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# The assessment of components involved in illusion formation using a long-term decrement procedure

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Available evidence seems to indicate that illusion decrement represents reorganization of cognitive components involved in visual-geometric illusions. Observers viewed one of the two forms of the Mueller-Lyer illusion, containing differential opportunities for peripheral structural interactions, for a 10-min test session on each of 5 successive days. The magnitude of the distortion decreased to a different asymptotic level in each of the two configurations with the form, with more opportunity for structural interactions showing the higher asymptote. Thus, this asymptote probably represents the structural or physiological contribution to the illusory distortion.

The investigation of visual geometric illusions began well before psychology became a separate discipline. Since the first treatment of several illusion configurations by Oppel (1854), hundreds of different patterns which lead to visual distortions have been catalogued. Many different mechanisms have been proposed to explain these illusory effects. However, the accumulation of data seems to indicate that no one mechanism can account for the observed variety of effects, or even for any single illusion configuration (Coren, 1970; Coren & Girgus, 1973a, 1974; Girgus & Coren, 1973). Most proposed illusion theories fall roughly into one of two classes. The first class suggests mechanisms that involve the structural properties of the optical and neural systems, while the second class suggests mechanisms that involve the way that visual information is processed cognitively.

Evidence in support of both sources of illusory distortion now exists. On the structural side, Chaing (1968) has proposed that simple degradation of the optical inputs, due to optical and spherical aberrations of the crystalline lens or diffraction of light at the pupillary aperture, can account for some distortions observed in figures containing converging and intersecting lines. Such figures include the Mueller-Lyer, Zoellner, and Poggendorff illusions. Coren (1969) has demonstrated that this source of distortion can account for approximately 22% of the effect observed in the Poggendorff illusion. The remaining 78% is then, presumably, due to other factors. Békésy (1967) and Ganz (1966) also utilize a structural source of illusory distortion when they propose that lateral inhibitory interactions operating on converging or intersecting line elements cause some of the obtained contour displacements and distortions. Coren (1970) and Girgus, Coren, and Horowitz (1973) have shown that removal of the converging line elements necessary for the operation of this mechanism does, in fact, reduce the magnitude of several classical illusions. However, even when all opportunities for such contour interactions have been removed, significant visual distortions in the classically observed directions still remain.

There is also evidence to support cognitive-judgmental factors in illusion formation. For example, Day (1972), Gregory (1968), Gillam (1971), and Leibowitz, Brislin, Perlmutter, and Hennessy (1969) have presented data which suggest that perspective cues are available in some illusion figures, such as the Ponzo, the Poggendorff, and the Mueller-Lyer. These cues may evoke constancy scaling mechanisms which, in turn, contribute to the formation of the illusion. Evidence implicating comparative judgmental processes, such as the accentuation of clearly perceived differences, seems to account for certain aspects of size contrast illusions, such as the Ebbinghaus illusion (Coren, 1971; Coren & Miller, 1974; Girgus, Coren, & Agdern, 1972;

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Massaro & Anderson, 1971; Pressey, 1967, 1971; Restle & Merryman, 1968). Confusion of the test and the inducing elements seems to play a part in other configurations, such as the Mueller-Lyer illusion (Carr, 1935; Coren & Girgus, 1973b; Erlebacher & Sekuler, 1969).

Given the existence of evidence for both structural and processing sources of illusory distortion, the experimenter's task must be to assess the relative contribution of each of these to the total illusion effect. One tool that may be used to separate these components is illusion decrement, which is defined as the gradual reduction in the magnitude of an illusion under conditions of free inspection with a figure subtending a visual angle of at least 2 deg.

Since it was first observed in the Mueller-Lyer figure by Heymans in 1886, illusion decrement has shown itself to be remarkably general and easy to obtain. Decrement of the Mueller-Lyer illusion has been repeatedly demonstrated (Judd, 1902; Day, 1962; Dewar, 1967). Decrement has also been observed in many other illusion figures, including the Zoellner, Poggendorff, Wundt-Hering, and Oppel-Kundt illusions (Coren & Girgus, 1972; Coren & Hoenig, 1972).

It seems reasonable to assume that the decrease in illusion magnitude with inspection reflects changes in the cognitive processing components rather than in the structural components of the illusion for several reasons. To begin with, it seems unlikely that a few minutes of inspection of a pattern will affect the magnitude of optical aberrations. In addition, there is no evidence that the gain of lateral inhibition is affected by the free viewing of a stimulus for a few minutes.

Cognitive factors seem to be implicated directly by the fact that illusion decrement responds to traditional learning variables such as the spacing of trials (Dewar, 1968; Mountjoy, 1958) and may cumulate over days and weeks (Judd, 1902). Direct manipulation of factors which should affect structural interactions, such as the number of converging and intersecting line elements, does not alter the rate at which the illusion decreases with inspection (Girgus, Coren, & Horowitz, 1973). Even more convincing evidence for a cognitive basis of decrement comes from Coren and Girgus (1974), who have shown that transfer of illusion decrement from one configuration to another depends upon perceived similarity, rather than upon formal physical similarity or the presence of common stimulus elements. Taken together, all these findings seem to indicate that illusion decrement represents a reorganization of cognitive process components which leads to illusion reduction.

To the extent that illusion decrement represents a reduction in the information processing or cognitive components of an illusion, an interesting opportunity presents itself. Suppose we allow decrement to continue over an extended period of time. We would expect the illusion magnitude to stabilize eventually at some asymptotic level. This asymptote should represent the optical and neural contributions to that illusion which are presumably unaffected by the decrement process. Consider Figure 1A, which shows the Brentano form of the Mueller-Lyer illusion. Since this form of the illusion contains many converging and intersecting line elements, we might expect that a considerable proportion of this commonly observed distortion is due to neural and optical effects. Figure 1B is a dot form of the illusion patterned after Coren (1970). Since all converging and intersecting lines have been removed from this form of the illusion, we might expect that the distortion observed in this configuration would be relatively free of structural components. This implies that, after an extensive decrement procedure, the Brentano form (Figure 1A) should still show significant illusory effects, reflecting the structural components in this form of the illusion. On the other hand, the dot form should have little or no illusory effects remaining after an extensive decrement procedure, reflecting the lack of structural components in this form of the illusion. In addition, the percentage of initial illusion magnitude that is found in the decrement asymptote should provide some indication of the size of the contribution of structural factors to that illusion configuration.

## METHOD

**Subjects**

Twenty volunteers, between 20 and 30 years of age and with vision that was either normal or corrected to 20/20, were used as

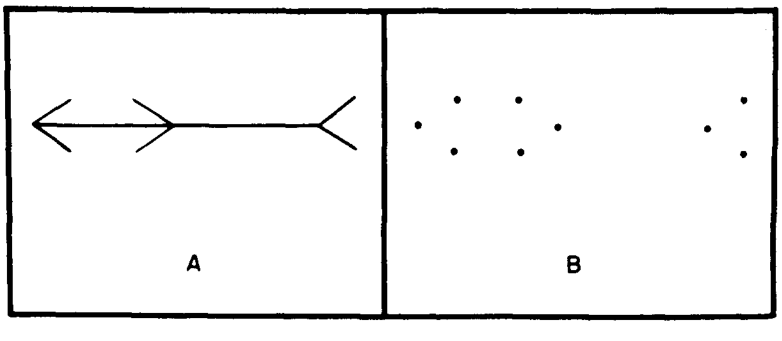


**Figure 1. (A) The Brentano form of the Mueller-Lyer illusion. (B) Coren's dot form of the Mueller-Lyer which minimizes the opportunity for structural interactions.**

subjects. Each was assigned to one of the two Mueller-Lyer variants.

**Stimuli and Apparatus**

The two illusion configurations shown in Figure 1 served as stimuli. Each was constructed using 1-mm black lines or dots. The reflectance of the lines was 5.1%; the reflectance of the background was 79.6%. For each configuration, the apparently longer half of the illusion was made adjustable through a tonge-and-groove arrangement. The length of the fixed shaft was 8 cm (which corresponded to a visual angle of 12 deg). The wings of the figure were 2 cm long and formed a 45-deg angle with the horizontal. Readings were taken directly from a scale affixed to the adjustable portion of the apparatus.

**Procedure**

The subject sat with his head immobilized in a head-and-chin rest and viewed his assigned stimulus. Subjects were instructed to set the two segments of the figure so that they appeared to be equal.

An exposure session consisted of 10 min of inspection of the illusion configuration, during which the observer was required to move his eyes from vertex to vertex across the figure. At 1-min intervals during this inspection period, the subject set the adjustable portion of the stimulus to apparent equality with the nonadjustable position. Between settings, the stimulus configuration was set at actual equality. Before each setting, the experimenter set the adjustable portion of the stimulus to a randomly assigned, variable starting point, such that this portion of the stimulus was either obviously too long or obviously too short. Obviously too long starting points were alternated with obviously too short starting points throughout the experiment for each subject. Each observer served for five inspection periods, one on each of 5 consecutive days.

## RESULTS AND DISCUSSION

Figure 2 presents the data from this experiment. Since the Brentano form of the illusion contains converging line elements which should maximize structural contributions to the distortion while the dot form of the illusion is totally devoid of such elements, it is not surprising to find a larger initial distortion for the Brentano form of the illusion (22.7%) than for the dot form (8.5%). This difference in initial illusion magnitude is highly significant ($t = 48.21$, $df = 18$, $p < .001$).

When we look at the data obtained during the first test day, it is clear that both illusion configurations show decrement with inspection. The decrease in illusion strength over time for both configurations is significant (Brentano form: $F = 6.24$, $df = 10/81$, $p < .01$; dot form: $F = 5.11$, $df = 10/81$, $p < .01$). Both configurations show approximately the same absolute reduction in illusion magnitude, each diminishing by approximately 5 mm. There is no significant difference in the absolute amount of illusion decrement for the two forms ($t = .44$, $df = 18$).

Now let us look at the first judgments on each of the 5 days of testing. As can be seen in Figure 2, there is a consistent reduction in the initial illusion magnitude which the subjects show in consecutive sessions. An analysis of variance on the first judgments for each session reveals a significantly decreasing linear trend for both the Brentano form ($F = 4.68$, $df = 1/36$, $p < .05$) and the dot form ($F = 4.51$, $df = 1/36$, $p < .05$) of the illusion.

While there is a clear day-to-day decrease in initial distortion for both figures, there seems to be no systematic change in the asymptotic levels reached over the course of 5 days of exposure. For each of the two configurations, each inspection session seems to end with about the same level of residual illusory distortion. Thus, if we analyze the last judgments for each of the five sessions, we find no significant trends for either the Brentano form ($F = .82$, $df = 1/36$) or the dot form ($F = 1.17$, $df = 1/36$).

As predicted, the asymptote for the Brentano form is much higher than the asymptote for the dot form ($t = 38.66$, $df = 18$, $p < .001$). After five exposure sessions, 35% of the initial illusion magnitude of the Brentano form has disappeared. The 65% of the initial illusion magnitude which remains is still significantly different from zero ($t = 72.84$, $df = 9$, $p < .001$). As suggested above, this residual distortion should reflect the contribution of structural factors to this form of the illusion. This hypothesis is supported by the fact that the dot form of the illusion, which lacks the converging line elements and hence the opportunity for structural interactions, shows a

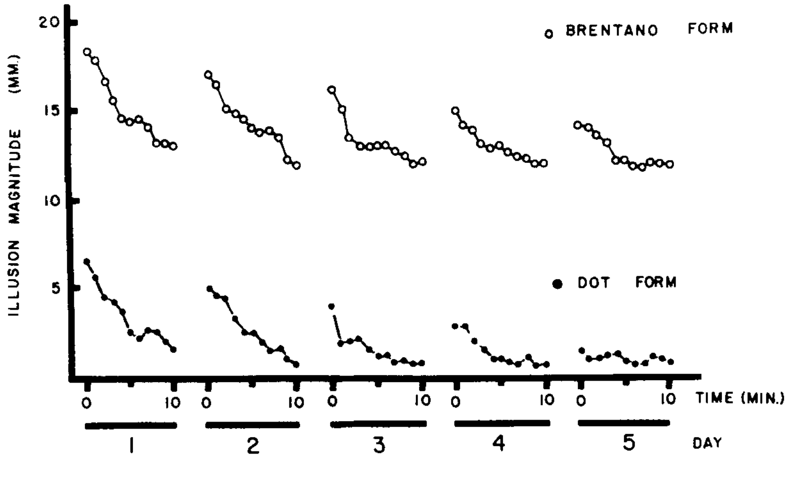


**Figure 2. Illusion magnitude in millimeters plotted as a function of time in seconds for the 5 days of exposure.**

residual distortion of only 12% after the fifth inspection session. This 12% residual illusion is not significantly different from zero ($t = 1.81$, $df = 9$). This result would seem to imply that there is little or no structural involvement in the dot form of the Mueller-Lyer illusion.

It should be noted that there are two structural mechanisms that have been suggested to account for illusion decrement. There are cortical satiation effects (Köhler & Fishback, 1950) and the adaptation of specific feature analyzers (Coltheart, 1971). However, it is difficult to understand why either of these mechanisms would lead to the steady decrease in initial illusion magnitude from one day to the next in the Brentano form or indeed to any systematic decrease in illusion magnitude in the dot form.

There are both theoretical and methodological implications which emerge from these data. Theoretically, these findings seem to support the contention that illusion decrement represents a reorganization of the information processing strategies which an observer utilizes. It seems clear that illusion decrement primarily affects the process components of illusion formation. Thus, methodologically, the decrement technique can be viewed as an important tool that can be used to separate the structural from the process components in any given illusion configuration.

The actual nature of the cognitive reorganization involved in illusion decrement is not yet well understood. However, data has been accruing which seems to indicate that active exploration via eye movements plays a role. Thus, Coren and Hoenig (1972), Day (1962), and Festinger, White, and Allyn (1968) all report little or no decrement when a figure is steadily fixated as opposed to large decrement in illusion magnitude for free scanning conditions. The source of the information for the cognitive restructuring seems to come from erroneous eye movements. Festinger, White, and Allyn (1968), Judd (1905), and Stratton (1906) have all shown that the eye movements tend to be erroneously long over the apparently long segment of the figure and erroneously short over the apparently short segment. Each eye movement is usually accompanied by a corrective flick which brings the fovea back to the vertex. The nature of the correction necessary to recenter the eye should provide the observer with information as to the magnitude and direction of the distortion, which could be used in the recomputation of the percept toward veridicality. Such an analysis is rendered more likely by the fact that when illusion configurations are too small to permit effective scanning (i.e., less than 2 deg) little or no decrement is found even with prolonged viewing (Hoenig, 1971; Pollack & Chaplin, 1964). Such an analysis of the source of information utilized in decrement makes it likely that the cognitive factors involved in the destruction of the illusion are potentially quite different from the cognitive factors involved in the initial illusion formation.

There may, of course, be some relatively immutable process components that remain unaffected by the decrement procedure. These may be present, along with structural factors, in the 65% of the initial illusion that is found in the asymptote for the Brentano form. Other techniques will be needed to separate such factors from purely structural factors. Nonetheless, the data from this experiment clearly show that approximately 35% of the Brentano form and virtually all of the dot form of the Mueller-Lyer illusion can be ascribed to information processing mechanisms of illusion formation.

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