Mondrian, Eye Movements and the Oblique Effect

James A. Schirillo (schirija@wfu.edu) and Jordan E. Plumhoff (plumje3@wfu.edu)
Department of Psychology, Wake Forest University
Winston-Salem, NC 27109 USA

Abstract

Observers prefer paintings by Piet Mondrian in their original orientation compared to when rotated – "The Oblique Effect" (Latto et al., 2000). We tested whether eye movements could provide any insight into this aesthetic bias. We presented 8 Mondrian paintings (1921-1944) on a computer monitor in their original and seven rotated positions to 10 observers. These 64 images were randomly presented for 20 sec each while recording eye movement duration and saccade length. During a 5 sec ISI observers used a 1-7 Likert-scale to report how (dis)pleasing they found each image. In 6 cases an original orientation was judged as significantly more pleasing than a rotated image, while a rotated image was preferred in 3 cases. Overall, over the 20 sec trial interval, fixation durations increased linearly, while fixation duration increased more for pleasing than for non-pleasing images. Moreover, saccade distances oscillated over the viewing interval; with the pleasing image fit being more variable (i.e., saccade distance oscillations were larger) than the non-pleasing image fit. Both these findings agree with earlier work by Nodine, Lochear and colleague; and suggest that the more pleasing an abstract painting is, the greater the diversive/specific types of image exploration become (Berlyne, 1971).

Keywords: Eye Movements; Fixation Duration; Saccade Extent; Oblique Effect; Mondrian, Aesthetics

Introduction

The psychophysical 'oblique effect', first named by Stuart Appelle (1972), is the principle that "our perception of oblique or diagonal lines is slightly inferior to our perception of horizontal and vertical lines" (Latto et al., 2000). Perhaps the earliest mention of the oblique effect in the vision literature was cited by Mach (1861) who found that observers were more accurate at matching a line parallel to a horizontal or vertical comparison line than to an oblique line (Mach 1861, cited in Westheimer 2003). Higgins and Stultz (1949) also found that observers showed 20% higher visual acuity when lines passing through their visual field were horizontal or vertical as compared to oblique lines. In 2000, Latto and colleagues studied a related phenomenon that they also called "The Oblique Effect". They showed that observers preferred eight paintings by Mondrian in their original orientation compared to when they were rotated to one of seven positions in 45^0 increments. They also found an interaction between frame orientation and component orientation such that the preference for horizontal and vertical components was balanced by a preference for components that were parallel to the surround frame. Observers preferred images that had original horizontal and vertical frames to those that had original oblique frames because their components were parallel to the surround frame. They concluded that there were two factors that reduced the appeal of Mondrian paintings; one being rotation per se, and how that might have affected the overall balance of the painting and the other was the introduction of obliquely oriented components.

Latto et al. (2000) compared the oblique effect to orientational anistropy where perceptual discrimination is slightly inferior in the oblique orientation and instead observers prefer the vertical and horizontal orientation of stimuli, such as lines in a vernier acuity task. The purpose of the present study was to replicate Latto et al.'s (2000) findings, while also determining whether eye movements could provide any insight into the causes that might underlie this aesthetic bias, since orientational anisotropy is often considered to be due to a low-level process.

Mondrian felt so strongly that he should use only horizontal and vertical lines, that when a fellow artist of the movement, Theo van Doesburg, insisted on using diagonals, Mondrian broke off their friendship and left the de Stijl art movement which he helped to found (Esman, 1994).

By examining eye movement patterns, in particular fixation durations and saccade extent, we can establish whether Berlyne's (1971) hypothesis that greater diversive/specific types of image exploration occur as images become more aesthetically pleasing. That is, we can determine whether observers will have longer dwell times over the viewing duration of a painting if it is seen as interesting versus if it is seen as not interesting. Moreover, we can determine if saccade length will show greater fluctuations for pleasing images, indicating shifts between diversive and specific viewing. Using the abstract work of Mondrian is especially conducive to these measures in that, unlike a realistic image, the painting can be rotated and still be interpreted as a coherent work of art.

Much of the research to date on aesthetics and psychology has focused on high-level cognitive contributions. Even the use of lower-level eye-movement measurements has contributed only by showing how having an increase in such movements correlate to an increase in information contained within the image (Antes, 1974; Hochberg, 1976). By using Mondrian's abstract work, the information content is minimized as a variable, while rotating such images holds constant whatever information content that is present. Using eye movement recordings in this way emphasizes whatever lower-level contributions are relevant to making aesthetic judgments.

Method

We presented 8 abstract Mondrian paintings (1921-1944); 4 with traditional horizontal and vertical frames (16.3^0 X 16.3^0) and 4 with oblique frames (22.6^0 X 22.6^0); on a 21" computer monitor in either their original or 7 rotated positions (i.e., 0^0, 45^0, 90^0, 135^0, 180^0, 225^0, 270^0 and 315^0; see Figure 1 for one example) to 10 observers (introductory psychology students, who participated in the one hour experiment for course credit. None of the students were familiar with the works of Mondrian nor any of these specific paintings. There were 6 males and 4 females, with an average age of 19. They were not aware of the purpose of the experiment).

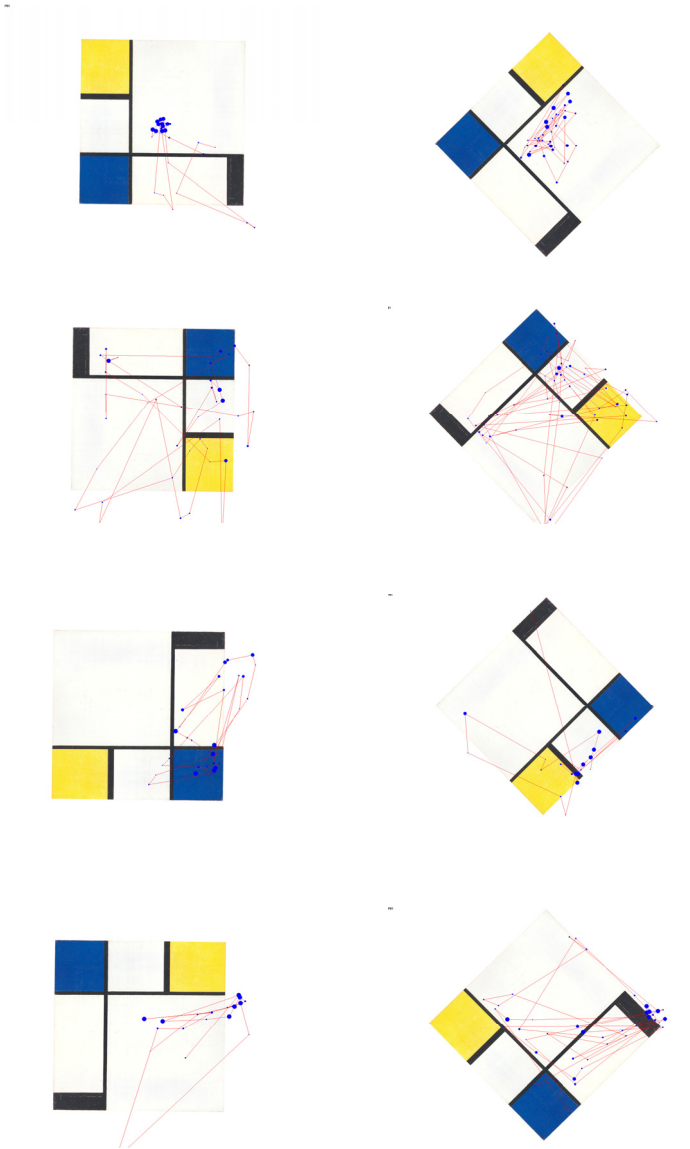

Figure 1. One original Mondrian (top-left) and 7 rotated versions that include 20 sec eye-scan pathways (red lines) and dwell times (blue dots) made from one observer. Size of blue dots correlate positively with length of dwell time.

These 64 images were randomly presented for 20 seconds each while recording eye movement duration and saccade length using an Applied Science Laboratories Model 501 Eye Tracker 6000 series. During a 5 sec ISI observers used a 1-7 Likert-scale to verbally report how (dis)pleasing they found each image.

Results

Pleasingness scores were normalized as z-scores. Using these z-scores, we ran 8 paired-samples t-tests (1 for each image) comparing each original image to all of its rotations. From these t-tests we found 9 pairs of images (i.e., cases) that were statistically significantly different on pleasing ratings from each other. Across the 10 observers for the eight pictures and their seven rotations, in only 6 cases was an original orientation judged as statistically significantly more pleasing than a rotated image, while a rotated image was preferred in 3 cases. These images z-scores are presented as cases in Figure 2. The fact that statistical significance occurred in only a small number of cases might be due to the fact that unlike Latto et al.'s (2000) study, which had 30 observers view each image for 5 seconds, the current study used only 10 observers and had them view each picture for 20 seconds while simultaneously having their eye movements recorded.

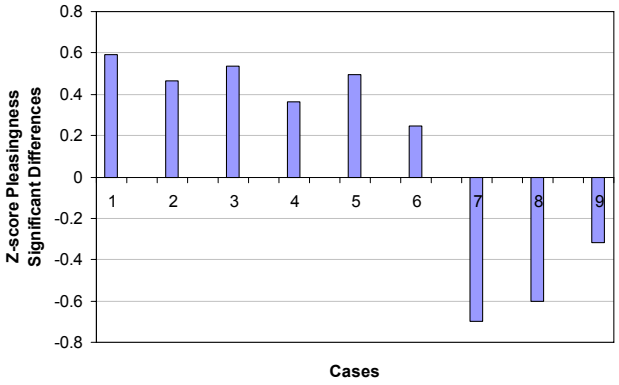

Figure 2. Significant z-score differences between original and rotated Mondrians. The first six cases refer to a picture in its original orientation compared to one of its rotated versions, while the last 3 cases refer to a picture in its rotated orientation compared to its original orientation.

We ran a 2x9x10 (pleasingness x cases x bins) repeated measures ANOVA to look for patterns across the duration of the scan. For our dependent measure we broke the duration time of each image scan into 10 equal bins (10% of fixations in each bin). Our independent measures were average interfixation degrees (i.e., saccade extent) and fixation durations for each observer. We then looked to see what level polynomials were significant fits to the data, and we plotted this trend line. We did this for all 18 images of the 9 significant case-pairs. This allowed us to examine patterns for each image, across the duration of each scan,

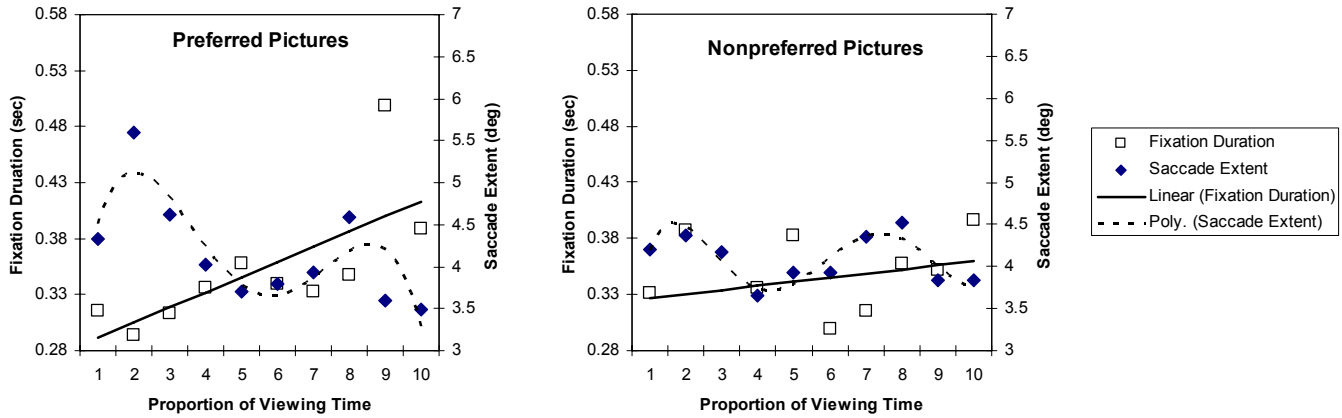

Fig. 3. Means of Fixation Durations (open squares) and means of Saccade Extent (closed diamonds) as a function of proportion of viewing time for (a) preferred, and (b) non-preferred Mondrians.

and compare the scanning pattern for original versus rotated and preferred versus non-preferred images.

Overall, over the 20 sec trial interval, fixation durations increased linearly (not exponentially as Hochberg (1976) describes; see Figure 5), where images fixation duration increased more for pleasing (Fig. 3a – solid line; $y = 0.014x + 0.28$; $R^2 = 0.51$; $p<0.002$) than non-pleasing images (Fig. 3b – solid line; $y = 0.004x + 0.32$; $R^2 = 0.28$; $p<0.046$). These slopes were statistically significantly different ($F(1,9) = 5.792$, $p<0.039$).

Moreover, saccade distances oscillated over the viewing interval; with the pleasing image fit being more variable (i.e., saccade distance oscillations were larger – Fig. 3a – dashed line; $R^2 = 0.74$) than the non-pleasing image fit (Fig. 3b – dashed line; $R^2 = 0.80$). These effects were not statically significant at the linear level, and only were significant as a 5th order polynomial for the preferred images and as a 4th order polynomial for the non-preferred images.

Such a discovery could not be predicted by simply examining the overall pattern of eye movements. This is because each observer's eye movement patterns were unique to each orientation of a specific Mondrian (e.g., note the pronounced differences across the 8 images in Figure 1). This was true when comparing the data sets across all 10 observers (Figure 4 provides one example). Two facts are made evident in Figure 4. First, the patterns of fixations differ. That is, in the original orientation the overall pattern of fixations lies across a broad 45^0 diagonal, but in the rotated version the bulk of the fixations form a tilted L-shape, following the oblique orientation of the two main black lines – but predominately lying within the larger white diamond. This can also been seen in Figure 1. This indicates that observers are indeed influenced by the orientation of the painting, where the black lines can have either more or less of an effect.

The second point is that there are *no* fixations in the original Mondrian's upper-left yellow square! Note that the observer in Figure 1 also did not fixate on the yellow square in five of the eight images. This is dramatic in that it is one of the few colored regions making it likely to draw exogenous attention to itself, and therefore should attract eye movements. Findings such as these were found in several eye scans of different paintings (both in their original and rotated positions). This suggests that while observers were sensitive to some elements of the pictures (e.g., the oblique black lines in Figure 4's rotated picture), other elements were neglected (e.g, the yellow square in the original image). Thus, viewing the pictures was not driven solely by saliency.

Figure 4. Fixations for 10 observers on an original (left) and rotated (right) Mondrian. Each observers fixations are shown as a different colored symbol.

Discussion

Both of the eye movement patterns exhibited in Figure 3 - fixation durations and saccade extent - agree with earlier work by Nodine, Lochear and colleague; and suggest that the more pleasing an abstract painting is, the greater the diversive/specific types of image exploration become (Berlyne, 1971). This can be seen by the progressively longer fixation durations across the 20 second viewing time, with this parameter enhanced when the pictures were pleasing compared to when they were non-pleasing. It can

also be seen by having greater saccade oscillations present with pleasing versus non-pleasing pictures.

Hochberg (1976) analyzed Antes (1974) eye movement patterns made using realistic images. He did this to try and better understand how eye movement patterns related to the extent an image contained extractable information. While the current findings are in agreement with Hochberg's analysis of fixation duration (e.g., compare the solid line in Figure 5 to those in Figs. 3a & 3b), they do not agree with his analysis of saccade extent, in that these did not gradually decrease (e.g., compare dashed line in Figure 5 to those in Figs. 3a & 3b). This may be due to the abstract nature of the Mondrians, as opposed to data collected using Antes (1974) realistic works (e.g., Fig. 6).

Antes (1974) work compared regions the viewer found interesting (as noted in Figure 6's numbers on the divided lower image) to dwell times. Using this method he found some exciting correlations. That is, more interesting (informative) portions of the pictures received longer dwell times. However, we did not ask observers to designate "regions of interest" (i.e., rate informativeness). This is because with Mondrian's abstract work we did not anticipate it would be possible to discern which regions would be considered of particular interest, other than black lines and color-filled regions. However, the above finding that the upper left yellow square (Figure 4; and also in Figure 1) was not fixated by any observer suggests that we revisit this question in future studies. Moreover, it is clear that the rotation of each Mondrian has a pronounced effect on the pattern of fixations each observer exhibits (e.g., Figs. 1 & 4). This indicates that bottom-up processes may account for the majority of the patterns generated, something that could not be discerned using only realistic pictures in the original rotation.

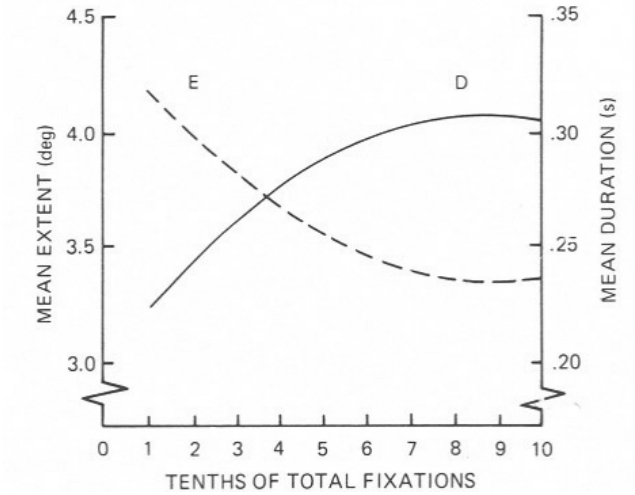

Figure 5. Hochberg's representation of the change in fixation duration and in saccade extent (After Hochberg, 1976; data by Antes, 1974).

Figure 6. *Morning on the Cape* by Leon Kroll, as used by Antes (1974).

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