An examination of colour-contingent pattern aftereffects*

G. KEITH HUMPHREY¹, RICK GURNSEY² and PAMELA J. BRYDEN¹

¹Department of Psychology, University of Western Ontario, London, Ontario, N6A 5C2, Canada
²Department of Psychology, Concordia University, 7141 Sherbrooke St. W., Montreal, Québec, H4B 1R6, Canada

Received for publication 11 October 1993

Abstract—The McCollough effect (ME) is an example of a pattern-contingent colour aftereffect. This study describes some characteristics of another visual aftereffect linking pattern and colour here called a colour-contingent pattern aftereffect (CCPA). After inducing with, for example, a magenta and black radial pattern and a green and black pattern of concentric circles, presentation of a green homogeneous field evoked a faint image of a radial pattern superimposed on the field, whereas presentation of a magenta homogeneous field produced a faint image of concentric circles. The pattern was blurred and fleeting, occurring with the onset of the homogeneous field, but nevertheless was evoked reliably. Various properties of these colour-contingent pattern aftereffects are reported. Although the aftereffects have some of the characteristics of the ME, the CCPA is not as long lasting as the ME, and, unlike the usual ME, it is abolished if eye-movements are made during induction.

INTRODUCTION

Colour aftereffects contingent on pattern orientation were first reported by Celeste McCollough (1965) and have since often been referred to as McCollough effects or MEs. The procedure used to induce an ME is simple. Two differently oriented grating patterns, such as a green and black horizontal grating and a red and black vertical grating, are viewed alternately for several minutes. If horizontal and vertical, black and white gratings are subsequently viewed, the white bars in the test grating appear to be faintly coloured in a hue complementary to the induction colour. In the present example, the horizontal grating would appear pink, whereas the vertical grating would look green.

Several theoretical accounts of the ME and related aftereffects have been given (for reviews see Humphrey, 1994; Skowbo et al., 1975; Stromeyer; 1978), but we will concentrate on the theories developed by Barlow and Foldiak (1989), Barlow (1990a) and Dodwell and Humphrey (1990, 1993), as they are most pertinent to the experiments described here.

Both Dodwell and Humphrey and Barlow and Foldiak propose that MEs and other aftereffects are a reflection of functional processes that are involved in a continuous calibration of the visual system. The proposal of Dodwell and Humphrey owes much to the theorizing of Helson (1964) and Andrews (1964) (see also Gibson, 1937; Ullman and Schechtman, 1982). Both Helson and Andrews noted that perceptual systems are sensitive to the statistical properties

*These results were presented at the 1992 Annual Meeting of the Canadian Society for Brain, Behaviour, and Cognitive Society, Quebec City, Canada.
of sensory input, and adjust their output based on the statistical distribution of the input. Helson (1964) postulated that in making psychophysical judgements, the observer sets up an implicit scale based on the statistical properties of the set of objects being judged. The essential idea in his adaptation level theory is that there is a 'neutral point' or adaptation level, that is in some sense the 'centroid' of psychophysical judgements. Perceptual judgements are made in relation to this neutral point and changes in adaptation level occur in response to particular perceptual 'diets'.

Andrews (1964), building on Helson's ideas, suggested a function for such changes in adaptation level. Andrews was concerned particularly with the question of matching the internal representation of the world to external properties. Some of these external properties are statistical in nature and reflect properties of the visual input that occur in the long run. Consider an example given by Andrews (1964). In the long run, the average movement of elements in the visual field is zero in all directions. This is a long-range statistical property of the world, but it is violated all the time in the short run, so to maintain stability such short-term fluctuations are ignored. If, however, the criterion is consistently violated in the 'diet' of stimulation applied to the visual system, the discrepancy between the general statistical property of zero motion, and its local perturbation will be detected. The long-range criterion could be violated by, for example, imposing linear motion in one part of the field over a substantial period of time. Andrews proposes that in response to this input, the visual system, through an error correction device (ECD), changes the internal representation to attempt to reduce the discrepancy. Generally speaking, this device will impose an inverse transformation on its input.

Dodwell and Humphrey argued that McCollough effects are due to changes, controlled by ECDs, in the contingent adaptation levels. Specifically, MEs are generated because the zero correlation that exists in the long run, and on average, between colour and contour orientation is violated by the high correlation between colour and contour orientation during the induction period. To maintain the internal representation of the long-run zero correlation between a particular colour and orientation in the presence of the artificially high induced correlation during ME generation, the system recalibrates. The recalibration can be seen as an attempt to decorrelate colour and orientation.

Barlow and Foldiak (1989) and Barlow (1990a) have recently proposed a theory of the ME and other aftereffects that is similar in some aspects to that of Dodwell and Humphrey (1990). As in the Dodwell and Humphrey account, Barlow and Foldiak note that ME induction introduces unusual correlations between variables such as colour and orientation. According to their theory, it is necessary to keep such perceptual dimensions separate, because the nervous system will not be able to establish new associations if the independent probabilities of the elements separately involved in the association (i.e. colour and orientation) cannot be known or represented (see also Barlow, 1990b). The mechanism for keeping the dimensions separate—that is, decorrelating them—is an 'anti-Hebbian' mechanism that during ME induction increases inhibition between mechanisms coding for colour and orientation. Barlow and Foldiak (1989) and Barlow (1990a,b) also propose that the inhibition is bidirectional— from form to colour as well as from colour to form.