Perspex screen being given the coordinates 0,0), along both horizontal and vertical axes, were computed across artists.

Standard errors of judgments of the focal point of gaze: To analyze variability of participant judgments, a 2(Artist: Manet versus Other) x 2 (Ambiguity: low versus medium) x 2 (Dimension: horizontal versus vertical) ANOVA repeated over all factors with the standard errors computed for each participant across portraits.

The main effects of Artist, Ambiguity and Dimension were all significant ($F(1,14) = 147.95$, $p < .001$, $\eta_p^2 = .914$; $F(1,14) = 27.21$, $p = < .001$, $\eta_p^2 = .660$; $F(1,14) = 18.23$, $p = < .001$, $\eta_p^2 = .566$: see Figure 2). Judgments were more variable to Manet's portraits ($M = 2.75$, $SE = .19$) than to those of Others ($M = .94$, $SE = .14$); to medium ($M = 2.07$, $SE = .166$) than low ($M = 1.62$, $SE = .122$) ambiguous portraits; and on the horizontal ($M = 2.05$, $SE = .16$) than vertical ($M = 1.64$, $SE = .13$) dimension. The two-way interactions between Artist and Dimension and Ambiguity and Dimension were significant ($F(1,14) = 23.46$, $p = < .001$, $\eta_p^2 = .626$; $F(1,14) = 81.44$, $p = < .001$, $\eta_p^2 = .853$) as was the three-way interaction between Artist, Ambiguity and Dimension ($F(1,14) = 9.96$, $p = < .001$, $\eta_p^2 = .416$). Only the two way interaction between Artist and Ambiguity failed to reach significance ($F(1,14) = 1.59$, $p = .229$, $\eta_p^2 = .102$). Further analyses of these interactions revealed the interaction between Ambiguity and Dimension only reached significance in the case of Manet's portraits ($F(1,14) = 68.53$, $p = < .001$, $\eta_p^2 = .830$; $F(1,14) = .08$, $p = .220$, $\eta_p^2 = 0.016$ respectively). In the case of Manet, increasing ambiguity only increased variability on the vertical dimension and not

the horizontal dimension ($F(1,14) = 103.52$, $p = < .001$, $\eta_p^2 = .881$). Variability actually reduced on the horizontal dimension as ambiguity increased ($F(1,14) = 97.74$, $p = < .001$, $\eta_p^2 = .875$).

Mean distance of judgments of focal point of gaze from the center of the Perspex Screen: The main effects of Ambiguity and Dimension were significant ($F(1,14) = 62.36$, $p < .001$, $\eta_p^2 = .817$; $F(1,14) = 21.54$, $p < .001$, $\eta_p^2 = .606$) but the main effect of Artist failed to reach significance ($F(1,14) = 0.27$, $p = .610$, $\eta_p^2 = .019$). Portraits with moderate gaze ambiguity ($M = 3.20$, $SE = 0.21$) had a perceived focal point of gaze further from the center of the Perspex screen than did portraits with low gaze ambiguity ($M = 1.38$, $SE = 0.24$). Gaze was judged further from the center on the horizontal ($M = 2.83$, $SE = 1.87$) than vertical dimension ($M = 2.1$, $SE = 1.86$). The two way interactions between Ambiguity and Artist and Ambiguity and Dimension were both significant ($F(1,14) = 44.49$, $p < .001$, $\eta_p^2 = .761$; $F(1,14) = 14.27$, $p = .002$, $\eta_p^2 = .505$; the two-way interaction between Artist and Dimension did not reach significance ($F(1,14) = 1.21$, $p = .290$, $\eta_p^2 = .079$). The three-way interaction between Artist, Ambiguity and Dimension was significant ($F(1,14) = 70.25$, $p < .001$, $\eta_p^2 = 0.834$). The three-way interaction is shown in Figure 2. Breaking down this interaction using two-way ANOVAs revealed no main effect or interaction on the horizontal axis (both Fs < 1) but a highly significant interaction with Artist and Ambiguity on the vertical axis ($F(1,14) = 69.75$, $p < .001$, $\eta_p^2 = .833$). Increasing ambiguity was associated with estimates of gaze position that were significantly more deviated from the center in Manet's portraits. In contrast, the opposite was true for the Other portraits, where estimates of gaze position were less deviated from the center as

ambiguity increased, ($F(1,14)$ = 102.53 and 17.78, both ps < .001, η_p^2 = .859 and .559 respectively).

Considering the 22 cm distance from Perspex screen to computer screen, the upward shift of 5.28 cm equates to a 14.58° raise in visual angle of gaze from the center in Manet's portraits with moderate gaze ambiguity. In contrast, the 1.13 cm upwards shift for the Other artists equates to raising gaze by of 2.94°. (The effect of misalignment in the horizontal dimension resulted in a rightward shift of the visual angle of gaze by 8.33° in both Manet portraits and the other artist portraits.)

Figure 2 about here

Discussion

The results of Experiment 2 reveal clear evidence in support of an association between gaze ambiguity determination of the focal point of gaze. In Manet's portraits, and in contrast to those of Other artists, increased gaze ambiguity was associated with judgments of the focal point of gaze on the vertical dimension being shifted away from the center of the Perspex screen as well as being more variable across participants. These data are consistent with our predictions of the estimation of gaze from a single pupil.

The data also remove the possibility that it is only ambiguity of focal point in depth that participants are responding to in Manet's portraits. Misalignment on the horizontal might be interpreted as reflecting some uncertain point of convergence beyond the spectator. Indeed, it might be that tolerance of misalignment on the horizontal axis is why ambiguity is not associated with a

shift in focal point of gaze away from the center. And why Manet's portraits are treated much like those of Other artists in respect of misalignment on the horizontal axis. In contrast, however, the association of ambiguity and misalignment on the vertical axis cannot be accounted for in such a manner.

The fact that Manet painted portraits where ambiguity of gaze was associated with a shift in the focal point of sitters away from spectators, need not imply that pupil misalignment is a mechanism for creating the double relation described by Fried. For this to be so, evidence of a relationship between gaze ambiguity and spectator address would need to be found. In particular, participants making fixations to the eye region when considering spectator acknowledgement could be interpreted as reflecting consideration of pupil alignment and thereby judgments of gaze ambiguity. We sought evidence for such focus on the eye region when participants considered spectator acknowledgement in Experiment 3.

Experiment 3

Participants

Twenty-one participants took part in the experiment but the data from one participant was removed as they acknowledged switching the response key mapping during the task. The remaining 20 (11 women) had a mean age of 21 years 3 months (range 19-45 years).

Apparatus and Stimuli

Paintings were presented on a ViewSonic Graphics Series G225f CRT monitor with screen size 40.60 cm x 30.80 cm. Participants were seated at a distance of 70 cm giving a visual angle of 30.11° by 23.75° for the screen. Screen resolution was 1024 x 768 with a refresh rate of 100 Hz. Participants responded

by clicking buttons on a ResponsePixx button-box. An SR Research Limited Eye-Link 1000 eye tracker operating at 1000 Hz was used to record monocular eye movements and a nine-point calibration was used to no more than 0.5° of visual angle error. A chinrest (with headrest) was used to stabilize the participant's head. The set of 94 portraits used in Experiment 1 were shown at a consistent height of 24.50 cm centered on the screen giving a visual angle of 19.85° for each portrait height. The width of the pictures shown on the screen varied between 13.90 and 36.80 cm for the Manet set giving visual angle widths between 11.34° and 29.46°. The width of the pictures shown varied between 18.70 and 32.40 cm for the Other set giving visual angle widths between 15.22° and 20.06°.

Procedure

After completing a visual acuity test (Freiburg Visual Acuity Test, Bach, 1996), participants viewed the same 94 painting as viewed in Experiments 1 and 2, at the same viewing distance as in Experiment 1. Each participant was introduced to the idea of acknowledgement through reading a short written description[3]. Following calibration, the participant's task was to undertake the following task: rate the extent to which the primary figure in the painting acknowledges your presence on a scale of 1-4 (1 - does not acknowledge my

[3] We are interested in exploring spectators' perceptions of a series of paintings. Paintings can be absorptive or theatrical; the viewer may be acknowledged by the figures in the painting, or not. We are interested in what participants use to judge acknowledgement of the viewer by the primary figure in the painting. Some paintings may have more than one figure, but we are only interested in the primary figure.

presence at all, to, 4 - I am fully acknowledged by the primary figure). Responses were made via a response box.

Trials began with a fixation point centered at the middle of the screen used to check for drift. Once the experimenter accepted fixation as being centered they progressed to the trial where the participant was shown a painting on the screen until a response was made. The order of portraits was randomized for each participant.

Results

First, the mean ratings of spectator acknowledgement were correlated with the mean gaze ambiguity ratings taken in Experiment 1. Pearson's correlation was (r= -.21, p = .021, n = 94, one tailed-test).

To explore the eye movements made when considering acknowledgement, fixations shorter than 60 ms or longer than 1200 ms were removed from the dataset and not analyzed, as were fixations that coincided with display onset or the response. All told 5.47% of the data were excluded and the final data set consisted of 12471 fixations. The data were analyzed in a 2 (Artist : Manet versus Others) x 2 (Ambiguity: low versus medium) design. Two sets of analyses were performed on the eye movement data. In the first analysis, only fixations made within a defined ROI around the eyes were considered. In the second analysis, all fixations made to portraits were considered. The two analyses are presented together graphically in Figures 3, 4 and 5 for each of the eye movement measures presented. A final analysis examined whether Manet used pupil misalignment as a mechanism for creating a double relation through analysis of the proportion of fixations made in the eye region of the portraits.

This analysis has the advantage of scaling the data to account for differences in image size.

Figures 3 – 5 about here

Eye ROI

With respect to mean number of fixations (see Figure 3), the main effects of Artist and Ambiguity reached significance ($F(1,19) = 6.15$, $p = .023$, $\eta_p^2 = .245$ and $F(1,19) = 12.79$, $p = .002$, $\eta_p^2 = .402$ respectively). The mean number of fixations was higher to Other artist portraits ($M = 4.16$, $SE = 0.64$) than to Manet portraits ($M = 3.39$, $SE = 0.38$). The mean number of fixations was higher to medium ($M = 4.24$, $SE = 0.61$) than low ($M = 3.31$, $SE = 0.42$) ambiguity portraits. The interaction between Artist and Ambiguity did not reach significance ($F(1,19) = 0.85$, $p = .368$, $\eta_p^2 = .043$).

With respect to mean fixation duration, the main effect of Ambiguity reached significance ($F(1,19) = 15.10$, $p = .001$, $\eta_p^2 = .443$: see Figure 4). The mean fixation duration was longer to low ($M = 462.25.34$, $SE = 15.51$) than medium ($M = 416.39$, $SE = 15.04$) ambiguity portraits. Neither the main effect of Artist, nor the interaction between Artist and Ambiguity reached significance ($F(1,19) = 0.015$, $p = .903$, $\eta_p^2 = .001$ and $F(1,19) = 0.127$, $p = .726$, $\eta_p^2 = .007$ respectively).

With respect to total fixation duration (the sum of all fixation durations in the eye region), the main effects of Artist and Ambiguity were both significant ($F(1,19) = 6.73$, $p = .018$, $\eta_p^2 = .26$ and $F(1,19) = 5.68$, $p = .028$, $\eta_p^2 = .230$

respectively: see Figure 5). Total fixation duration was longer to Other artist portraits (M = 1657.37, SE = 242.44) than Manet portraits (M = 1364.62, SE = 154.95) and to medium (M = 1624.77, SE = 227.62) than low (M = 1397.23, SE = 170.79) ambiguity portraits. Again, the interaction between Artist and Ambiguity failed to reach significance ($F(1,19) = 0.40$, $p = .533$, $\eta_p^2 = .021$).

Full Portraits

With respect to mean number of fixations, the main effects of Artist, Ambiguity, and the interaction between Artist and Ambiguity all failed to reach significance ($F(1,19) = 0.77$, $p = .391$, $\eta_p^2 = .039$; $F(1,19) = 3.66$, $p = .071$, $\eta_p^2 = .161$ and $F(1,19) = 0.24$, $p = .631$, $\eta_p^2 = .012$ respectively: see Figure 3).

With respect to mean fixation durations, the main effect of Ambiguity was significant ($F(1,19) = 6.516$, $p = .019$, $\eta_p^2 = .255$: see Figure 4). The mean fixation duration was longer to low (M = 394.19, SE = 10.55) than medium (M = 374.32, SE = 11.26) ambiguity portraits. The main effect of Artist and interaction between Artist and Ambiguity both failed to reach significance ($F(1,19) = 2.36$, $p = .141$, $\eta_p^2 = .110$ and $F(1,19) < 0.01$, $p = .991$, $\eta_p^2 = .000$ respectively).

With respect to total fixation duration, the main effect of Artist and Ambiguity, and the interaction between them failed to reach significance ($F(1,19) = 1.64$, $p = .216$, $\eta_p^2 = .079$, $F(1,19) = 2.09$, $p = .164$, $\eta_p^2 = .099$ and $F(1,19) = 0.310$, $p = .584$, $\eta_p^2 = .016$ respectively: see Figure 5).

Proportions

To explore the proportions of eye movements to the eyes compared with the full portrait, we calculated the proportion of fixations to the eyes (relative to

elsewhere in the painting), and the proportion of the total fixation duration on the painting that was spent on the eyes.

With respect to mean proportion of fixations, the main effects of Artist and Ambiguity reached significance ($F(1,19) = 50.68$, $p < .001$, $\eta_p^2 = .727$ and $F(1,19) = 14.02$, $p < .001$, $\eta_p^2 = .425$ respectively). The proportion of fixations to the eyes was higher for Other artist ($M = 0.69$, $SE = 0.03$) than to Manet ($M = 0.60$, $SE = 0.03$) portraits. The mean proportion of fixations was higher to medium ($M = 0.69$, $SE = 0.03$) than low ($M = 0.62$, $SE = 0.03$) ambiguity portraits. The interaction between Artist and Ambiguity did not reach significance ($F(1,19) = 0.02$, $p = .892$, $\eta_p^2 = .001$).

With respect to the proportion of total time spent on the eyes, the main effects of Artist and Ambiguity reached significance ($F(1,19) = 33.38$, $p < .001$, $\eta_p^2 = .637$; $F(1,19) = 4.63$, $p = .045$, $\eta_p^2 = .196$). The proportion of total fixation duration to the eye region was larger to Other artist ($M = .75$, $SE = 0.04$) than Manet ($M = .68$, $SE = 0.04$) portraits and to medium ($M = .73$, $SE = 0.04$) than low ($M = .70$, $SE = 0.04$) ambiguity portraits. The interaction between Artist and Ambiguity failed to reach significance ($F(1,19) = 0.316$, $p = .580$, $\eta_p^2 = .016$).

Discussion

The findings of Experiment 3 confirm that spectator acknowledgement in these portraits is judged primarily by focusing on the eye regions of portraits (even though other details are important, especially in the case of Manet). In addition, they show that ratings of spectator acknowledgement are related to judgments of gaze ambiguity. These two findings are consistent with the

conditions laid out in the Discussion of Experiment 2 for gaze being a mechanism for establishing Fried's 'double relation'.

The third finding from Experiment 3 is that gaze ambiguity is associated with the pattern of visual inspection used when making decisions about spectator acknowledgement with decision times increasing with ambiguity. This finding suggests that visual behavior is sensitive to the construction of gaze in portraits beyond the mere presence of eyes.

The final finding is that participants could judge spectator acknowledgement faster in response to portraits painted by Manet than by the Other artists. The important point being that this result held across unambiguous and ambiguous portraits. We interpret this finding as showing that Manet signaled acknowledgement, or its absence, more strikingly than did Other artists. However, given the overall frequency with which his portraits are judged as having ambiguous gaze reported in Experiment 1, it is the rapid signaling of the absence of acknowledgement that is the dominant response to his portraiture.

General Discussion

In the present study we sought evidence of a systematic structure of pupil misalignment in the portraiture by Édouard Manet. Experiment 1 showed that Manet, more than Other artists, systematically misaligned pupils in the sitters of his portraits, especially by using misalignment on the vertical axis. Pupil misalignment (especially on the vertical axis) is associated with gaze ambiguity (Experiment 1) as well as a sense of spectators not being acknowledged by sitters (Experiment 3). In the case of Manet, misalignment on the vertical axis was associated with the perceived focal point of gaze being shifted away from the center of the screen. In addition, misalignment on the vertical axis was

associated with variability in the perceived focal point of gaze across participants (Experiment 2). Together, these findings suggest an attribute of Manet's portraits judged as having ambiguous gaze is that they work against the Mona Lisa effect (Bruce and Young, 1998) where spectators view sitters as looking towards them. That they do so leads to two related findings from Experiment 3: a relatively speedy determination of spectator acknowledgement and gaze shifted from the center to additional details in portraits.

Given the fundamental nature of gaze for socio-cognitive processes (e.g. Calder et al. 2007), the influence of gaze on spectatorship is deterministic and experienced by all (or more correctly all neurotypical) spectators. Manet had a failsafe device to challenge spectatorship through pupil misalignment. Moreover, it was a device that could be calibrated to create more or less ambiguity, especially along the vertical axis (Experiments 1 and 2).

The eye movement data from Experiment 3 show the impact of gaze ambiguity on patterns of fixations. Gaze ambiguity is associated with increased the number of fixations and reduced fixation durations to the eye region. To be clear, spectators were less inclined to make longer fixations on the eye region when they experienced increased gaze ambiguity. Quite whether the inclination to make an increased number of short fixations arose because spectators were attempting to resolve gaze ambiguity, or because the perceived ambiguity caused them to discontinue extended fixation is not clear and will require further work to determine. What is clear, though, is that pattern of increased numbers of short fixations arose in the context of increased gaze misalignment that Manet, in particular, incorporated into many of his portraits.

That said, the eye movement data also reveal a second attribute of Manet's portraits. Beyond the effect of gaze ambiguity, participants fixated longer beyond the eye region in Manet's portraits than in those of the Other artists. What qualities or image attributes define this second influence on fixations to Manet's portraits is beyond the present study. These factors most likely include gaze aversion (potentially, this may also explain the shorter fixations discussed above) and objects of significant interest within the portraits, as well as the distinctive use of textured brushstrokes in areas of the paintings (see Wollheim (1987, pp. 170-173) on the strategic use of "embelishment" in Manet's portraits). All of these attributes certainly influence spectator acknowledgement in his portraits.

A possible limitation on our claim that Manet, in particular, systematically manipulated gaze is that it is extremely difficult, if not impossible, to be certain that the Other portraits used in the study provide the perfect control stimuli. The inclusion of portraits by Fantin-Latour and Courbet for participants to judge is our effort to provide a naturalistic and appropriate control in relation to gaze judgments. The naturalistic control uses artists working contemporaneously with Manet, and whose painting explored many of the same themes as his. At the very least their inclusion shows that the effects we report are not found when gaze judgments are made for any or all portraits. This is not a trivial observation especially when considered in the context of the art historic discussion on gaze that focuses heavily on Manet's portraiture.

Pupil misalignment is not unique to Manet's portraits in that it occurs naturally in the world and is called strabismus. To extend our enquiry we ask: is Manet's use of misalignment related to strabismus? To address this question, we

asked a group of nine practicing ophthalmologists (mean age 40 years 7 months, range 23 years to 58 years) to rate a subset of 30 of Manet's portraits for their likelihood of representing strabismus, and to classify the kind of strabismus represented within the painting. In ophthalmology, strabismus is classified along a number of dimensions including horizontal (technically classified as eso/exotropia) and vertical dimensions (technically classified as hyper/hypotropia). These data are presented in Table 1. Correlating the mean ambiguity ratings from all other participants with the average likelihood of strabismus, as scored by the ophthalmologists, reveals a significant correlation of $r = 0.57$ ($p < 0.01$). This significant correlation can be interpreted as showing that the gaze ambiguity perceived by our participants reflects Manet's painting of strabismus within his portraits. The correlation probably underestimates the true level of agreement between participants and ophthalmologists. Where ophthalmologists and the other participants disagreed (relatively high ambiguity rating from novices and a low probability of strabismus from ophthalmologists) this tended to be because the portraits were of whole bodies where the eyes were small and hence hard to classify (e.g. *Monsieur Brun*, *The tragic actor*, *Young man in the costume of a Majo*).

In the real world, by far the most common form of strabismus is esotropia (around 60% of neuro-developmental cases). One can ask whether Manet's depiction of strabismus was informed by his experience of strabismus in the real world. On average, the group of ophthalmologists rated 12/30 portraits as showing exotropia and only 1/30 as showing esotropia (they reported 5/30 and 3/30 as showing hyper- and hypo-tropia, respectively). These data show that it cannot be the case that Manet's practice was informed by his experience of

multiple cases of strabismus in the real world. He may, in contrast, have been influenced by an individual case, or cases, which had exotropia. An alternative possibility is that he depicted patterns of ocular alignment that were, in his experience, novel.

Does something connect the portraits where ambiguity is greatest relative to when it is absent or minimized? We explored whether the likelihood of use of either horizontal or vertical misalignment changed systematically over time or subject matter. First, Figure 6 shows the probability of Manet painting a portrait where the majority of participants rated pupils as misaligned along horizontal or vertical axes or aligned along both axes over his career. The graph shows some evidence of an increased rate of painting misaligned than aligned images in mid-career, but the difference is modest.

Figure 6 about here

Second, Manet's sitters can be divided into four categories: family members, artists (including painters, writers and actors), models (both professional and non-professional) and society figures. We can find no discernible trend for a greater frequency of use of ambiguity in some groups relative to others. Probably important to interpreting this absence of effect is that Manet's financial circumstances were such that he did not need to seek commissions nor conform to his sitters' expectations in relation to the work that he produced. The society figures group in that sense did not significantly differ from the others in that the portraits came about as a result of Manet's interest in the specific individual rather than through commission (Stevens, 2013).

Finally, we felt it important to address the remote possibility that the sitters that Manet selected did have strabismus. First, it is clear from the photographic portraits that exist of many of Manet's sitters, that they did not in actuality have strabismus (see for example Figure 7 and compare it to Figure 1). Second, Manet painted multiple portraits of some sitters. If the paintings were veridical, and the sitters genuinely had strabismus, then this would be evident in consistency across paintings. There is, however, no such consistency, and consequently, it seems very unlikely to be the case that the representation of strabismus reflects reality. In summary, in the preceding discussion we have provided evidence of the structured use of pupil misalignment to invoke gaze ambiguity by Manet in his portraits.

Figure 7 about here

We make one final point to locate this study within a larger project. The present study is part of a broader enterprise to show how basic concepts from cognitive psychology can contribute to the understanding of art spectatorship. Elsewhere, we have shown how perceptual transformations and exemplar models of memory provide a context for understanding serial artworks using Monet's series of Rouen cathedral and Warhol's death and disaster series as case studies (Kass, Harland, & Donnelly, 2015a; 2015b). We have also shown how expertise influences information sampling to resolve structural and narrative ambiguity using Manet's *A Bar at the Folies-Bergère* (Harland et al., 2014). Here we show how pupil misalignment is linked to ambiguity of gaze, and suggest that this relationship is fundamental to socio-cognitive mechanisms and to creating

the experience of facingness. The observations we have made are, in each case, novel and they allow us to suggest that whether by intention or accident, Monet, Manet and Warhol produced artworks whose enduring interest partially lies in their challenge to cognitive processes that itself establishes meaning in the work.

References

Bach, M. (1996). The Freiburg Visual Acuity Test – automatic measurement of visual acuity. *Optometry & Vision Science, 73,* 49–53.

Bruce, V., & Young, A. (1998). *In the eye of the beholder: the science of face perception*. Oxford University Press.

Calder, A. J., Beaver, J. D., Winston, J. S., Dolan, R. J., Jenkins, R., Eger, E., & Henson, R. N. A. (2007). Separate coding of different gaze directions in the superior tepmoral sulcus and the inferior parietal lobule. *Current Biology, 17,* 20-25. doi:10.1016/j.cub.2006.10.052

Cowie., R., Mitchell, R., & Reinhardt-Rutland, T. (1993). The Devil's Torpedo Tubes: a new Impossible Object considered in relation to the IO model of human vision. In *AI and cognitive science '91* (pp. 278-296). London: Springer. doi: 10.1007/978-1-4471-3562-3_18

Crary, J. (2001) *Suspensions of perception; Attention, spectacle and modern culture*, Cambridge, MA: MIT Press. doi:10.1002/acp.751

Fried, M. (1980). *Absorption and theatricality: Painting and beholder in the age of Diderot.* Berkeley and Los Angeles, CA: The University of California Press.

Fried, M. (1996). *Manet's modernism, or, the face of painting in the 1860s*. Chicago, IL: The University of Chicago Press.

Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze Cuing of Attention: Visual Attention, Social Cognition and Individual Differences. *Psychological Bulletin*, 133, 4, 694-724. doi:10.1037/0033-2909.133.4.694

Harland, E. J., Liversedge, S. P., Gillett, J. R., Mann, C. M, Kass, J., Godwin, H. J., & Donnelly, N. (2014). Modes of address in pictorial art: An eye movement

study of Manet's Bar at the Folies-Bergère. *Leonardo, 47,* 3, 241-248. doi:10.1162/LEON_a_00676

Howard, I.P., Rogers, B.J. (1995) Binocular Vision and Stereopsis. Oxford University Press.

Jainta, S., Blythe, H.I., Nikolova, M., Jones, M.O. & Liversedge, S.P. (2015). A comparative analysis of vertical and horizontal fixation disparity in sentence reading. *Vision Research*, 110, 118-127. doi:10.1016/j.visres.2015.03.008

Kass, J. M., Harland, B & Donnelly, N. (2015). Abstracting the set: Monet's cathedrals and stable mental concepts from serial pictorial artworks. *Art & Perception, 3,* 139-150. doi:10.1163/22134913-00002030

Kass, J. M., Harland, B. and Donnelly, N. (in press). Warholian repetition and the viewer's affective response to artworks from his Death and Disaster Series. *Leonardo.*

Livingstone, M. S., & Conway, B. R. (2004). Was Rembrandt stereoblind? *New England Journal of Medicine, 351,* 1264-1265. doi:10.1056/NEJM200409163511224

Livingstone, M. S., & Conway, B. R. (2005). Was rembrandt stereoblind. *New England Journal of Medicine, 352,* 631-632. doi:10.1056/nejm200502103520622

Marmor, M. F., & Ravin, J. (2009). *The Artist's Eyes.* New York, NY: Abrams.

Pippin, R. B. (2014) *After the beautiful: Hegel and the philosophy of pictorial modernism.* Chicago, IL: University of Chicago Press.

Rensink, R. A., O'Regan, J. K., & Clark, J. J. (1997). To see or not to see: The need for attention to perceive changes in scenes. *Psychological Science, 8,* 368-373. doi:10.1111/j.1467-9280.1997.tb00427.x

Singerman, H. (2003). Noncompositional effects, or the process of painting in 1970. *Oxford Art Journal, 26,* 127-150. doi:10.1093/oxartj/26.1.125

Stevens, M. (2013) *Manet: Portraying life.* London: Royal Academy of Arts.

Verstegen, I. (2011). Due varietà in se: Practices of engagement in Bronzino's portraits, *Source: Notes in the History of Art, 30,* 26-32. doi:10.1086/sou.30.4.23208495

Wall, J. (2002). Unity and fragmentation in Manet. In T. de Duve, A. Pelenc, & B. Groys (Eds.), *Jeff Wall* (pp. 83-86). London: Phaidon Press.

West, R. W., & Van Veen, H. G. (2007). Gaze as depicted in Vermeer's girl with a pearl earring. *The Journal of General Psychology, 134,* 313-328. doi:10.3200/genp.134.3.313-328

Wollheim, R. (1987). *Painting as an Art.* London: Thames & Hudson.

Table 1

Listing of all Portraits used in Experiments 1-3, with Overall Probability and Gaze Ambiguity Data from Experiment 1. Also presented is Probability of Type of Strabismus by Reported by Ophthalmologists (see General Discussion).

	Experiment 1				Ophthalmic specialists				
Artist and Painting	Year	*P*(H)	*P*(V)	Ambiguity	Strabismus	*P*(Exo)	*P*(Eso)	*P*(Hyper)	*P*(Hypo)
Manet									
Boy with cherries	1860	0.42	0.38	1.94					
Madam Brunet	1860	0.61	0.31	1.81					
Spanish singer	1860	0.29	0.21	1.39	0.67	0.23	0	0.12	0.12
Boy with a dog	1861	0.29	0.38	1.45					
Boy with the sword	1861	0.48	0.34	1.87	1.22	0.56	0	0	0.34
Nymph Surprised	1861	0.26	0.07	1.45					
Gypsy with cigarette	1862	0.32	0.38	1.71					
Lola de Valenca	1862	0.29	0.10	1.68					

Mlle Victorine in the costume of an espada	1862	0.23	0.28	1.35	0.67	0.23	0	0	0.23
Street singer	1862	0.55	0.24	2.19					
Victorine Meurent	1862	0.52	0.34	1.58	1.22	0.45	0	0.12	0.12
Young man in the costume of a majo	1863	0.45	0.52	2.71	1.33	0.34	0	0.67	0
Young woman reclining in Spanish Costume	1863	0.52	0.66	2.39	2.67	0.67	0	0	0.45
Head of Christ	1864	0.35	0.93	2.58					
Angelina	1865	0.55	0.28	2.06					
Beggar with duffle coat	1865	0.39	0.48	1.74	2.44	0.45	0	0.34	0
The tragic actor	1865	0.26	0.34	2.55	1.22	0.12	0.34	0.12	0
The Fifer	1866	0.29	0.38	1.68					
The Lecture (Manet's wife)	1866	0.58	0.45	1.81					
The Philosopher	1866	0.48	0.17	1.39	0.56	0.34	0	0.23	0

Young lady with parrot	1866	0.42	0.31	1.58	1	0.34	0	0.23	0.23
Zacharie Astruc	1866	0.52	0.14	2.10	1.11	0.45	0	0	0
Soap bubbles	1867	0.29	0.10	1.45					
Emile Zola	1868	0.13	0.38	1.87					
Theodore Duret	1868	0.39	0.62	2.19					
Young man peeling a pear	1868	0.52	0.34	1.65					
Eva Gonzales	1870	0.42	0.41	2.10					
In the garden	1870	0.58	0.59	2.65	2.22	0.67	0	0.12	0
Repose: Berthe Morisot	1870	0.48	0.52	2.74					
Suzanne Manet	1870	0.35	0.28	1.87					
Monsieur Tillet	1871	0.71	0.21	2.10	0.78	0.34	0	0	0.12
Berthe Morisot holding a bunch of violets	1872	0.58	0.45	2.19					
Berthe Morisot reclining	1872	0.74	0.41	2.19					

The brunette with bare breasts	1872	0.65	0.45	2.27					
Veiled young woman	1872	0.48	0.41	2.87	3.56	0.89	0	0.34	0
Gare saint lazare	1873	0.61	0.34	1.77					
Le Bon Bock	1873	0.45	0.45	1.97	1.67	0.67	0	0	0
Margaite de Conflanins wearing a hood	1873	0.58	0.45	1.97					
Woman with fans	1873	0.55	0.45	1.94					
Berthe Morisot with fan	1874	0.58	0.55	2.35					
Berthe Morisot with hat, in mourning	1874	0.35	0.59	2.23	3.67	0.67	0	1	0
Gilbert Marcellin Desboutin	1875	0.39	0.69	2.29					
Woman with Umbrella	1875	0.42	0.48	2.26	1	0.34	0.12	0	0.12
Young woman with a book	1875	0.29	0.41	2.29	0.67	0.34	0	0	0
Stephane Mallarme	1876	0.77	0.55	2.48	3.56	0.89	0	0	0
Antonin Proust, study	1877	0.39	0.48	1.55					
Faure as Hamlet	1877	0.26	0.31	1.77	.56	0.23	0	0.12	0.12

Nana	1877	0.26	0.31	1.65					
The plum	1877	0.23	0.45	1.87	0.67	0.23	0	0.12	0
Lady with a black fichu	1878	0.29	0.45	2.45					
Le journal illustre	1878	0.19	0.45	2.23					
Lina Campineanu	1878	0.48	0.45	2.16					
Marguerite Gauthier	1878	0.42	0.69	2.07	4	0	0	0.89	0
Self portrait with a palette	1878	0.35	0.31	2.1					
Self portrait with skull cap	1878	0.29	0.45	1.84	2.67	0.67	0	0.12	0.34
Emilie Ambre in the role of Carmen	1879	0.48	0.21	1.65					
Isabelle Lemonnier (Jeane Femme en	1879								
Robe du Bal)		0.48	0.41	2.19	0.78	0.12	0.12	0	0.23
Isabelle Lemonnier with white scarf	1879	0.58	0.31	2.00					
Madame Manet in the conservatory	1879	0.35	0.24	2.32					
Monsieur Brun	1879	0.26	0.14	1.87	0.78	0.34	0	0.12	0

Woman with a gold pin	1879	0.45	0.24	1.84					
Antonin Proust	1880	0.48	0.17	1.81	0.44	0.12	0.23	0.12	0
Corner of the café concert	1880	0.48	0.34	1.84					
Isabelle Lemonnier	1880	0.29	0.52	2.06	0.89	0.23	0.23	0	0.23
Isabelle Lemonnier with a muff	1880	0.45	0.59	1.77	0.67	0.12	0.12	0	0.23
The promenade	1880	0.45	0.31	1.68					
Henri Rochefort	1881	0.26	0.21	1.61					
Henry Bernstein as a child	1881	0.26	0.24	1.58	1.11	0.56	0	0	0
Pertuiset, Lion Hunter	1881	0.48	0.28	2.03	2.89	0.89	0	0.23	0
Head of Jean Baptiste Faure	1882	0.74	0.45	2.71					
Courbet									
Portrait of Juliette Courbet	1844	0.19	0.14	1.29					
Portrait of H. J. van Wisselingh	1846	0.62	0.38	2.10					
The Cellist, self-portrait	1847	0.52	0.43	1.90					

Self-Portrait (Man with Pipe)	1848	0.43	0.29	2.57
Portrait of Pierre Joseph Proudhon (1853)	1853	0.29	0.05	1.43
Portrait of a Spanish Lady	1855	0.38	0.67	2.14
Portrait of Mlle. Jacquet	1857	0.29	0.19	1.48
Portrait of Pierre Joseph Proudhon (1865)	1865	0.33	0.24	1.62
Portrait of Jules Valles	1865	0.29	0.14	1.33
Jo, la belle Irlandaise	1866	0.43	0.71	2.1
Portrait of Chenavard	1869	0.67	0.86	2.62
Portrait of Paul Verlaine	1871	0.62	0.19	1.67
Fantin-Latour				
Self-Portrait	1859	0.48	0.24	1.81
Portrait of James McNeil Whistler	1865	0.57	0.14	1.95

Self-Portrait	1867	0.33	0.29	1.86
Portrait of Edouard Manet	1867	0.24	0.29	1.52
Mademoiselle de Fitz James	1867	0.24	0.10	1.05
A Leitura	1870	0.48	0.19	1.24
Portrait of Madame Leon Maitre	1882	0.38	0.48	2.05
Madeleine Lerolle	1882	0.29	0.48	1.57
Charlotte Dubourg	1882	0.38	0.24	1.62
Portrait of a Woman	1885	0.38	0.43	1.62
Portrait of Leon Maitre	1886	0.10	0.14	0.76
Portrait of Sonia	1890	0.29	0.10	1.05

Note. Aggregated data across participant groups A and B are shown in columns 3-5 (H=Horizontal, V=Vertical, Amb=Gaze ambiguity (0=unambiguous, 5=completely ambiguous)). Data from the ophthalmologist group (Strabismus=likelihood that the picture represents a form of strabismus (0=certainly not, 5=certainly yes), Exo-, Eso-, Hyper- and Hypo- tropia) reported in the General Discussion is shown in columns 6-10.

Figure 1. Example of a portrait used in the study. Stéphane Mallarmé (1876). Reproduced with permission. © RMN-Grand Palais (musée d'Orsay)/Hervé Lewandowski.

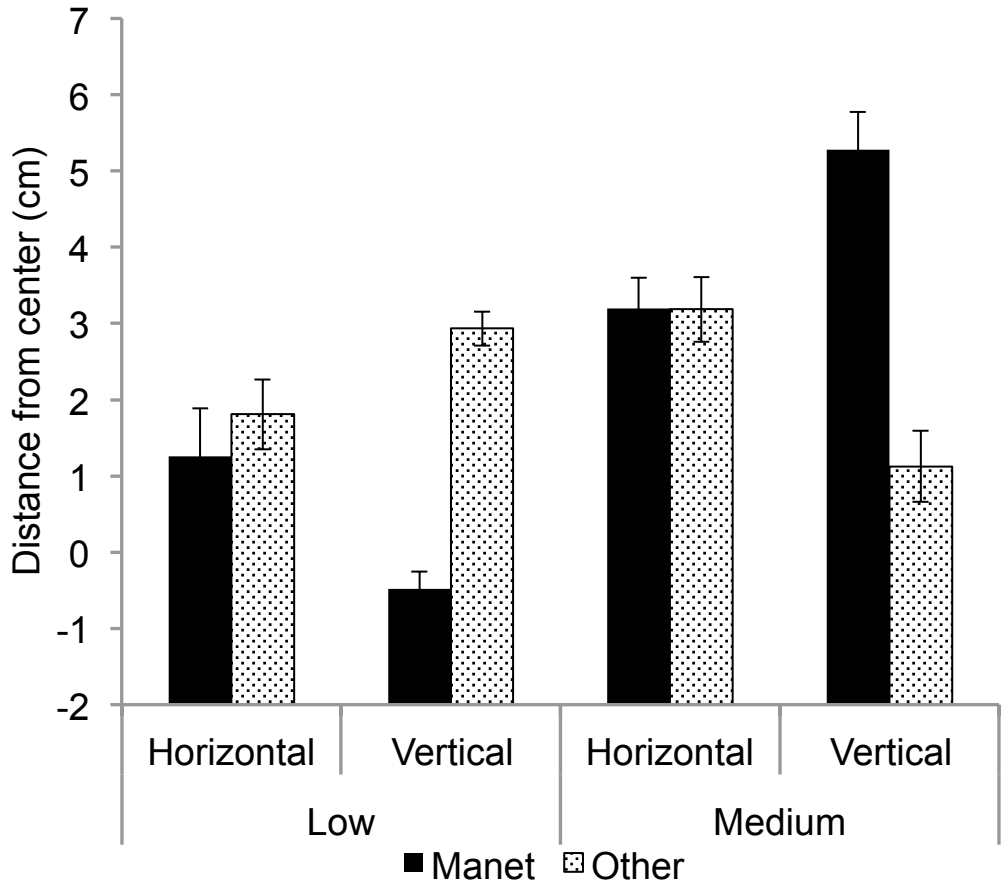

Figure 2. The mean deviation (in cm, with *SE*) from the center of the Perspex screen of focal point of gaze of portraits in Experiment 2. The data are shown for both deviation along horizontal and vertical axes and for Manet and Other artists.

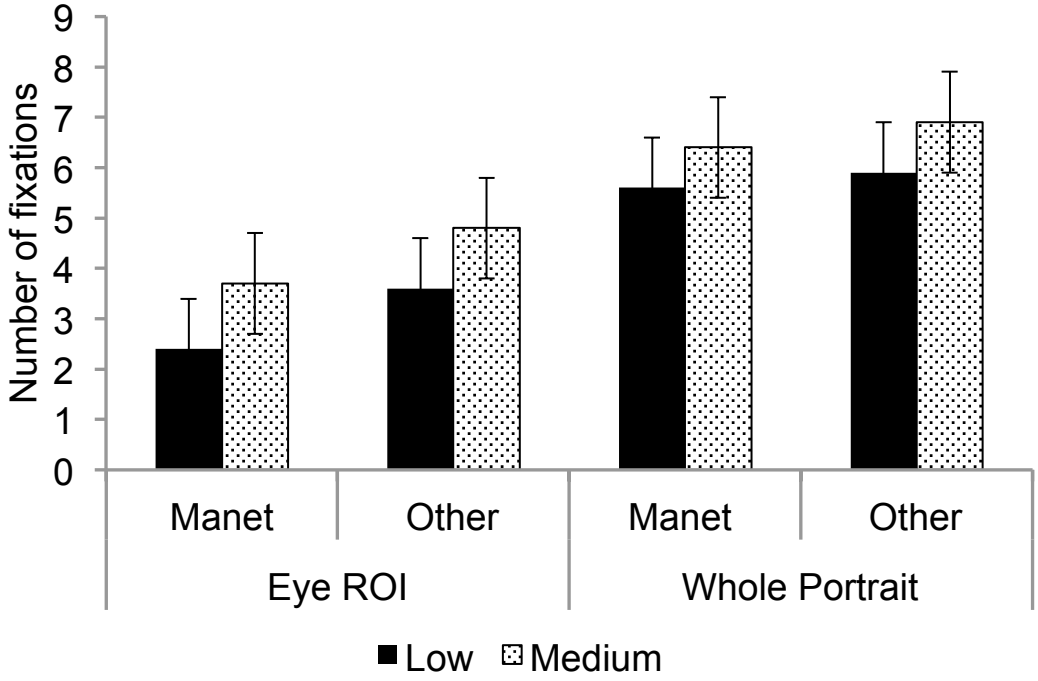

Figure 3. Mean number of fixations (with *SE*) to the eye region only and to full portraits in Experiment 3. The data are shown for both low and medium ambiguity portraits and for Manet and Other artists.

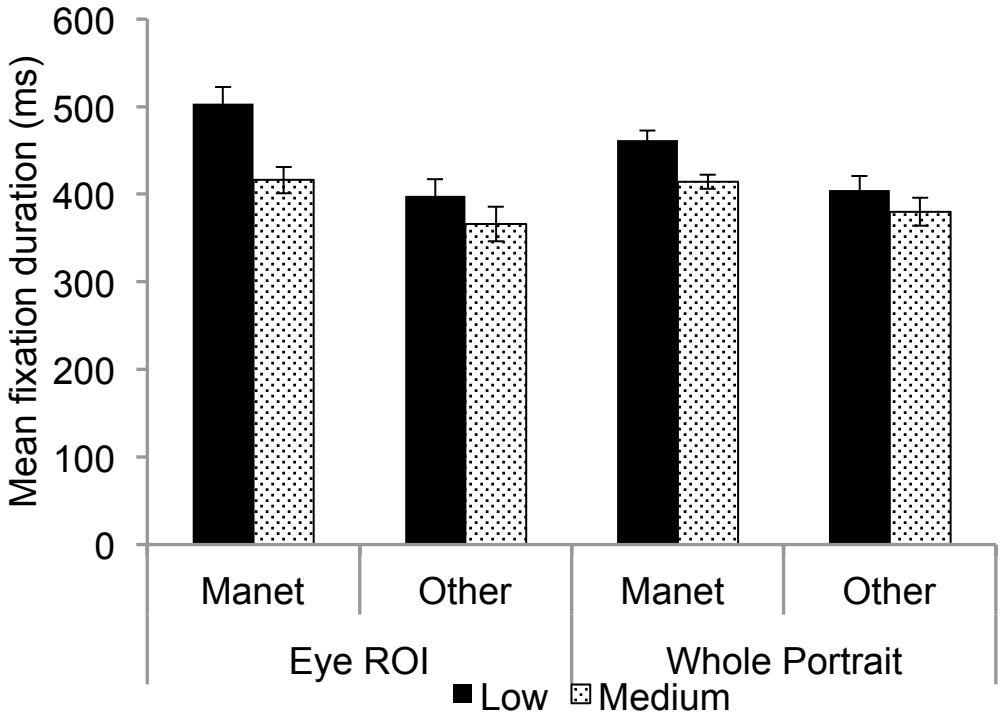

Figure 4. Mean fixation duration (with *SE*) to the eye region only and to full portraits in Experiment 3. The data are shown for both low and medium ambiguity portraits and for Manet and Other artists.

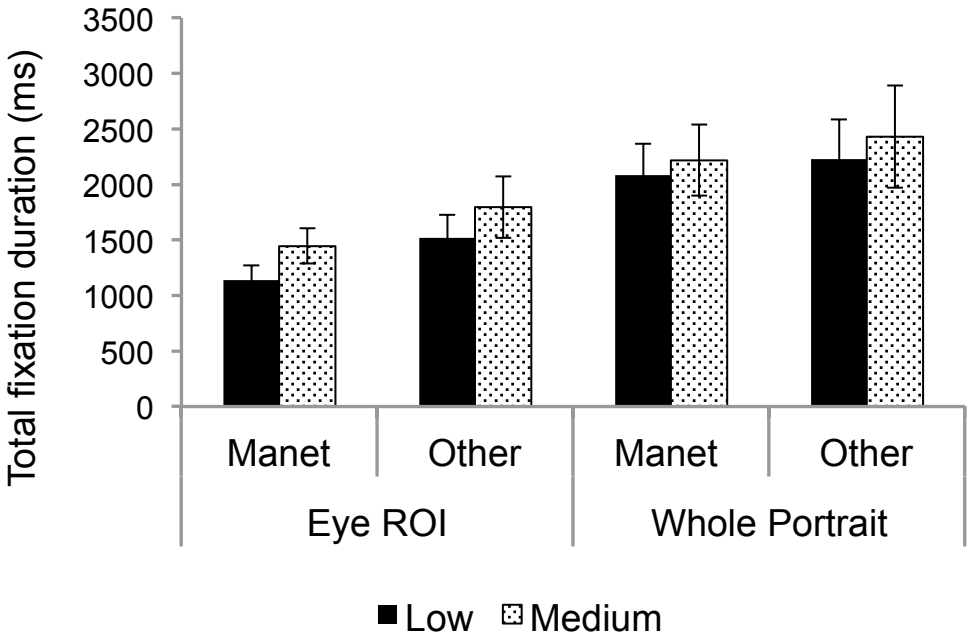

Figure 5. Mean total fixation duration (with *SE*) to the eye region only and to full portraits in Experiment 3. The data are shown for both low and medium ambiguity portraits and for Manet and Other artists.

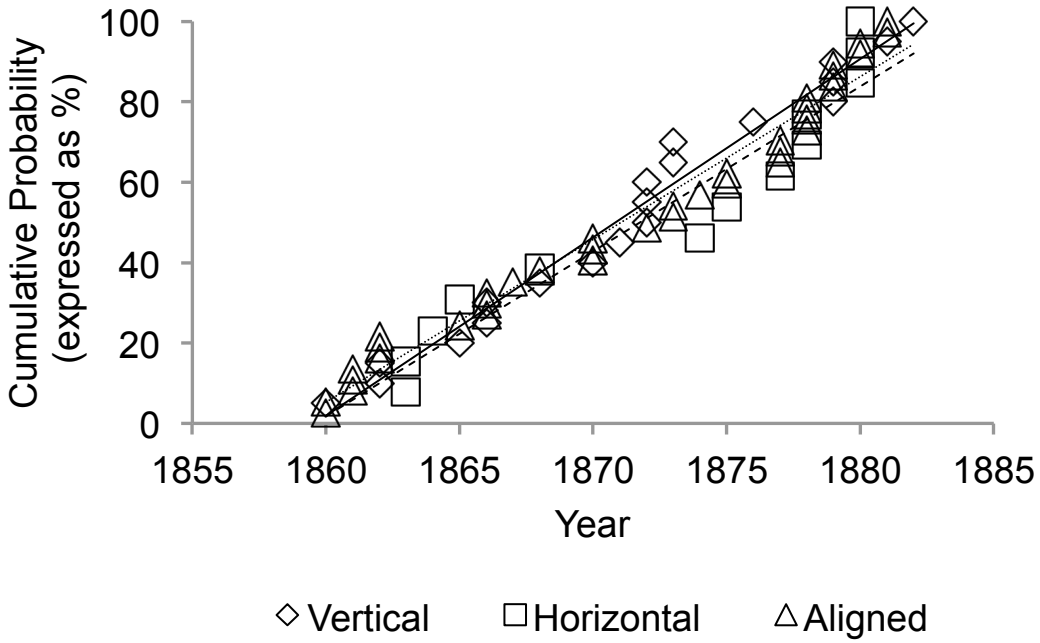

Figure 6. Cumulative probability, by year, of Manet's painting of aligned and misaligned gaze. Misaligned gaze is split by misalignment on vertical or horizontal axes.

Figure 7. Photograph of Stéphane Mallarmé.