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Duration, time constant, and decay of the linear motion aftereffect as a function of inspection duration

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Subjects rated the strength of the motion aftereffect (MAE) produced by the upward motion of a horizontal grating in two experiments. Inspection periods ranged from 30 to 900 sec in Experiment 1 and from 20 to 120 sec in Experiment 2. A minimum of 22 h elapsed between trials. The decay time constant increased as the square root of the inspection duration for values between 1 min and 15 min of inspection. The ratings suggested that the MAEs consisted of three phases: an initial maximum-strength phase, a decay phase, and a tail. The duration of all three phases increased and the decay rate decreased with increasing inspection duration over the entire range. The results indicate that duration, time constant, and decay rate are not fixed properties of the motion-processing channels in the visual system.

Early studies of the motion aftereffect (MAE) found that the duration and time constant increased as inspection duration increased up to 5 min (Bakan & Mizusawa, 1963; Eysenck & Holland, 1960; Holland & Eysenck, 1960; Taylor, 1963), whereas more recent studies found no increase in duration after about 30-60 sec of inspection (Bonnet, 1973; Lehmkuhle & Fox, 1975). The latter description has received support from Sekuler (1975), who found that the elevation of direction-specific motion detection thresholds increased with increasing inspection duration up to about 100 sec of adaptation, whereas inspection durations of 35-45 min yielded threshold values nearly identical to those for 100 sec of adaptation.

The more recent literature may be questioned for two reasons. First, a number of studies suggest that direction-specific motion thresholds and MAEs may have different temporal properties. For example, Rose and Evans (1983) found that saturation of contrast adaptation did not occur for a horizontal grating viewed for up to 20 min, and Magnussen and Greenlee (1985) found that saturation of contrast threshold stabilized only after approximately 30-60 min of adaptation. They also found that the recovery of the threshold elevation aftereffect followed a power function, not an exponential function as does the MAE (Keck & Pentz, 1977; Taylor, 1963). In addition, Sekuler (1975) reported that recovery from protracted exposures required extra time, an observation that suggests longer time constants. Second, Hershenson (1988) reported preliminary quantitative results that suggested that the duration and time constant increased linearly and MAE strength declined less rapidly with increasing inspection durations between 30 sec and 15 min.

The importance of this issue goes beyond the description of properties of the MAE. Durations and time constants have been used for comparisons among MAEs produced by different kinds of stimulus patterns, and subsequently for inferring the existence of processing channels in the visual system that are specifically sensitive to components of these patterns (e.g., Beverley & Regan, 1979; Cavanagh & Favreau, 1980; Regan & Beverley, 1978). If the duration and time constant vary with inspection duration, comparisons could not be made without taking inspection duration into account.

In the present experiments, the properties of the MAE are described as a function of inspection duration for durations up to 15 min. The MAEs studied were produced by the upward rectilinear motion of a horizontal grating. MAEs were described by subjects as the perceived downward rectilinear motion of the stationary grating. This MAE is called the *linear* MAE to distinguish it from rotation, size-change, and motion-in-depth MAEs (Beverley & Regan, 1979; Regan, 1986; Regan & Beverley, 1978, 1985). Experiment 1 sampled the range between 30 and 900 sec, and Experiment 2 sampled values between 20 and 120 sec, the region in which the MAE has been reported to reach "saturation."

EXPERIMENT 1

Method

Stimulus. The stimulus was a horizontal square-wave grating of alternating black (India ink) and white bars on a continuous paper loop. The bars and spaces subtended approximately 0.2° of visual angle (spatial frequency approximately 2.5 cycles per degree). The grating moved upward at a rate of 6 Hz (velocity = 2.4° per sec), and was visible within a square aperture that measured approximately 4.5° of visual angle on a side. The stimulus field was illu-

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minated by overhead fluorescent lights, and a projector lamp focused on the surface of the stimulus. The illumination falling on the stimulus was approximately 1.4 lx.

Procedure. There were six inspection durations: 30, 60, 180, 300, 600, and 900 sec. Only one test was performed on a given day, allowing a minimum of 22 h to elapse between tests. A series consisted of tests using all inspection durations once. Within series, the order of inspection duration was selected randomly. Each subject participated in four series.

The subjects were instructed to fixate the center of the aperture monocularly with the right eye. There was no fixation point, but the experienced subjects had no difficulty maintaining fixation near the center because the frame provided an anchor. The subjects were informed of the passage of inspection time at the 10-, 5-, 2-, and 1-min marks and at 30 and 15 sec. When 10 sec remained in the inspection period, the experimenter marked each remaining second. When the motion of the grating stopped at the end of the inspection period, the subjects maintained fixation at the center of the grating. They rated the strength of the MAE continuously using an 11-point scale on which 10 represented the *strength of perceived motion of the MAE immediately upon cessation of the motion of the inspection stimulus*, and 0 represented *no perceptible motion*.[1] Note that 10 described the initial perceived strength of motion of the MAE. Consequently, the scale did not index absolute strength. The subjects stopped rating the MAE strength when they rated it 0 on two consecutive vocalizations.

Subjects. The subjects were 3 undergraduate students. They practiced using the rating scale on rotation MAEs in two 1-h sessions.

Results and Discussion

Analyses. The protocol from each trial was a continuous record of the vocalized rated strength of the MAE as a function of time. A typical protocol produced by the short inspection durations began with the MAE strength's being rated 10 immediately upon cessation of stimulus motion, continued with a succession of decreasing strength ratings, and concluded with a single 1 rating. The protocols for the longer inspection durations differed in the initial and final phases: they began with a series of 10 ratings and concluded with a series of 1 ratings.

The protocols were sampled every 5 sec. There were four direct measures: total duration of the MAE, duration of the first phase, duration of the decay phase, and duration of the tail—and one indirect measure—decay time constant. The first phase was the maximum-strength phase, the portion of the protocol during which the strength of the MAE was rated 10. The decay phase was the portion of the protocol between the last 10 rating and the first 1 rating, inclusive. The tail was the portion of the protocol during which the strength of the MAE was rated 1.

The decay time constant is the time it takes for the strength of the MAE to drop to $1/e$ of its original value. Because the protocols contained three distinct phases on many trials, time constants were calculated using the decay portion of the protocol and then corrected for the shift in origin. The function relating MAE strength to *time after onset of the decay phase* has the following form:

$$S_d = S_{max}\exp(-t_d/\tau_d),$$

where S_d is the strength of the MAE at time t_d measured from the onset of the decay phase, S_{max} is the maximum strength of the MAE (the initial strength of the MAE on a given trial and also the strength of the initial phase), and τ_d is the time constant that is an index of the decay rate during *the decay phase only*. The subscript indicates that these values apply only to the decay phase. The time constant for any given value of inspection duration must be corrected for the duration of the maximum-strength phase:

$$\tau_I = \tau_d + D_{max},$$

where τ_I is the time constant for inspection duration I, τ_d is the time constant for the decay phase, and D_{max} is the duration of the maximum-strength phase.

For each trial, least-squares lines were fit to the logarithm of the strength ratings as a function of time during the decay phase. These lines were excellent fits, accounting, on average, for 90% ±5% of the variance. Time constants were calculated from these lines. Intercepts were not analyzed because the method called for MAE strength to be rated 10 at $t = 0$ for all trials.

Analyses of variance were computed separately on log transforms of total duration, duration of decay phase, and time constants. Duration of the maximum-strength phase and duration of the tail were not subjected to analyses of variance because there were too many empty cells. Although the subjects differed markedly in performance [$F(2,9) = 194.12$, 195.92, and 97.63, for total duration, duration of decay, and time constant, respectively; all ps $< .001$], none of the interactions was significant [$F(10,45) = 2.42$, 3.47, and < 1, respectively]. Therefore, geometric means were used in the figures and tables.

Total duration. The duration of the linear MAE increased as a function of inspection duration. The linear trend contrast [$F(1,45) = 317.48, p < .001$] accounted for 89% of the variance due to inspection duration. The relationship usually produces a straight line on log-log axes, indicating a power function (Keck & Pentz, 1977; Sekuler, 1975; Taylor, 1963).

Figure 1 is a log-log plot of the total duration and time constant of the linear MAE as a function of inspection duration. The function relating MAE duration to inspection duration has the form

$$D_L = kI^x,$$

where D_L is the total duration of the linear MAE, I is the inspection duration, and x is the exponent of the power function. In the log-log plot, a slope of 0.5 would indicate that MAE duration varied as the square root of the inspection duration. A comparison line with such a slope is included in the figure. The slope of the line fit to all points was 0.39. However, the rate of increase in the duration of the MAE for inspection durations below 180 sec of inspection appears to be different from that for inspection durations above 180 sec of inspection. The exponent was 0.49 for inspection durations of 180 sec and above, and 0.33 for inspection durations of 180 sec and below, with all points approximately 0.4 log units above the comparison line. Thus, the square root relationship was ap-

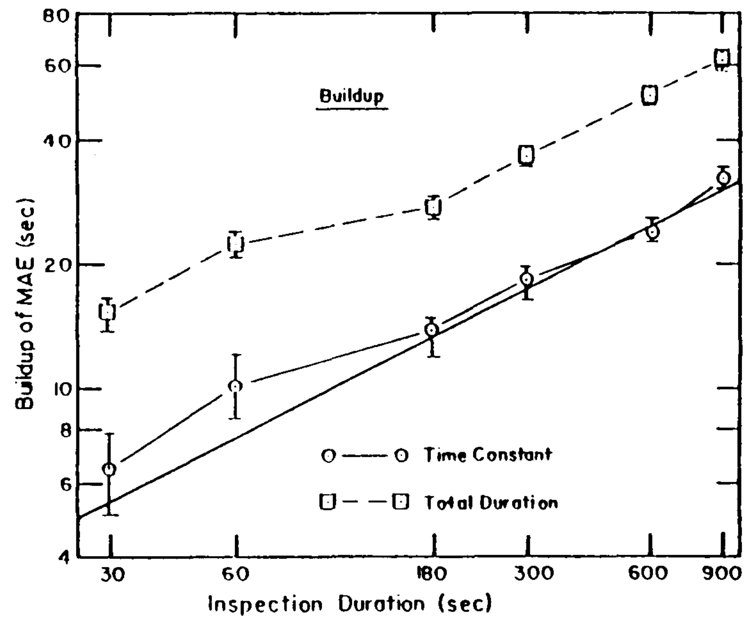

Figure 1. Total duration of the motion aftereffect (MAE) and decay time constant (in sec) as a function of inspection duration for durations between 30 and 900 sec. The comparison line has a slope of 0.5 on the log-log plot—the square root relationship. Vertical lines indicate ±1 standard deviation on the same scale.

proximated for inspection durations of 180 sec (3 min) and above, up to 900 sec (15 min).

Maximum-strength phase. The subjects continued to rate the MAE 10 for a period of time before they rated it 9, and the period of time appeared to be a function of inspection duration. That portion of the protocol during which the strength of the MAE was rated 10 was called the maximum-strength phase. Table 1 shows the number of times the strength of the MAE was rated 10 for 5 sec after cessation of stimulus motion. The number of 10 ratings increased with increasing inspection duration. In addition, Subject G.K. rated MAE strength 10 three times 10 sec after cessation of stimulus motion, and once a full 15 sec after the stimulus had stopped. Subject L.T. rated the strength 10 once 10 sec after cessation of stimulus motion. It should be noted that these data reflect responses of the subjects. Whether the MAE actually has an initial full strength plateau is important but cannot be determined by these procedures.

Duration of decay phase and time constant. The decay of the MAE is generally indexed by the decrease in strength with increasing time after cessation of stimulus motion. The relationship usually produces a straight line on semilog axes, indicating an exponential function (Keck & Pentz, 1977; Sekuler, 1975; Taylor, 1963). Because the MAE did not begin to decay immediately, the decay phase was defined as that portion of the protocol between the last 10 rating and the first 1 rating, inclusive. It should be clear, then, that the exponential decay function reported for MAEs actually applies only to the decay phase.

Table 1
Number of 10 Ratings 5 Seconds After Cessation of Stimulus Motion at Each Inspection Duration

	Inspection Duration (sec)					
Subject	30	60	180	300	600	900
G.K.	0	1	2	3	3	4
L.T.	0	0	1	1	3	4
P.B.	0	0	0	0	0	1

Figure 2 shows the decay of the linear MAE as a function of inspection duration for durations between 30 and 900 sec. It contains a semilog plot of the least-squares lines fit to all strength ratings at a given inspection duration. The proportion of variance accounted for by each line is given in parentheses. The lines are positioned on the time axis to illustrate the relative average size of the maximum-strength phase for each inspection duration. For example, the MAE produced by the longest inspection duration (900 sec) had the longest delay along the line for the 10 rating (top of figure) before beginning to decline. Data points are included for the 900-sec adaptation duration. Clearly, the durations of the initial and decay phases increased and the rate of decay decreased with increasing inspection duration.

The duration of the decay phase and the decay time constant increased with increasing inspection duration. The linear trend contrasts [$F(1,45) = 392.46$ and 57.59, $p < .001$] accounted for 98% and 97% of the variance due to inspection duration, respectively. Figure 1 shows the time constant for each inspection duration on log-log

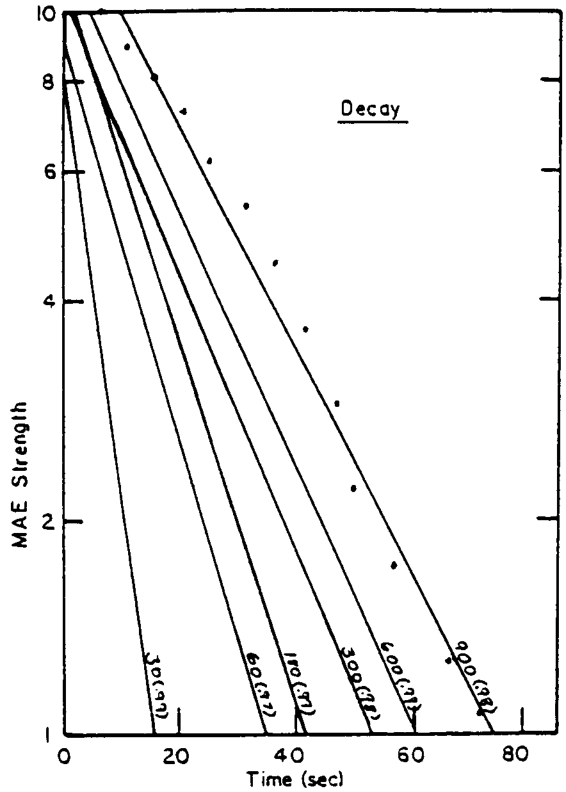

Figure 2. Decay of the linear motion aftereffect (MAE) as a function of inspection duration for durations between 30 and 900 sec. Data points are included for the 900-sec adaptation duration. Each line represents the drop-off in mean rated strength of the MAE over time (in sec) after cessation of stimulus motion. The proportion of variance accounted for by each line is given in parentheses. The positions of the lines represent an accurate picture of the relative temporal positions and rates of decay.

axes. The lines connecting the points are almost exactly parallel to those for total duration. The power function relating the time constant to inspection duration had the general form described above for the function relating MAE duration to inspection duration. For values at 180 sec of inspection duration and above, the exponent was 0.52. These points almost coincide with the comparison line. For the values at 180 sec and below, the exponent was 0.41. Thus, for inspection durations of 180 sec and above, the time constant approximated the square root of inspection duration. Taylor (1963) reported that the time constants for MAEs produced by inspections shorter than 80 sec differed from the square root relationship, whereas those produced by 80 and 320 sec of inspection followed the square root relationship. The present data extend the upper end of this relationship to 900 sec (15 min) of inspection. The lower end is investigated in Experiment 2.

Duration of tail. Only one subject ended all ratings with a single rating of 1. For the other subjects, the number of 1 ratings increased with increasing inspection duration. Both rated the MAE strength 1 only once after short inspection durations (180 sec and less). For longer inspection durations, Subject G.K. rated the strength 1 an average of 1.5, 2.5, and 2.75 times, and Subject L.T. rated it 1 an average of 2, 2.25, and 3 times after 300, 600, and 900 sec of inspection, respectively.

EXPERIMENT 2

The duration of the MAE and the time constant increased as the square root of the inspection duration for inspection periods over 180 sec in duration in Experiment 1. Taylor (1963) reported this rate for the line connecting the points at 80 and 320 sec of inspection, but did not test the values between them. Experiment 2 assessed the properties of the linear MAE for inspection durations between 20 and 120 sec.

Method

Stimulus and Procedure. The stimulus was the same as in Experiment 1. The procedure was the same except that inspection durations were 20, 40, 60, 80, 100, and 120 sec. Responses were recorded on tape along with clicks from a metronome set for 1-sec intervals. Calculations were based on 1-sec time samples using the ratings that coincided with the clicks on the tape. Each subject participated in three series.

Subjects. There were 5 subjects. Two (M.H. and P.B.) had previously participated in an experiment using the rating scale. The others practiced using the rating scale on rotation MAEs in two 1-h sessions.

Results and Discussion

Qualitatively the protocols were similar to those obtained in Experiment 1 for short inspection durations. The lines fit to the logarithm of the strength ratings as a function of time were excellent fits, accounting for 91% ±5% of the variance on average. Analyses of variance were computed separately on log transforms of the total duration, duration of the decay phase, time constants, and duration of the tail. The subjects differed markedly in their performance on duration of decay phase, time constants, and duration of the tail [$F(4,10) = 11.07$, 6.87, and 11.62, respectively; all $ps < .01$], but not for overall duration [$F(4,10) = 1.90$, $p > .05$]. None of the interactions was significant [$F(20,50) = 2.03$, 2.00, 1.80, and 2.03 for total duration, duration of decay phase, time constant, and duration of the tail, respectively]. Therefore, geometric means appear in the figures.

Total duration. The duration of the MAE increased as a function of inspection duration. The linear trend contrast [$F(1,50) = 137.35, p < .001$] accounted for 99% of the variance due to inspection duration. Figure 3 is a log-log plot of the total duration, time constant, and duration of the tail of the linear MAE as a function of inspection duration. A comparison line with a slope of 0.5 is included. To retain the clarity of the figure, the standard deviations were not included. They averaged 1.4 ±0.1, 1.5 ±0.1, and 2.0 ±0.2 for total duration, time constant, and duration of tail, respectively.

The figure also contains a plot of the MAE durations reported by Lehmkuhle and Fox (1975), who measured the velocity and duration of the MAE by having subjects

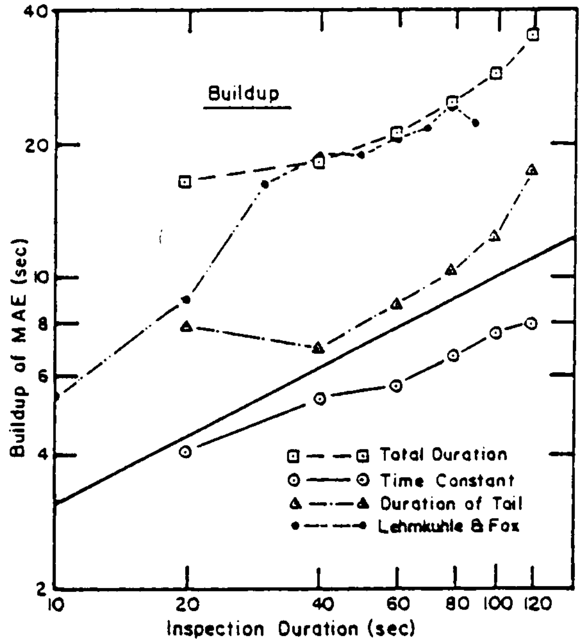

Figure 3. Total duration of the motion aftereffect (MAE), decay time constant, and duration of the tail (in sec) as a function of inspection duration for durations between 20 and 120 sec. The comparison line has a slope of 0.5 on the log-log plot—the square root relationship. The MAE durations measured by Lehmkuhle and Fox (1975) are plotted on the same axes.

move a throttle-like switch connected to a strip chart recorder. The values were estimated from an enlargement of the published graph for each subject. Geometric means computed from these estimates are shown in the figure. Clearly, the data of Lehmkuhle and Fox correspond to the present findings for inspection durations between 30 and 80 sec (possibly also 90 sec). This remarkable correspondence produced by experiments using very different measurement techniques supports the contention that, at least for these inspection durations, the experiments were measuring the same MAE properties. The meaning of the discrepant points at the short inspection durations is not clear.

Maximum-strength phase. The protocols in this experiment were similar to those in Experiment 1 except for the length of the maximum-strength phase. This phase lasted for 1 sec in only 31 of the 90 trials and never for 2 sec. One might be tempted to attribute these results to experimental error, suggesting that they represent a slight periodic delay in the subject's initiation of a 9 response. There is one important finding that militates against this interpretation, however. The number of 10 ratings increased with inspection duration: 3, 3, 5, 5, 8, and 7 for the six inspection durations, respectively.

Duration of decay phase and time constant. The duration of the decay phase and the decay time constant increased with increasing inspection duration. The linear trend contrasts [$F(1,50)$ = 71.18 and 60.60, $p < .001$] accounted for 95% and 96% of the variance due to inspection duration, respectively. Figure 3 shows the time constants for each inspection duration plotted on log-log axes. The line fit to the points for 60 sec and above had a slope of 0.48 and was about 0.1 log unit below the comparison line. The line fit to the points for 60 sec and below had a slope of 0.32. Thus, the time constant approximated the square root of inspection duration for inspection periods of 60 sec (1 min) or longer.

Figure 4 shows the decay of the linear MAE as a function of inspection duration for durations between 20 and 120 sec. It is a semilog plot of the least-squares lines fit to all strength ratings at a given inspection duration. The lines are positioned on the time axis to illustrate the relative average size of the maximum-strength phase for each inspection duration. The proportion of variance accounted for by each line is given in parentheses. Clearly, the durations of the initial and decay phases increased and the rate of decay decreased with increasing inspection duration.

Duration of tail. The duration of the tail increased with increasing inspection duration. The linear trend contrast

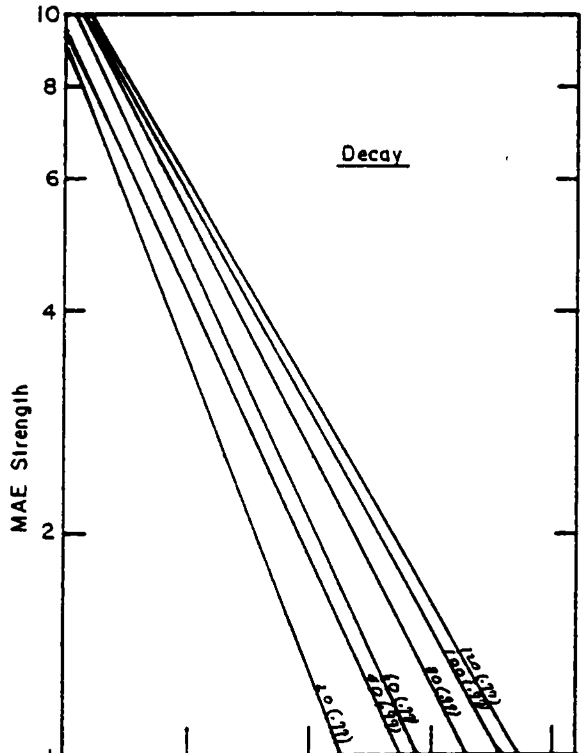

Figure 4. Decay of the linear motion aftereffect (MAE) as a function of inspection duration for durations between 20 and 120 sec. Each line represents the drop-off in mean strength of the MAE over time (in sec) after cessation of stimulus motion. The proportion of variance accounted for by each line is given in parentheses. The positions of the lines represent an accurate picture of the relative temporal positions and rates of decay.

[$F(1,50) = 80.14, p < .001$] accounted for 91% of the variance due to inspection duration. Figure 3 shows the mean tail durations for each inspection duration. The values between 40 and 100 sec of inspection, inclusive, approximate the square root relationship. The line fit to these points has a slope of 0.61.

The values for the two endpoints were not consistent with the others. Whether they represent response or measurement error is not clear. Nevertheless, they illustrate one of the possible pitfalls in using total duration as a measure of MAE strength: overall duration may be distorted by abnormal tail durations. It is advisable, therefore, to use the time constant as a representation of the properties of the MAE.

GENERAL DISCUSSION

The most important finding is that the duration, time constant, and decay rate are not fixed properties of the motion-processing channels in the visual system. They are dependent upon inspection duration for durations at least up to 15 min. The increase in duration and decay time constant with inspection duration was described by a power function, and the decay was described by an exponential function, as in previous studies of the MAE (Beverley & Regan, 1979; Bonnet, 1973; Keck & Pentz, 1977; Taylor, 1963). The ratings suggested that the linear MAE consisted of three phases: an initial maximum-strength phase, a decay phase, and a tail. The duration of each of the phases increased with increasing inspection duration. For inspection durations above 60 sec, the time constant increased approximately as the square root of the inspection duration. This relationship held up to 900 sec (15 min) of adaptation.

Can the results of these two experiments be attributed to methodological artifact or to response bias? Although the possibility can never be ruled out with certainty, it seems unlikely for a number of reasons. First, at least 22 h elapsed between trials. If biasing factors were operating, they would have to carry over trials that were spaced very far apart, yet would have to be precise enough to generate the specific relationships found. Second, subjects were aware of the range of inspection durations used and possibly "expected" to observe longer lasting MAEs following longer inspection periods. However, it is unlikely that this kind of "expectancy" could have produced the precise results described above because the order of inspection duration was randomized within series, three series were presented, and only one inspection duration was tested on a single day.

Third, it is possible that the report of a maximum-strength initial phase was an artifact of the rating scale: it may have forced an artificial limit on the sensitivity of the subject at the extremes. Consequently, they may not have noticed the slight decrease in strength that occurred immediately upon cessation of the motion of the stimulus. This explanation also seems unlikely because the subjects were calling out numbers immediately, and continued to do so. There was no absolute initial decrement that had to be reached before saying 9 and it is unlikely that they anticipated a future perception in their momentary rating of the strength of the MAE. Subjects were completely free to respond as soon as the slightest decrement was noticed, and it seems reasonable to assume that they did so.

Finally, there is the clear demonstration that the procedure used in these experiments produced durations and time constants that are comparable to those of Taylor (1963) and Lehmkuhle and Fox (1975), who used very different procedures. Taken together, these arguments support the conclusion that the data represent accurate pictures of the time course of the linear MAE. How can the description of the MAE reported here be reconciled with studies that describe a saturation point located between 30 and 100 sec of inspection? It is possible that the earlier experiments were identifying the region in which the rate of buildup decreased rather than a point where the MAEs reached saturation.

It is interesting to note that Taylor (1963) found the square root relationship between inspection duration and time constant using a rotating stimulus, a rotating disk marked with an irregular pattern. The similarity between his findings and the outcomes of these experiments can be interpreted in two ways. It could mean that the rotation MAE and the linear MAE are mediated by the same underlying mechanisms (channels). If this is true, the evidence raises questions about the existence of a separate channel for "rotation" (Cavanagh & Favreau, 1980; Regan & Beverley, 1985). An alternative explanation is that the linear and rotation MAEs are mediated by different mechanisms (channels) but that the two mechanisms manifest the same slope in the relationship between their respective time constants and inspection durations. The difference between them might be made manifest in other parameters.

Of the many hypotheses that could be offered to account for the complex findings, one is explored here because it has an empirical foundation based in the MAE. If Regan and Beverley (Beverley & Regan, 1979; Regan, 1986; Regan & Beverley, 1978, 1985) are correct, the visual system is composed of complex input channels that are arranged in a hierarchical structure. The lowest level of structure in the hierarchy is the motion detector, the structure whose activity presumably gives rise to the linear MAE. In Regan and Beverley's conception, the output of motion detectors feeds into higher levels to produce activity that signals the presence of such stimuli as size change or rotation. The output of size-change detectors is fed, in turn, to a higher level whose activity signals the presence of motion-in-depth.

In the context of this picture of the visual system, stimulation by a moving grating activates a set of motion detectors that are sensitive to the specific direction of motion. This activity stimulates, in turn, the components of the higher level units to which these particular units are connected. The buildup of the MAE that was observed for inspection durations up to 60 sec could represent the buildup to saturation of the MAE activity associated with the initial subset of responding motion detectors. Longer inspection durations could produce no additional activity in the lower level structures, but could activate components of structures at higher levels (e.g., one side of a size-change detector). Consequently, the afteractivity that results in MAEs produced by inspection durations greater than 60 sec would be the result of the afteractivity in the motion detectors plus the afteractivity in the components of higher structures.

This interpretation leads to the interesting prediction that the contribution from the higher level structures should be detectable in the aftereffect if the appropriate test stimulus is provided. Beverley and Regan (1979) reported just such an observation. They found that ramping antiphase stimulation by the vertical sides of a square produced a size-change MAE and that, after the size-change MAE had decayed, a motion-in-depth MAE was observed. If a similar outcome were projected for the moving grating fixated for longer than 60 sec, one would expect to experience a higher level MAE, perhaps a size-change or rotation MAE, given the appropriate test stimulus.

Clearly, it is not possible to generalize from measurements using a single grating at a single luminance level. Nevertheless, if the data provide an accurate description of the effect of inspection duration on the duration, time constant, and decay of the linear MAE, one can ask what they imply about our conception of the mechanisms that produce the MAE. First, one could safely say that the mechanisms are more complex than has been proposed because it usually has been assumed that recovery begins immediately (Barlow & Hill, 1963; Keck & Pentz, 1977; Sekuler, 1975; Sekuler & Pantle, 1967; Sutherland, 1961). Moreover, it is frequently assumed that the duration and time constant are independent of inspection duration and can be used to characterize the underlying structures that mediate the MAE (e.g., Cavanagh & Favreau, 1980; Regan & Beverley, 1978). The data reported here suggest that this assumption requires reevaluation.

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NOTE

1. There are two reasons why matching or nulling were not used in this experiment. First, the strength of the MAE declines rapidly. Even the relatively short time it takes to make an adjustment can correspond to a large loss in MAE strength. To avoid this problem, a magnitude estimation procedure was used whereby subjects rated the strength of the MAE by continuously calling out numbers between 10 and 0. Second, the attempt to compensate for the loss in MAE strength during measurement by introducing an additional inspection period after each setting makes it impossible to determine the effect of a specific inspection duration or to evaluate the role of the additional periods. To avoid this problem and to minimize the possible additive effects of repeated exposures to the moving inspection stimulus and to test conditions (Hershenson, 1985; Kalfin & Locke, 1972; Keck & Pentz, 1977; Masland, 1969), only one trial was run on a given day. Thus, a minimum of 22 h separated trials throughout the experiment. Clearly this procedure did not eliminate the interaction with the previous adaptation. Indeed, Hershenson (1985) demonstrated a small but perceptible spiral aftereffect 3 days after viewing a rotating spiral for 30 sec. The 22-h minimum trial separation was selected as a compromise.

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