UK. There were 6,298 hospital admissions over a 720-day period, a mean of 8.75 per day. The 'Kp-sums', also consisting of integer values, averaged 15.73 per day. Analyses were carried out with both the raw data (n) and logarithmic transformations ($\log_{10}(n+1)$).

Same-day correlation coefficients were calculated between the two values within each of 24 successive 30-day periods. Serial correlations were calculated, separately for geomagnetic activity and for heart attack admissions, between pairs of readings separated by 1, 2, ... 31 days. Finally, over the full 720-day period, correlations were calculated between geomagnetic readings on day 0, and hospital admissions on days −15, −14, ... +14, +15 days.

The results were qualitatively similar for the raw and the log-transformed data. Results reported below refer to the log transforms. The serial correlations of the admission data gave significant values (>3 s.e. from 0) at 7 days ($r = +0.15$), 14 days ($r = 0.16$) and 21 days ($r = 0.12$). A complex day-of-week variation over the full period ($\chi^2_6 = 67.8$), mainly characterised by a deficiency of admissions on Sundays, confirms the validity and demonstrates the origins of this finding. The serial correlations of the geomagnetic data gave significant positive results (>3 s.e.) at 1/2 days ($r = 0.50$ at 1 day), 16/17/18/19 days (0.17 at 17 days) and 25/26/27/28 days (0.21 at 27 days). The 27-day cycle represents the period of rotation of the Sun. None of the 720-day-period correlations with intervals of −15, ... 0, ... +15 days showed significant positive or negative correlations; the greatest absolute value was $r = +0.06$ (1.46 s.e.). None of the intra-30-day-period same-day correlations between medical and magnetic data gave a significant value, either positive or negative.

Despite the fact that our methods and materials were sensitive enough to detect serial correlations within each of the individual data sets, our examination failed to confirm the Indian observations. Although there is no clear explanation of the difference between the two investigations, three hypotheses should be considered: (1) heart attacks may have different aetiologies in the two countries, (2) the two sets of electrocardiographic equipment may differ, the Indian equipment being susceptible to external magnetic fields, thus affecting the relative likelihoods of different diagnoses, (3) temporal fluctuations in the Indian medical data, with a period differing from our own 7-day cycle, and due to different social customs, may have interacted coincidentally with one or other of the periodic variations observed in the geomagnetic field.

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1. Malin, S. R. C. & Srivastava, B. J. *Nature* **277**, 646 (1979).
2. *Geomag. Bull.* no. 3 (1969); no. 4 (1970).

Perception of illusory movement

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Intensive studies of visual illusion have rarely shown examples of polymorphic responses[1–3]. We show here that, using figures consisting of stripes shaded from dark to light, arranged in repeating sectors, an illusion of movement can be induced in about 75% of observers when viewed peripherally. The responses of the viewers fall into four categories. This polymorphic response suggests a genetic origin.

Figure 1 shows the figures used during the experiments. The four categories of response into which viewers could be divided were: (1) N, seeing no movement, or a slight, inconsistent, jerky motion; (2) DL, seeing smooth continuous movement in the direction from dark to light shading; (3) LD, seeing smooth, continuous movement in the light to dark direction; and (4) V, sometimes seeing smooth, continuous movement in the DL direction, sometimes in the LD direction. The individuals of the N class who see a slight, jerky movement consistently see this in the DL direction. A sample of 678 subjects showed 24.9% N, 59.0% DL, 6.5% LD and 9.6% V. The subjects were tested with two figures in which the shaded sectors were arranged in a spiral and the polarity of the shading was opposite. Sensitive subjects see the illusory movement in opposite directions in the two figures. Care was taken not to bias the responses of the subjects who were simply asked to give their responses to the figures, no mention being made of motion, rotation, and so on. Reaction to the figures in repeated tests separated by intervals ranging up to 2–3 years is remarkably constant, that is, the classification has a high repeatability.

The polymorphism of response suggested a genetic explanation and, therefore, a parent–offspring survey was made of individuals in 83 families. The LD and V classes were grouped to give the data shown in Table 1. There are no differences between sexes nor between reciprocal matings, and the data have been grouped over sexes and reciprocal matings. If we examine the types of matings from N×N to N×DL, to DL×DL, to DL×LD–V, there is a progressive decrease of the frequency of N progeny. There is a clear parent–offspring correlation, indicating that there is either a strong genetic causation or an equally strong familial effect of common environmental factors.

A number of twins were tested to allow separation of genetic and environmental factors. Concordance was computed as the number of twin pairs having the same response divided by the total number of twin pairs. The concordance for MZ twins (29 pairs) was 0.90, for DZ twins (41 pairs) was 0.56, and for non-twin sibling pairs was 0.53 (213 pairs). The concordance for unrelated pairs was 0.40. The differences between MZ and DZ twins are significant, indicating that there is a fairly strong genetic component. Clearly, more data are needed, but the agreement between the parent–offspring and the twin comparisons indicate that the illusory-movement perception (which we are terming the 'escalator' illusion) offers considerable promise for further detailed studies.

If our data are sub-divided by academic disciplines it is apparent that the incidence of the escalator effect differs between academic disciplines. Faculty and graduate students of three departments were tested: Fine Arts, 4.7% N (42 tested), Biological Sciences, 22.5% N (40 tested), Psychology, 56.2% N (42 tested). The Biological Sciences department does not differ from the general expectation of 24.9% N. The other two departments differ significantly from each other, and from the general expectation. Tests of progeny of Fine Arts and Psychology faculty gave the following results: Fine Arts, 5.9% N (17 tested), Psychology, 35.0% N (20 tested). The regression of the progeny towards the population mean of 25% agrees with the genetic determination of the character. These results support the surprising conclusion that genetic differences in

Table 1 Parent–offspring survey of individuals of 83 families

Parental mating type (and no. of matings)	Response type of offspring (%) N	DL	LD
N×N (10)	18 (52.9)	12 (35.3)	4 (11.8)
N×DL (28)	22 (28.6)	43 (55.8)	12 (15.6)
DL×DL (33)	5 (5.1)	77 (77.8)	17 (17.2)
DL×LD–V (9)	1 (3.8)	15 (57.7)	10 (38.5)
N×LD–V (2)	1 (25.0)	0	3 (75.0)
LD–V×LD–V (1)	0	3 (75)	1 (25.0)

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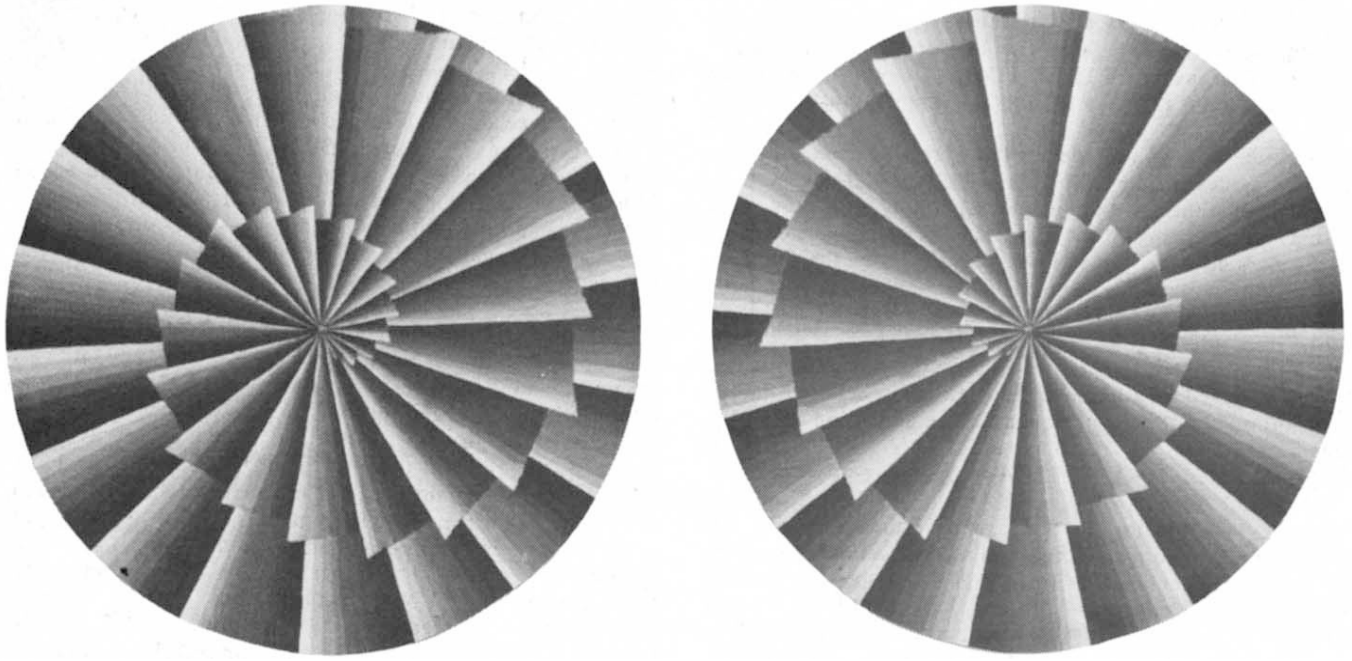

Fig. 1 The two illustrations presented to observers.

sensitivity to the 'escalator' figures are involved in career selection. We have identified in our sample of Fine Arts undergraduate students, five who transferred out of the programme. All were N ($P = 0.001$). Presumably the complementary process occurs in the Psychology programme. Genetic determinism of a sociological polymorphism is known—similar differences between career groups can be found for colour blindness.

'Escalator' illusion is a feature of peripheral vision not occurring within 5° of the point of fixation when seen at distances of several feet. The possibility that this phenomenon is due to small polarised eye movements is discounted, (1) by seeing simultaneous rotation in opposite directions in spiral figures, (2) by seeing simultaneous movement in opposite directions in parallel and rectilinear figures, and (3) by seeing the simultaneous different movements continuously whilst making fairly large eye movements.

Tests were made to determine whether real rotation would suppress or enhance the rotation of the figures induced by the 'escalator' effect. The two figures were mounted side by side and rotated at the same rate. Subjects viewed these figures peripherally centering their vision mid-way between the figures and below them. The two disks were concordant, having their DL shading in the same direction, or discordant, one disk having the DL shading in the clockwise direction whereas its neighbouring disk was shaded DL in the anticlockwise direction. It was found that if the rate of rotation is slow (0.68 r.p.m.) then DL subjects differ in their perception of the rates of rotation of the disks, depending on whether they are concordant or discordant. They see the concordant disks as rotating at the same speed in 91% of trials. Conversely, they see in the discordant disks, one disk as rotating faster than the other. The disk seen as rotating at a faster rate is the one in which the DL shading is in the same direction as the real rotation. This was reported in 68.0% of trials. If the real rotation is reversed, then the identification of the faster disk is also reversed. N subjects gave quite different results in their perception of the discordant pair of disks, reporting the expected difference in apparent rate of rotation in only 18.0% of trials. At slower rates of rotation the agreement of results with expectation increased to 90.0% in DL subjects and to 59.7% in N subjects. At very slow rates of rotation in the range of 0.1–0.4 r.p.m., DL subjects note for the discordant pair of disks that the disk in which the DL shading is in the opposite direction to the real rotation, appeared to be stopped whereas the adjacent disk was still perceived as rotating. Reversing the direction of the real rotation reversed the identification of the disk that was not rotating. N subjects noted the same apparent cessation of rotation only at lower rates of rotation 0.12 r.p.m. and with less consistency. It is apparent that our original test procedure does identify a real difference of visual perception, with the difference being of degree: N subjects are not 'blind' to the 'escalator' effect, but have a much lower sensitivity than DL subjects.

It is rather surprising that the intensive studies of visual illusions[1–3] have rarely identified examples of polymorphisms but a possible explanation of this is that such studies have involved refining figures until they are 'strong'; that is perceived by all subjects in all conditions. If figures are, instead, refined to maximise discrimination, then it is possible that polymorphisms of visual perception will be found to be as general as polymorphisms of other characters.

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1. Gregory, R. L. *Eye and Brain; the Psychology of Seeing* (World University Library, London, 1966).
2. Robinson, J. O. *The Psychology of Visual Illusions* (Hutchinson, London, 1972).
3. Coren, S. & Girgus, J. S. *Seeing is Deceiving* (Wiley, New York, 1978).

Underwater behavioural thermoregulation in the adult stonefly, *Zapada cinctipes*

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Some adult insects survive extremely low temperatures using various physiological mechanisms[1,2]. Here I report that the adult stonefly, *Zapada cinctipes* (Banks) (Plecoptera: Nemouridae), behaviourally thermoregulates at subzero night temperatures by entering the water.

The study site, a small pond formed by an artificial diversion of Sagehen Creek, was located in the Sierra Nevada Mountains 9 km north of Truckee, California (39°25′N, 120°12′W, elevation ~2.0 km).

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