Aftereffect of visual movement: Storage in the absence of a patterned surround

E. R. STRELOW* and R. H. DAY
Monash University, Clayton, Victoria 3168, Australia

Storage of the visual movement aftereffect is shown to occur if, after movement, the stationary target remains clearly visible in a surround that is dark and featureless. This finding is considered in terms of the earlier observation that the movement aftereffect is reduced or eliminated when the target surround is featureless. It is noted that current hypotheses in terms of direction-specific units cannot easily explain the storage of the movement aftereffect.

It was shown earlier (Day & Strelow, 1971) that the visual movement aftereffect (MAE), the apparent movement of a stationary pattern in the opposite direction to preceding real movement, is either eliminated or markedly reduced in the absence of a patterned surround. This reduction occurs when the surround is completely dark and also when it is visible but plain and featureless. The MAE reduction is large and consistent, following linear movement of bars, but less marked with rotary movement of a sectorized disk. The greatest reduction of MAE occurs when the surround is dark or featureless during both the inducing (target moving) and test (target stationary) phase, but significant reduction occurs with a dark or featureless surround during only one of these phases. It is emphasized that reduction occurs when the moving or stationary target is clearly visible throughout the inducing and test phases of a trial.

The MAE has been attributed to adaptation of one group of direction-specific units following their prolonged stimulation, so that when the target stops moving, the difference in activity levels between two groups of units is in the direction associated with opposed movement (Barlow & Hill, 1963; Sekuler & Pantle, 1967; Sutherland, 1961). This has been called the direction-of-difference explanation and has been invoked in accounting for numerous sensory aftereffects (Day & Singer, 1969). With the modification that the direction-sensitive units respond and adapt to a moving pattern in the presence of an adjacent stationary pattern (i.e., to relative movement), this explanation could account for the reduced MAE when the surround is dark during the inducing phase but patterned during the test phase. However,

it is more difficult to account for the substantial reduction obtained for the MAE when the surround is dark or featureless only during the test phase, since the direction-sensitive units would presumably adapt fully during the inducing phase.

Two possible explanations of MAE reduction with a featureless surround during the test phase can be considered. First, it is conceivable that in the absence of a patterned surround, the threshold for the detection of real and apparent movement is higher. The aftereffect, normally a very slow apparent movement, is simply not detected and reported. Evidence for this explanation is provided by Brown's (1931) finding that the threshold for movement detection increases with surround homogeneity.¹ Second, it is possible that the MAE is inhibited and the adapted state of the units prolonged. Spiegel (1962, 1965) noted that this type of inhibition (which he called storage) occurred when S was in darkness, immediately after the inducing period. He found that the MAE, which normally dissipates after about 10 sec, was still quite strong when the room was illuminated again.

In the experiment described here, storage of the MAE has been investigated in the absence of a patterned surround but with the moving and stationary target clearly visible and fixated throughout. To anticipate the outcome, it was shown that the aftereffect was considerably reduced during a 10-sec test phase with a dark surround but occurred at almost full strength when the patterned surround was reintroduced.

METHOD

Apparatus

The target was a pattern of vertical black and white bars, 1.9 cm wide, each subtending a visual angle (VA) of .75 deg in a 6-cm circular aperture (3 deg VA),

viewed from a distance of 152 cm. The bars moved from left to right at a velocity of 2.25 deg VA/sec (inducing phase) or were stationary (test phase). A central fixation point was marked on clear plastic which covered the aperture. A circular cardboard surround, 65.5 cm in diam (25 deg VA), with a central 6-cm aperture which coincided with the circular target, was marked with 1.9-cm (3 deg VA) vertical black and white bars. The surround was illuminated by incandescent sources mounted behind S, so that the luminance of the light bars was 3.48 fL. The target was illuminated from behind, so that the light bars were 3.48 fL when the incandescent lamps were on and 2.13 fL when the lamps were off to darken the surround. This change in target luminance due to ambient light was insufficient to affect the MAE substantially (Collins, 1965). The walls behind the surround and the table on which it was mounted were black. It is emphasized that the moving or stationary target was entirely clear and visible throughout, and that when the incandescent lamps were off, the target alone was visible in the otherwise dark room.

To record and measure the MAE, S was required to move a carriage laterally by hand at the same apparent speed as the MAE. A pen mounted on the carriage left a trace on a chart moving at right angles to the direction of the carriage. The apparent velocity of the MAE could be obtained by measuring the slope of the trace at intervals after the cessation of real movement. The tracking and recording equipment were on S's right and out of his field of view.

Subjects

There were 12 volunteer Ss paid at the rate of \$1.00 per hour for their services.

Procedure

One practice observation of the MAE was followed by two practice trials in which S tracked the MAE. After a 10-min rest each S observed under two conditions with a 3-min rest between and with the order of presentation counterbalanced across Ss. In the first condition (PP) the patterned surround was visible during both the 90-sec inducing phase and the 20-sec test phase. In the second condition (PDP) the inducing phase was the same as for PP, but the 20-sec test phase consisted of a 10-sec period with a dark and featureless surround, followed by 10 sec in which the surround pattern was visible. During the period with dark surround only the stationary target was visible. Throughout both phases S was instructed to fixate the center of the target and a warning to prepare to track the aftereffect was given a

*Requests for reprints should be sent to E. Strelow, Department of Psychology, Monash University, Clayton, Victoria 3168, Australia.

Fig. 1. Apparent velocity of stationary bars during 20 sec with patterned surround (PP) and during 10 sec with dark surround followed by 10 sec with patterned surround (PDP). In the latter condition the patterned surround was introduced at the point indicated by the arrow.

few seconds before the end of the 90-sec inducing period.

RESULTS

The MAEs for the two conditions are shown in Fig. 1 as mean apparent velocity plotted at 2-sec intervals during the 20-sec test phase. In Condition PP there was a greater initial apparent velocity than for PDP, followed by a steady decline. As expected from previous data (Day & Strelow, 1970), the apparent velocity of the MAE during the period with dark surround in PDP was less than for the same 10 sec of PP with patterned surround. However, with the reintroduction of the pattern in PDP, apparent velocity, which had virtually reached zero, increased dramatically, and at the end of the 20-sec period the MAE velocity for PDP was greater than for PP. An analysis of variance of apparent velocities at the end of the test phase for the two conditions showed the difference to be significant, $F(1,11) = 4.88$, $p < .05$. The total apparent movement distance tracked for the two conditions was 42.8 mm for PP and 37.2 mm for PDP. This difference did not achieve significance, $F(1,11) = 1.11$, $p > .05$.

DISCUSSION

The data shown in Fig. 1 indicate that

when the surround to the stationary target is dark and featureless, the MAE is "stored" and is "released" from storage when a visible pattern is introduced in the surround.

Both Spigel (1962) and Honig (1969) have reported storage effects but under different conditions to those used in the present investigation. Spigel noted that storage occurred when the total visual field was dark or patternless for a period following induction, and Honig observed that storage occurs when the target present during the test phase is different from that fixated during the inducing phase. The novel aspect of the results reported here is that the same target is clearly visible throughout, and only the surround is dark and featureless during part of the test phase.

It is clear that the reduced MAE resulting from absence of a patterned surround during the test phase with the target pattern stationary does not represent failure or elimination of the processes associated with the aftereffect, but their suppression and storage. It is as if the system, while primed by prior induction, cannot be triggered until a stationary background pattern is introduced. It is also clear that the explanation of the MAE in terms of direction-specific units as

described above is not directly or easily applicable to these data. According to the direction-of-difference explanation, the MAE is the result of fatigue or adaptation of specific neural units. Recovery from adaptation should occur equally well in the presence or absence of surround pattern stimulation, yet the present experiment shows that this is not the case. It becomes necessary either to add another postulate to the direction-of-difference hypothesis to account for "storage" or to attempt a new model of the MAE which can account for these findings.

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NOTE

1. While further experiments are necessary to reach a firm conclusion, the data so far do not indicate that the velocity of real movement with a dark featureless surround is markedly different from that with a visible patterned surround. To date, we have been unable to replicate Brown's findings. We have not found a reduction in the velocity of real movement in the absence of patterned surround.

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