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AN OBLIQUE EFFECT IN THE SELECTION OF LINE ORIENTATION BY TWENTIETH CENTURY PAINTERS

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ABSTRACT

In 88 paintings from the Israel Museum, Jerusalem the proportions of horizontal, vertical, and oblique lines were determined in order to ascertain whether artists preferentially use lines orientated in the horizontal and vertical directions rather than the oblique. Frame orientations were also examined to determine their effect on these line orientations. The results showed a preference for the vertical and the horizontal over the oblique. This effect was very robust, occurring with both landscape and portrait formats and over a variety of different styles and categories of paintings. There was also an interaction between line orientation and frame orientation with an increased use of vertical lines with portrait format paintings and an increased use of horizontal lines with landscape format. It is suggested that the basic finding of an orientation anisotropy in line selection is related to the oblique effect in line perception, the finding that horizontal and vertical lines are more readily perceived than oblique lines in a wide variety of situations. This supports the idea that stimuli like horizontal and vertical lines, which are preferentially processed by the visual system, are also aesthetically more powerful.

INTRODUCTION

Orientation anisotropy (the oblique effect) is defined as "a small but consistent superiority in performance when visual stimuli are horizontal or vertical as opposed to oblique" (Appelle, 1972). The effect appears on a wide variety of

perceptual tasks in humans, both adults and children, and throughout the animal kingdom.

The earliest observation of the oblique effect was probably by Jastrow (1893). Subjects were required to copy visually presented lines or to set other visually presented lines to a specified orientation. Results indicated a marked superiority for horizontally or vertically orientated stimuli. More recent studies have verified this result (Andrews, 1965, 1967a, 1967b; Bouma & Andriessen, 1968; Smith, 1962).

Emsley (1925) showed that maximum acuity occurred with horizontal and vertical orientation, minimum acuity occurred for stimuli orientated at 45° or 110-140°. This effect was initially attributed to astigmatism, but after correcting lenses were fitted to the subject, the phenomenon still remained and was termed "residual astigmatism." Ogilvie and Taylor (1958, 1959) measured the ability to perceive very fine wires and found that oblique wires had to be twice as wide as horizontal and vertical wires to be perceived. Higgins and Stultz (1948) found that tilting the head so as to align the retinal field with obliquely orientated lines improved their visibility. This suggested that it was the image orientation that was more important than the object orientation. Later studies have been more ambiguous on this point (Attneave & Olson, 1967, 1970; Attneave & Reid, 1968; Horn & Hill, 1969; Luria, 1963).

Much other psychophysical experimentation has produced robust evidence to suggest that the human perception of oblique lines is somewhat inferior to the perception of horizontal and vertical lines (Appelle, 1972; Campbell & Kulikowski, 1966; Davidoff, 1974; Essock, 1990; Heeley & Buchanan-Smith, 1994; Heeley & Timney,1988; Zlaskova, 1993). The oblique effect is now established as one of the most robust effects in human psychophysics.

Animal studies have also provided evidence for the preferential processing of horizontal and vertical stimuli (see Appelle, 1972 for a review of the early literature). Monkeys, in particular, show a clear oblique effect (Bauer, Owens, Thomas, & Held, 1979; Harwerth, Smith, & Boltz, 1980).

A number of attempts have been made to provide evidence for the underlying neural mechanisms for the oblique effect following the discovery of orientation detectors in the visual cortex of cats and monkeys by Hubel & Wiesel (1959, 1977). There are now several studies showing that in some subdivisions of the visual cortex of animals there are more cells responding to horizontal and vertical than to oblique orientations (Coppola, White, Fitzpatrick, & Purves, 1998; DeValois, Yund, & Hepler, 1982; Kennedy, Martin, Orban, & Whitteridge, 1985; Mansfield & Ronner, 1978; Pettigrew, Nikara, & Bishop, 1968).

In humans, Maffei and Campbell (1970) found an oblique effect for visual evoked potentials. There is no substantive evidence at the single neuron level, although, in the only relevant study, Marg, Adams, & Rutkin (1968) found no obliquely orientated receptive fields in a sample of three cells.

The most likely explanation for the dominance of horizontal and vertical orientations over oblique in perception is therefore that more Hubel and Wiesel orientation detectors in the visual cortex are tuned to horizontal and vertical than to oblique lines and edges.

Whatever the exact mechanism, it is clear that lines, especially horizontal and vertical, together with some geometric patterns, the human body, the human face, stick figures, the human hand (Enns & Gilani, 1988; Horn, Haver, & Schwartz, 1976) appear to have privileged access to the human visual system. It has been proposed (Latto, 1995; Martindale, 1984) that one of the factors influencing aesthetic preferences is the amount of neural activity the stimuli being judged generates in the nervous system. Put simply, the suggestion is that the more activity a stimulus generates the more it is liked. It follows from our present understanding of the nature of visual processing in the brain that the more neurons responding to a stimulus the better it is processed. So stimuli, like lines and faces, which have privileged access to the human visual system will also be those stimuli which we prefer. The term "aesthetic primitive," using "primitive" in the sense of primary or fundamental, has been coined to describe these (Latto, 1995). So an aesthetic primitive is a stimulus or property of a stimulus that is intrinsically interesting, even in the absence of narrative content, because it resonates with the properties of the visual system processing it.

The theory of aesthetic primitives predicts that the oblique effect in visual perception will result in a preference for horizontal and vertical lines over oblique lines. Mondrian arrived at this conclusion from his own subjective experience and his move into abstraction was closely linked to a commitment to the horizontal and vertical. Indeed he felt so strongly about this that when in 1932 van Doesburg, another founding member of the De Stijl group of painters, insisted on using diagonals, he broke off his connection with the group (Jaffé, 1970). We have shown that Mondrian was correct in his judgment: paintings composed of horizontal and vertical lines are preferred to those composed of oblique lines, even if frame orientation is controlled for (Latto, Brain, & Kelly, 2000).

The question then arises as to whether this aesthetic oblique effect, a preference for horizontal and vertical over oblique, has influenced the composition of paintings by other artists. The present article addresses this by analyzing the proportions of horizontal, vertical, and oblique lines in a representative sample of 20th-century paintings.

METHOD

Paintings

Eighty-eight 20th-century paintings, reproduced in *On Paper, In Paper, With Paper* (Perry-Lehmann, 1990), a catalog of paintings exhibited in the Israel Museum, Jerusalem, Israel, were used for the study. This catalog was assembled

to "fully reflect the art of the twentieth century and its main trends comprehensively." It presents contemporary and local aspects of the 20th-century art collection (on permanent display in the Israel Museum), including "Israeli, European and American art in drawings, prints, illustrated books and livre d'artistes."

The catalog (and exhibition) is divided into seven thematic sections or categories: "The human figure," "The self portrait," "Landscape and nature," "Towards abstraction," "Signs and symbols," "Form is the message," and "Readymade." The catalog contains ten color plates and one hundred black-and-white illustrations. The latter were used for the study, omitting those paintings where there were no discernible lines (within the definition below) and, in one case, where the frame was square and therefore could not be classified as either "landscape" or portrait.

Procedure

A 360° protractor was used to define the orientation of each line and a 30 cm ruler was used to measure its length. All lines of a particular orientation were measured together in a particular painting, but the order was varied by systematic rotation from painting to painting.

The boundaries for each orientation are shown in Figure 1. They were defined as follows (angles are relative to the vertical axis): vertical 0-30°, 150-210°, 330-360°, oblique 30-60°, 120-150°, 210-240°, 300-330°, and horizontal 60-120°, 240-300°. So each orientation was allocated 120° in total.

A line was defined as a continuous brush-stroke of minimum length approximately 5 millimeters and not deviating in direction more than 5° during its length. The lines measured were one of either shading, outlines, or boundaries. If an area existed with no marked outline, but was surrounded by a distinctly separate color, the boundary between these two colored areas was measured as a line. Only dominant lines and lines that composed the main part of the illustration were measured. Lines that continuously changed direction, i.e., comprised a circle or an arc of a circle or a series of joined arcs were not counted and therefore ignored. The direction of lines on the paintings were determined using the protractor and were measured by the ruler in the specified order.

Once all the individual lengths were measured, the total length of lines in each orientation for each painting was calculated. From this, the proportion of lines in each orientation was found by dividing by the sum of the lines in all three orientations. This provided the principal dependent variable for the study.

The dimensions of each painting were also recorded, from which the frame format was assigned accordingly. Frame dimensions with a greater height dimension than width were termed "portrait," whereas frame dimensions with a greater width dimension than height were termed "landscape."

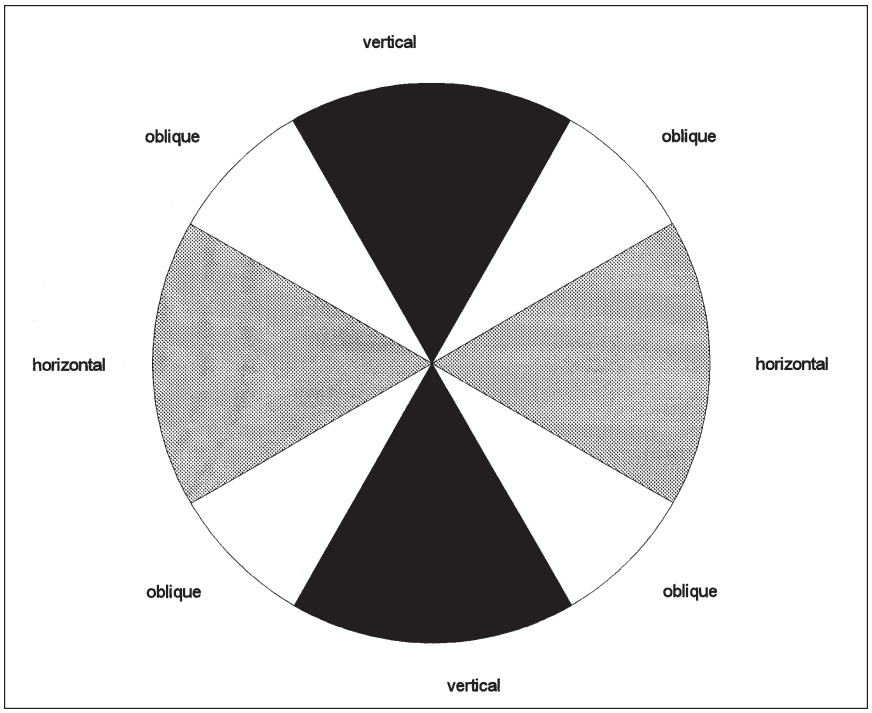

Figure 1. The boundaries of the three categories used to define the orientation of lines in the paintings studied.

The distribution of orientations was analyzed using a three factor mixed ANOVA with one within subject factor (line orientation) and two between subject factors (frame format and painting category). Since the dependent variable (orientation) was a proportion adding up to one for each painting, this did not show main effects in the between subject factors, but it did show if there were interactions between the proportions of the different line orientations and the factors of frame format and painting category. The lack of such an interaction indicated that the pattern of orientation proportions did not vary across the factor. A significant interaction indicated that the factor had some bearing on the pattern of orientations which was investigated by post hoc *t*-tests.

RESULTS

The proportions of lines in the three orientations for all eighty-eight paintings are shown in Figure 2. There was a significant difference between orientations, $F(2,150) = 18.85$, $p < 0.001$. Post-hoc comparisons of individual orientations

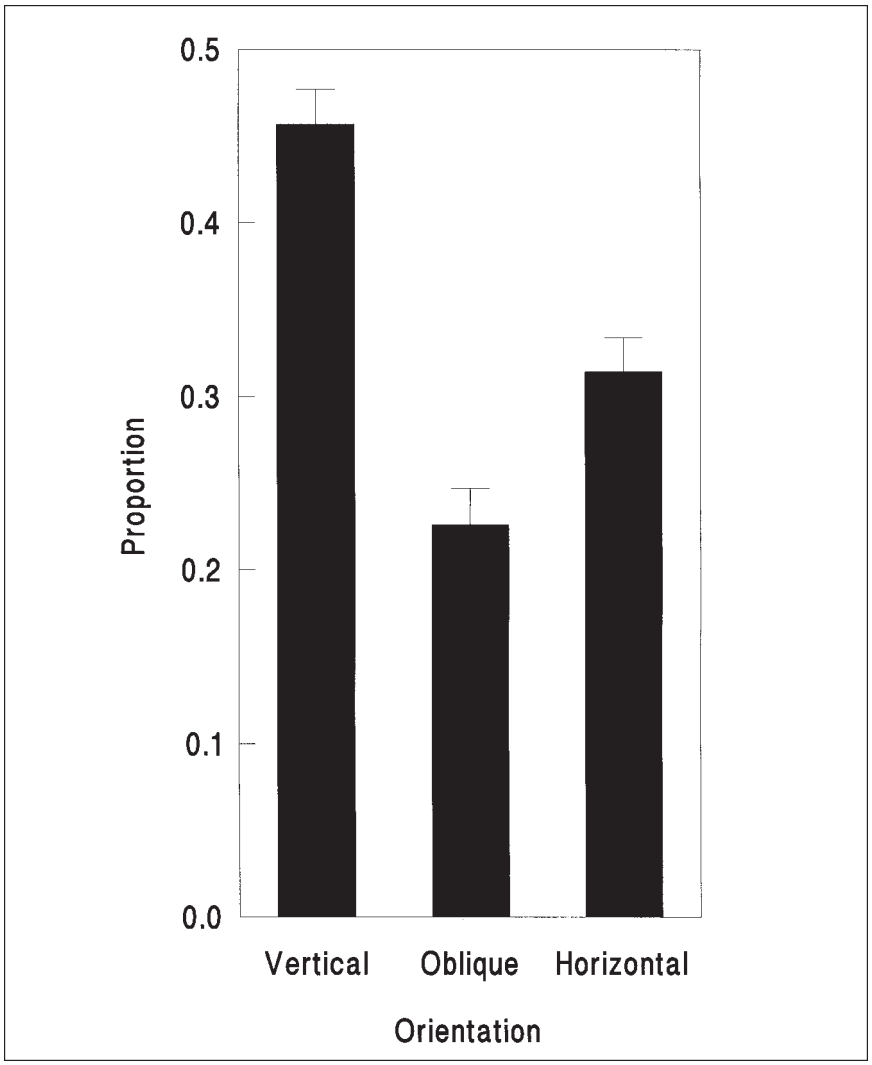

Figure 2. The proportions of lines in each of the three orientations over all the paintings.

showed that there was a greater proportion of vertical than oblique, $t(87) = 6.32$, $p < 0.001$, horizontal than oblique $t(87) = 2.481$, $p = 0.015$, and vertical than horizontal, $t(87) = 4.28$, $p < 0.001$.

The proportions of lines in the three orientations broken down according to frame format are shown in Figure 3. There was no difference between the different frame formats, $F(1,75) = 0.04$, $p = 0.841$, but there was an interaction between line

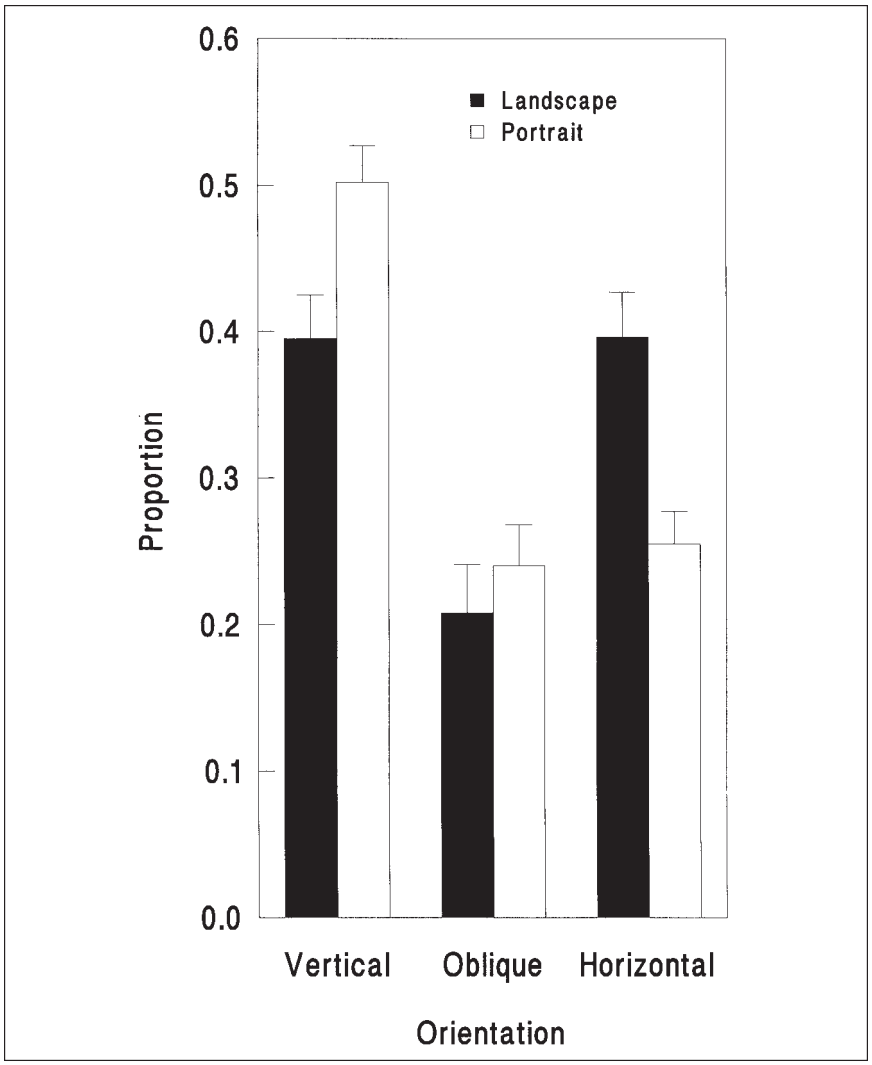

Figure 3. The proportions of lines in each of the three orientations, sub-divided according to the format of the paintings.

orientation and frame format caused by an increased use of vertical lines in portrait format paintings and an increased use of horizontal lines in landscape format paintings.

The proportions of lines in the three orientations broken down according to category of painting is shown in Figure 4. There was no difference between the

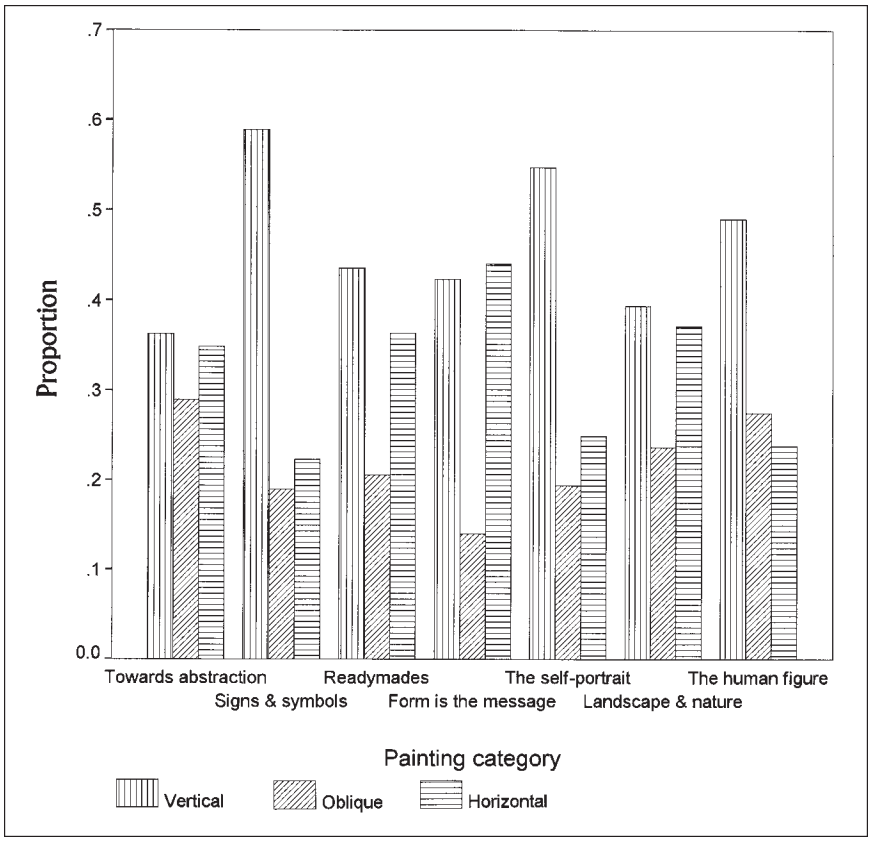

Figure 4. The proportions of lines in each of the three orientations, sub-divided according to the style of the paintings.

different categories, $F(6,75) = 1.69$, $p = 0.136$. Nor were there interactions between category and orientation, $F(12,150) = 1.55$, $p = 0.114$, category and frame format, $F(5,75) = 0.63$, $p = 0.675$, and category, orientation, and format, $F(10,150) = 0.78$, $p = 0.647$.

DISCUSSION

This analysis of a representative selection of 20th-century paintings from the Israel Museum, Jerusalem demonstrates that artists show a preference for horizontal and vertical over oblique lines in the composition of their paintings. This is a robust effect occurring with both landscape and portrait formats and over a wide variety of styles and categories of painting.

Although there is no difference between the landscape and portrait formats, there is a significant interaction between proportions of lines used in paintings and the format, with more vertical lines in portrait format paintings and more horizontal lines in landscape format paintings. All these effects seem to be largely independent of the category or style of the paintings. Different categories do not show different distributions of orientations, nor are there two- or three-way interactions between category and orientation or format.

This finding supports the idea, discussed in the Introduction, that there is an aesthetic oblique effect, a preference for horizontal and vertical over oblique, which influences the composition of paintings. Our visual systems are more responsive to horizontal and vertical than oblique which makes them aesthetically more potent as well. So artists tend to use more horizontal and vertical lines than oblique in their compositions. The extreme example of this is Mondrian, and we have shown that, independently of frame orientation, Mondrian's paintings are preferred when their component lines are horizontal and vertical (Latto, Brain, & Kelly, 2000).

There are two other possible explanations for the present finding of a preponderance of horizontal and vertical lines in paintings. The first is that there might be a framing effect such that lines parallel to the frame are most pleasing. The Mondrian study did not support this since, using his lozenge paintings, which have square frames rotated through 45°, we found that horizontal and vertical components were preferred even when they were not parallel to the frame edge. However, it remains at the least a potential contributory factor. The second possible alternative explanation is that artists, even when painting abstract forms, are simple reflecting the actual visual environment which we experience in our everyday lives. Since these contain more horizontal and vertical than oblique contours, even in pastoral environments (Coppola, Purves, McCoy, & Purves, 1998; Switkes, Mayer, & Sloan, 1978), a painting that reflected the real world would do so as well.

However, neither of these explanations excludes the proposition that there is an aesthetic oblique effect. On the contrary, the three explanations are mutually supportive. The over-riding use of horizontal and vertical frames could be due to our preference for these orientations, although the geometry of the built environment in which we normally view paintings must also have an influence. More important, the visual system has evolved to represent the visual environment as efficiently as possible (Field, 1987) and so the oblique effect in perception is there *because* of the preponderance of horizontal and vertical in the visual environment. (Interestingly, the most recent design of digital camera mimics this effect by arranging the sensor chips so that they respond preferentially to horizontal and vertical rather than oblique (Fox, 2000).) It is therefore because our visual systems are tuned to the particular visual environment in which we have evolved, that we find paintings that reflect that visual environment most pleasing. Horizontal and vertical edges are one, rather low level, example of these aesthetic

primitives. Other components of our visual world to which we are highly tuned, like faces, hands and the human form in general, provide others (Latto, 1995). Artists, working intuitively, discovered this and exploited it in their paintings long before science began analysing the nature of perception and the geometry of our visual environment.

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