Spatial phase and frequency in motion capture of random-dot patterns*

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Abstract—A square matrix of spots (A) was presented in rapid alternation with an uncorrelated matrix (B). If the square arrays are superimposed spatially one sees random incoherent motion. However, incoherent motion was seen only if the outer edges were exactly aligned. If the outline of matrix A is shifted horizontally by 1° in relation to B, then the edges are seen to oscillate to and fro. Surprisingly, all the dots in the matrix were seen to ‘adhere’ to the edges and to move horizontally (Ramachandran, 1981). We then aligned the edges again to produce incoherent motion and superimposed a sine-wave grating on the pattern. If the grating was moved horizontally then all the spots ‘adhered’ to it and moved horizontally as well. This illusion (‘motion capture’) was optimal (a) at a 90° spatial phase shift of the grating; (b) at low spatial frequencies (< 0.5 cycles); and (c) when the grating was alternated in step with the dot patterns. Density modulated gratings were just as effective. We conclude that the unambiguous motion signal derived from the grating is applied spontaneously to the dots as well.

INTRODUCTION

If two spatially separated spots of light are presented to the retina in rapid succession the spot will appear to move between the two locations, as commonly seen in traffic signals and neon advertisement signs. This phenomenon is usually called apparent motion (Anstis, 1970, 1978; Burt and Sperling, 1981; Julesz, 1971; Kolers, 1972; Korte, 1915).

Instead of a single spot one can use a square matrix of dots similar to those shown in Fig. 2 (bottom). If this pattern is presented in Frame 1 and then switched off and followed by a similar but uncorrelated pattern of dots in Frame 2 so that the two patterns are superimposed spatially, what one typically sees is ‘incoherent’ motion, i.e. the dots appear to move in random directions as in a detuned television set. Presumably each dot in Frame 1 moves to its nearest neighbour in Frame 2.

Recently we made the curious observation that such incoherent motion is seen only if the outer edges of the two random-dot matrices are properly aligned. If the outline of the matrix of dots in Frame 2 is shifted horizontally by (say) 1° in relation to Frame 1 then the edges of the dot patterns are seen to oscillate to an fro although the dots composing these edges are uncorrelated. This in itself was not surprising but what we noticed was that the entire matrix of dots, including dots that were near the centre of the display, was seen to move in the same left–right direction, i.e. all the dots were seen to ‘adhere’ to the moving edges. This was true even when the matrix itself subtended a square of 5° x 5° so that dots near the centre of the display were at a distance of nearly 2.5° from the moving edges (Ramachandran, 1981; Ramachandran, 1984). Elsewhere we have referred to this effect as ‘captured motion’ (Ramachandran and Anstis, 1983; Ramachandran and Cavanagh, 1985; *Presented at the symposium on stroboscopic motion at The American Psychological Association Annual Convention, Toronto, September 1984.*
Ramachandran and Inada, 1984). One can generate two such displays which move simultaneously in opposite directions, suggesting that eye movements are not responsible for the effect.

Why does the motion of dots near the centre of the display become synchronized with the oscillating edges? We wondered whether the low spatial frequencies associated with these edges were responsible for the effect and we investigated this by superimposing sine-wave gratings on dynamic random-dot patterns. We describe some preliminary results in this communication.

**EXPERIMENTAL APPROACH**

We began with two uncorrelated random-dot patterns which were displayed in a 4-channel tachistoscope driven by an electronic timer. Each dot matrix subtended a visual angle of 7.5° and the dots themselves were of about 2 min arc in diameter.