Note

The frame of reference in anomalous motion illusions and ergonomics of human fallacy [1)]

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The frame of reference in motion perception refers to a tendency that a particular moving visual area appears to be stationary. The frame of reference is manifest in induced motion or the motion aftereffect. In anomalous motion illusions, *e.g.* the Ouchi illusion, the frame of reference is determined by a variety of factors. (1) An anomalously moving area that surrounds another anomalously moving area strongly tends to be the frame of reference so that the inset appears to move while the surround appears to be stationary. (2) High-contrast areas tend to be the frame of reference as compared to low-contrast areas. (3) Areas of high spatial frequency appear to be more stationary than those of low spatial frequency. These characteristics are discussed from the ergonomic viewpoint of human fallacy.

Key words : anomalous motion illusion, human fallacy, frame of reference

1. The frame of reference in motion perception

The frame of reference in motion perception refers to a tendency that a particular moving visual area appears to be stationary. For example, the moon surrounded by moving clouds appears to move in the opposite direction. This phenomenon is called induced motion, in which the surrounding image is the frame of reference (Robinson, 1972, pp. 222-224; Wade and Swanston, 1987). Since the area charged with the frame of reference tends to be stationary, the reduced fraction of perceptual motion signals is converted to the apparent motion of the image of the moon that is physically stationary. This idea is called 'relative motion' (Wade and Swanston, 1987; Swanston, 1994) and requires a two-stage model of motion perception. In this case (induced motion), the surround works as the frame of reference.

The frame of reference is also observed in the motion aftereffect (Swanston and Wade, 1992; Swanston, 1994). After adaptation to the surround motion, observers see the motion aftereffect in the inset in the same direction as the adapting surround motion even if the inset is stationary through all periods. Moreover, the surround tends to be stationary in the test

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period when observers adapt to the surround motion. In this case (motion aftereffect), too, the surround works as the frame of reference.

Visual jitter is a phenomenon that a physically stationary area appears to move in a few seconds in a variety of directions after the other area was adapted to kinetic random noise (Murakami and Cavanagh, 1998, 2001), in which the former is physically stationary and the latter is dynamic in the adaptation period, while both areas are physically stationary in the test period. They claimed that this illusory motion signal is thought to come from miniature eye movements. Murakami and Cavanagh (1998) proposed the rule of the 'lowest dynamic signals' as the frame of reference. This hypothesis claims that an area that was adapted to dynamic signals generates weaker dynamic signals in the test period than does an area that was not given dynamic signals, and that the visual system assumes the former to be a veridically stationary area. In this case (visual jitter), the area that was adapted to dynamic stimuli serves as the frame of reference.

2. The frame of reference in anomalous motion illusions

In the history of the study of motion perception, great attention has recently been drawn to anomalous motion illusion, which refers to the motion perception that is seen in a physically stationary image without any adaptation to dynamic stimuli. The Ouchi illusion (Ouchi, 1977; Spillmann, Heitger and Schuller, 1986; Hine, Cook and Rogers, 1995, 1997; Ashida, 2002) (Figure 1) is a typical pattern, in which the inset appears to move while the surround does not. The necessary condition to generate this illusion is a retinal slip in the oblique direction as compared with the edges. Also in the variations of anomalous motion illusion of the Ouchi type, the inset appears to move while the surround appears to be stationary (*e.g.* Figure 2). In these cases, the surround works as the frame of reference.

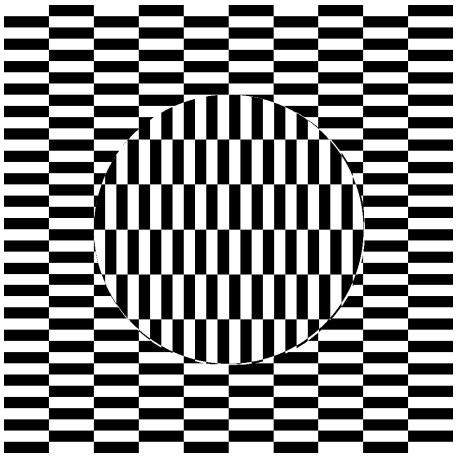

Figure 1. The Ouchi illusion. The inset appears to move while the surround does not.

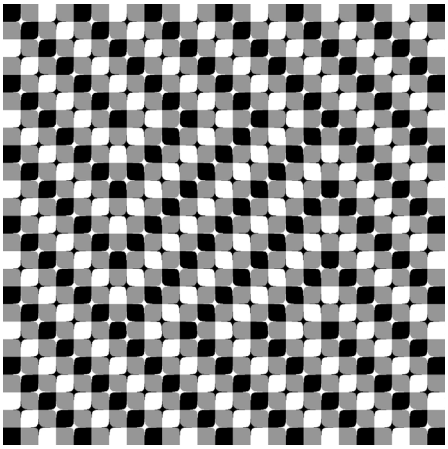

Figure 2. A sample of anomalous motion illusions. The inset appears to move horizontally when a vertical retinal slip occurs while it appears to move vertically when a horizontal retinal slip happens.

The second example of the frame of reference in anomalous motion illusions is that high-contrast areas tend to be stationary while low-contrast areas to be dynamic (Kitaoka and Ashida, 2002). When Figure 3 is moved, then low-contrast areas appear to move with a delay. In this case, the surround appears to move while the inset to be stationary. That is, this effect overcomes the strong tendency that the surround appears to be stationary. This suggests that the high-contrast area serves as the frame of reference.

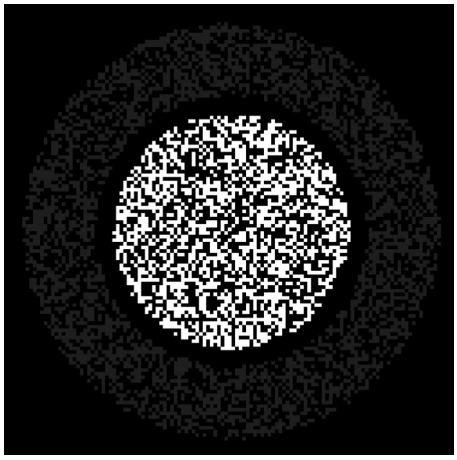

Figure 3. The tendency of high-contrast areas to be the frame of reference. The surround of low-contrast random dots appears to move while the inset of high-contrast random dots appears to be stationary. Try to sway, rotate, approach or move away from the figure with fixating at the center.

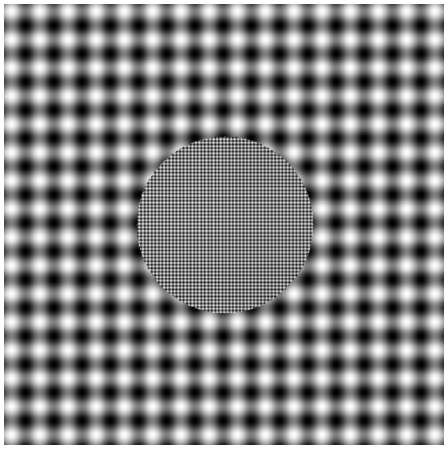

Figure 4. The tendency of high-spatial-frequency areas to be the frame of reference. The surround of a low-spatial-frequency plaid appears to move while the inset of a high-spatial frequency plaid appears to be stationary.

Figure 4 (Kitaoka, 2003) shows that the area of high spatial frequency appear to be stationary while that of low spatial frequency to be dynamic. In this case, too, the surround appears to move while the inset to be stationary. That is, this effect overcomes the strong tendency that the surround appears to be stationary. This suggests that the area of high spatial frequency serves as the frame of reference.

3. The frame of reference and human fallacy in motion perception

The surround has so far been known as the main source of the frame of reference. In anomalous motion illusions, too, the surround frequently works as the frame of reference. However, Figures 3 and 4 show exceptions, *i.e.* high-contrast areas and high-spatial-frequency areas also serve as the frame of reference. Both characteristics are contained in the images of objects that are well focused on. These characteristics may indicate in the drain that they are stationary objects since moving objects tend to show blurs and to be out of focus.

If high-contrast or high-spatial-frequency areas are actually moving while low-contrast or low-spatial-frequency areas are stationary, observers could be deceived and might possibly tumble down due to false visual

signals. Such 'fallacy' should be an important issue in the collaboration of the psychophysical study of visual illusion with the ergonomic study of human fallacy.

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