Temporal dynamics of early light adaptation

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This study investigated two aspects of visual sensitivity to a change in light level. The first experiment examined the time course of sensitivity to a small amplitude 1-s contrast pedestal presented on a 163-td pedestal within a 115-td surround. The largest contrast pedestal was an 8% contrast change that changed the steady pedestal threshold by only 0.03 log unit. Thresholds increased by 0.6 log unit or more at both onset and offset, with a return to baseline within 100 ms. The increment and decrement thresholds showed different time courses. Increment thresholds were raised before pedestal onset and decrement thresholds were raised before pedestal offset. These data were interpreted to show that increment thresholds measured at onset and offset of a contrast pedestal accessed on-pathways and decrement thresholds accessed off-pathways. In the second experiment, we examined the time course of sensitivity using a Crawford paradigm. Observers were dark-adapted and sensitivity was measured before, during, and after a 0.5-s, 68-td pulse. Test stimuli were slightly biased in chromaticity and the observer reported the presence and the hue appearance of the test, allowing separate estimates of detection and hue identification. Thresholds increased during the pulse but showed only a minimal overshoot. The test sensitivity for detection was poorer than for hue identification in the dark, but detection and identification were similar during the pulse. These data suggest that thresholds during sizable luminance pulses are determined in the PC-pathway.

Keywords: contrast saturation, dynamics, Crawford paradigm

Introduction

In 1947, Crawford (1947) published research that was destined to become a classic contribution to visual science. He was interested in the momentary blinding effect of artillery fire on dark nights. He used a 12° “conditioning” field of 0.5 s, on which was measured an increment threshold using a small (0.5°), brief (10 ms) test. The test was presented at a series of delays relative to the conditioning field onset. Thresholds were higher during the conditioning field, showing an overshoot at onset and offset, with some recovery during the conditioning pulse period. The overshoot showed a rapid recovery within 100 ms with further recovery during the 0.5-sec conditioning period. The results showed an unexpected finding. The threshold started to increase before the physical onset of the conditioning field. Crawford attributed this result to the fact that the intense conditioning flash showed a faster neural response than the threshold responses measured in the dark. A similar phenomenon occurred at offset. The offset effect was subsequently investigated more fully by Baker (1953).

The Crawford data suggested that multiple mechanisms were involved in thresholds measured at the onset and offset of a light stimulus or when thresholds were measured on briefly pulsed backgrounds (Alpern, Rushton, & Torii, 1970). These mechanisms became a focus of interest in the 1970s and 1980s, with development of a technique called the “probe-flash” paradigm. In a prototypical probe-flash experiment (Hood, Ilves, Maurer, Wandell, & Buckingham, 1978), the observer viewed an 8° steady background of fixed retinal illuminance. A 40' circular flash was presented for a 0.5-s period and thresholds were measured for a 2' probe of 10 ms. These experiments yielded a variety of effects, including cone saturation (Hood et al., 1978), multiplicative and subtractive neural adaptation (Hayhoe, Benimoff, & Hood, 1987), and the activity of multiple postreceptoral pathways (Finkelstein & Hood, 1981). Saturation measured in these studies occurred for very high flash intensities (over 10,000 td) with the probe presented at 250 ms after flash onset. This saturation was attributed to the cone receptor response. When the probe was presented at flash onset, spectral sensitivity suggested activity in a spectral opponent channel.

Saturation is a characteristic of all neurons. The contrast transfer function of retinal ganglion cells shows contrast saturation at high contrasts (Shapley & Victor, 1978). In the primate, MC-pathway retinal ganglion cells show saturation with achromatic contrast pulses of less than 10% and PC-pathway cells show a more linear contrast response (Kaplan & Shapley, 1986). Pokorny and
Smith (1997) suggested that such contrast saturation responses can be measured in human psychophysical studies.

The goal of this work was to evaluate two aspects of early light adaptation. First, we evaluated recovery from a contrast pedestal that was associated with only minor neural multiplicative or subtractive change. This study used the Pedestal-Δ-Pedestal Paradigm that was described in Pokorny and Smith (1997). In a second experiment, we returned to the original Crawford paradigm that used a large pedestal step from darkness. We incorporated a design using chromatic pulses and requiring one of three responses: “not seen,” “red,” or “green.” The test stimuli were slightly biased in chromaticity, and the observer reported the presence and the hue appearance of the test, allowing separate estimates of detection and hue identification. Four interleaved staircases were run concurrently; two (one for each chromaticity) reversed on either “either hue,” and the other two required a correct hue response. Correct hue identification requires activity in the parvocellular spectral opponent pathways and allows us to compare thresholds with those of the original Crawford paradigm.

Methods

Apparatus and Calibration

The stimuli were generated by a Macintosh PowerPC Computer with a 10-bit Radius video card, and were displayed on a Radius PressView SR or a NEC MultiSync FE750 17” color monitor. The monitor refresh rate was 75 Hz. The monitor system was operated by computer programs written in C language and compiled by CodeWarrior (Metrowerks, Inc., 1996) software. Observers responded using a mouse. The display image size of the monitor was about 75% of the maximum display area. The maximum luminance was 60 cd/m². The luminance output of each phosphor was measured at 1024 radiance levels and look-up tables allowed linear luminance control. The phosphor spectral distributions were measured with an Optronic Laboratories spectroradiometer (7540-PMT), and the chromaticities of the phosphors were used to calculate the desired chromaticities in the Boynton and Kambe (1980) relative cone troland space.

Observers

Two of the authors (CS and JP) and three individuals (HK, LS, and IY) naive to the experimental design served as observers. IY participated in both experiments. All observers had normal visual acuity (with refractive correction if necessary) and normal color vision according to the Neitz OT anomaloscope, the Farnsworth-Munsell 100-hue test, the Ishihara pseudoisochromatic plates, and the Standard Pseudoisochromatic Plates II test.

Procedure

An adaptive staircase determined the test retinal illuminance for each trial. In Experiment 1, a pair of staircases randomly alternated was used to measure thresholds in both an increment direction and a decrement direction. In Experiment 2, four staircases were randomly alternated to measure detection and hue identification of two chromatic tests. At the start of a staircase, an easily discriminable test contrast was present and on succeeding trials the step size was halved until a criterion step of 0.025 log unit was reached. The criterion was set in pilot studies to produce an efficient staircase, requiring about 60-70 trials. Once the criterion step size was reached, the staircases continued without further change in step size using a reversal rule (specified below for each experiment). Eight-to-ten reversals at the criterion step size were measured for each staircase. The average contrast at which the last six reversals occurred was taken as the estimate of the threshold contrast. The entire protocol was repeated 3 times to give an average threshold.

Experiment 1: Pedestal-Δ-Pedestal

Experiment 1 employed the Pedestal-Δ-Pedestal Paradigm described in Pokorny and Smith (1997). The rationale for the complicated pedestal-Δ-pedestal design was to separate the MC- and PC-pathway thresholds so that the characteristic contrast discrimination response of the MC-pathway could be followed.

The stimuli consisted of four 1° squares arranged as a four-square array with 0.07° gap separations. The test stimuli were displayed in the center of the monitor with an 8° by 8° uniform surround that also filled the gaps between the four squares. The display was viewed binocularly with natural pupils at a distance of 1 m and the chromaticity of the test and surround was metameric to the equal energy spectrum (EES) (0.66457, 0.997; chromaticity specified in the Boynton & Kambe (1980) relative cone troland space). The surround retinal illuminance was 115 td, and the four-square array was presented continuously as a steady pedestal at 162 td. The test stimulus was presented as an added four-square Δ-pedestal array during each trial. A small square fixation target (4.36’) in the monitor center provided a fixation guide.

The observer first adapted for 2 min to a uniform 115-td display that included the fixation target followed by 1 min of adaptation to the steady pedestal retinal illuminance. During each trial, the Δ-pedestal was presented for 1,000 ms, and one of the four squares (the target square) changed to the variable test luminance as a 26.67 pulse (two refreshes) after a Δ-pedestal-to-pedestal delay. The next trial then started after a 1-s inter-trial
interval. The observer was instructed that one square might appear brighter or darker than the other three and the task was to identify the “odd” square. At the start of a trial, the fixation target disappeared. The test square was selected randomly with equal probability at each position. At the trial conclusion, the fixation target reappeared together with a cursor. The observer used the mouse to place the cursor in the stimulus position judged differently. A mouse click at this position stored the result and reset the display for the next trial. No feedback was given. In Experiment 1, the reversal rule for was set at 3-correct-2-incorrect.

There were two protocols. In the first, the time course was examined with the Δ-pedestal fixed at 186 td. The delay of the test pulse from the Δ-pedestal onset was varied from -106.67 ms to 1213.33 ms, where negative values indicated that the test square was presented before the presentation of the Δ-pedestal array. The delays were presented in separate sessions. In the second protocol, three delays were examined: 0 ms, 26.7 ms, and 506.7 ms, and a series of seven Δ-pedestals was used at each delay. The Δ-pedestals varied from 141 to 186 td. Each session included three or four Δ-pedestals at a chosen delay. With zero delay, the protocol was similar to Pokorny and Smith (1997).

**Results**

Increment and decrement contrast discrimination thresholds measured with the Δ-pedestal to test delays from -106.7 to 1213.3 ms are plotted in Figure 1 as a function of the delay. The three panels show data of three observers. The dashed line shows the average Δ-pedestal threshold measured in the second protocol. Observers CS and YJ showed minimal difference (< 0.1 log unit) in these thresholds but HK was 0.2 log unit less sensitive in the temporal paradigm and showed more scatter in thresholds. Thresholds rose at Δ-pedestal onset, reached their maximum, and returned to near baseline sensitivity within 100 ms. Thresholds then rose again at the Δ-pedestal offset, and then returned to baseline within 100 ms. The time course for increments and decrements differed subtly but consistently among observers. The increment thresholds reached their first peak about 25 ms before Δ-pedestal onset but their second peak coincided with Δ-pedestal offset. In comparison, the decrement thresholds reached their first peak at Δ-pedestal onset but their second peak occurred about 25 ms before the Δ-pedestal offset.

The data could be described by modifying an equation to describe contrast saturation in the MC-pathway (Pokorny & Smith, 1997; Smith, Sun, & Pokorny, 2001). This equation describes contrast discrimination as dictated by a product of the threshold term, steady-state gain to the pedestal, and saturation to the Δ-pedestal:

\[
\log \Delta I = \log \left\{ \frac{|C_s + C|}{|C_s - (K_C)(C_s + C)|} \right\} + \log (KI),
\]

where \(|C_s + C|\) represents the absolute value of the Δ-pedestal Weber contrast \((\Delta P/\delta p)\), \(C_s\) represents the saturating contrast, \(K_C\) represents the criterion increment firing rate (comparable to \(\delta/\delta_{max}\) of a single cell), and \(K\) represents the overall scaling constant. The overall scaling constant, \(K\), incorporates threshold sensitivity and gain for the presumed MC-pathway. We can incorporate time dependence by adding an exponential time constant at onset and at offset to describe the recovery from saturation:

\[
\log \Delta I = \\
\log \left\{ \frac{|C_s + C|}{|C_s - (K_C)(C_s + C) \exp(-t/\tau)|} \right\} + \log (KI),
\]

where \(G_P\) represents the gain term at 162td and \((\Delta G)\) represents the added gain (1.15 fold) caused by the 24-td Δ-pedestal. This equation gives an instantaneous change in contrast at onset (or offset), which recovers exponentially with time constant \(\tau\). The peak advances

![Figure 1](https://example.com/figure1.png)

**Figure 1.** The time course of thresholds measured on a 1,000-ms contrast Δ-pedestal. Each panel shows data of a different observer. Increment thresholds are shown by open symbols and solid lines; decrement thresholds are shown by closed symbols and dashed lines. The lines represent fits of contrast saturation functions with an exponential time course. The horizontal line shows the average threshold measured on the steady-state pedestal in a separate experiment.
can be described by replacing \( \exp(-t/\tau) \) by \( \exp(-(t+k)/t) \) where \( k \) is a constant.

Figure 2. The thresholds measured on a 1,000-ms \( \Delta \)-pedestal at one of three fixed test delays, 0 (circles), 26.667 (squares), or 506.667 (triangles) ms. Increment thresholds are shown by open symbols and solid lines; decrement thresholds are shown by closed symbols and dashed lines. The lines represent fits of contrast saturation functions described in the text. Data from previous steady-state experiments are shown for comparison. The data are for observer HK.

The solid lines show fits of Equation (2) to the data of the three observers. For these fits, we allow variation of \( \tau, k, C_{sat}, \) and \( K \). The value of \( \tau \) varied from 23 - 40 ms. The values of \( k \) varied from 17 - 30 ms. The advance was required to fit the increment thresholds measured at \( \Delta \)-pedestal onset and to fit the decrement thresholds measured at \( \Delta \)-pedestal offset. The values for \( C_{sat} \) were 0.12 - 0.14. These values are consistent with values for contrast saturation in retinal ganglion cell data in the MC-pathway. In general, the quality of the fits was good. The use of a single exponential implies that the onset of saturation was instantaneous. However, data for early light adaptation show a more gradual rise. This could be modeled if the pathways mediating detection involved an average over cells with slightly varying time constants. There was no expectation that the time constant of the gain change should match the time constant of the contrast saturation. However, because the expected gain change was so small, there was no rationale to adjust the time constant.

Figure 3. The thresholds measured on a 1,000-ms \( \Delta \)-pedestal at one of three fixed test delays, 0, 26.667, or 506.667 ms. The data are for observer CS. The data format is as for Figure 2.

Figures 2-4 show the results of varying contrast at three fixed delays for the three observers. The upper panel shows data for increments and the lower panel shows data for decrements. Also shown on the graphs are data from the Steady-Pedestal Paradigms previously collected on all three observers (Smith et al., 2001). The data were fit by Equation (2). The parameters \( t, k, C_{sat} \) were those used to fit the delay data. The scaling \( K \) was
varied to account for day-to-day variability. Data were similar for all three observers. There was a steep V-shape at 0 delay, flattening at 26.7-ms delay. The thresholds at 506.7-ms delay corresponded well with the previous data from the Steady Pedestal Paradigm (Smith et al., 2001). The three observers were well practiced, having participated in a variety of contrast discrimination experiments over a one-year period. Their thresholds were low. The smallest fixed Δ-pedestal was approximately twice threshold. There was no indication of facilitation (dipper effect) or inhibition (bumper effect) (Bowen, 1997). The minimum of the V-shape occurred primarily for the zero Δ-pedestal, although there was some scatter among observers.

**Discussion**

We designed Experiment 1 to constrain the thresholds to the inferred MC-pathway. There were three critical aspects to the choice of stimulus parameters. Based on the Pokorny and Smith (1997) data, we chose (a) a short duration stimulus pulse to maximize the difference in steady pedestal and pulsed pedestal thresholds, (b) a steady pedestal level that produced a large difference between the inferred MC- and PC-pathway sensitivities, and (c) a Δ-pedestal amplitude that resulted in threshold retinal illuminances below the inferred PC-pathway threshold. The experimental parameters gave us a 0.7-0.8 log unit window where the MC-pathway is more sensitive than the PC-pathway. The data of Figures 1-4 are consistent with threshold mediation in the MC-pathway at all durations.

The two protocols, varying delay at a fixed Δ-pedestal or varying Δ-pedestal at a fixed delay, gave the same picture of contrast saturation in the MC-pathway. In the first protocol, the increment and decrement staircases yielded different time courses at onset and offset. This phenomenon may be related to MC-pathway ganglion cell data. The on-pathway saturates to an increment pedestal but is silenced by a decrement. Conversely, the off-pathway saturates to a decrement pedestal but is silenced by an increment. Recovery to a saturating pedestal is faster than recovery to a pedestal that drives the membrane potential below the spike threshold (Lee, Smith, & Pokorny, 1999). Our data are consistent with this phenomenon. In the second protocol, we found a consistent asymmetry between the increment and decrement thresholds. Increment thresholds were steeper for decrement Δ-pedestals and decrement thresholds were steeper for increment Δ-pedestals. This effect was consistent across observers and agreed with the time course data of Figure 1. Since the saturation effect and its recovery were advanced for increments measured at Δ-pedestal onset, the increment thresholds are lower than decrement thresholds for positive delays following onset. The reverse happened at Δ-pedestal offset. In the original experiment (Pokorny & Smith, 1977), increment and decrement thresholds were averaged, thus the effect was not noticed. A review of the raw data confirmed that the phenomenon was present. A similar phenomenon was previously reported by Bowen (1997) using a cosine mask (pedestal in our terminology) and a spatial test formed by a D6 waveform. We conclude that when contrast discrimination is measured on a brief contrast step, or on the rising or falling portions of a longer contrast step, increment thresholds reflect activity in an on-pathway and decrement thresholds reflect activity in an off-pathway.

Crawford (1947) first reported that thresholds are elevated in advance of a conditioning stimulus. He proposed either that the conditioning stimulus “overtook” the flash between retina and brain, or that
the perceptual process was sufficiently long as to allow interference of test perception by the conditioning stimulus. Subsequently, the phenomenon was termed backward masking and attributed to interactions among fast and slow pathways. In Experiment 1, we consider that our stimuli are processed within on- or off-MC-pathway cells responding to a contrast-saturating pulse. We suggest that the phenomenon might be caused by a contrast nonlinearity in the retina. Primate MC-cells (Benardete, Kaplan, & Knight, 1992; Kaplan & Benardete, 2001; Lee, Pokorny, Smith, Martin, & Valberg, 1990) and cat X- and Y-cells (Shapley & Victor, 1978, 1979; Victor, 1987, 1988) show a phase advance with contrast that has been attributed to a retinal contrast gain control (Victor, 1987, 1988). This effect is observed in pulse data (Lee, Pokorny, Smith, & Kremers, 1994), but is at most 8-12 msec. Our data show advances of 25 msec.

**Experiment 2: The Crawford Paradigm Revisited**

In Experiment 2, we replicated the Crawford (1947) experiment with chromatic test stimuli superimposed on a white pedestal (conditioning field in the Crawford terminology). The rationale for this protocol was to implement a hue identification response, which presumably is mediated by the PC-pathway. Thus, we could examine the form of Crawford early light adaptation in the PC-pathway.

The test stimulus was a 0.5° circular spot centered on a 12° diameter circular pedestal. The stimuli were viewed through a 3-mm artificial pupil. The luminance of the pedestal was 9.6 cd/m², with chromaticity metameric to the EES (0.66457, 0.997; chromaticity specified in the Boynton & Kambe, 1980, relative cone troland space). This luminance corresponded to 68 trolands with the artificial pupil. The light level was constrained by the light levels available on a CRT monitor, and was lower than in Crawford’s experiment. The steady-state rise in threshold was circa 1.4 log unit, compared with a 2.2 log unit rise for Crawford’s dimmest conditioning field. Three test stimuli were used: an EES test with chromaticity coordinates (0.66457, 0.997), a “greenish” test with chromaticity coordinates (0.640, 0.997) and a “reddish” test with chromaticity coordinates (0.690, 0.997).

For thresholds measured on the dark background, a large sheet of 0.3 neutral density filter (GamColor, Los Angeles, CA) was inserted in front of the monitor screen. The pedestal retinal illuminance was doubled to compensate for the filter. Two sets of four 12’ dots provided a fixation guide to the screen location in the dark periods. An inner set lay on the perimeter of a 4° diameter circle; an outer set lay on the perimeter of a 12.2° circle. The inner set provided fixation in the dark and was replaced by the pedestal. The outer set remained visible for the whole protocol.

At the beginning of each experimental session, observers viewed a dark screen with the fixation dots for 2 min. During each trial, the pedestal was presented for 506.7 ms. The test stimulus was presented as a brief pulse of 13.3 ms (one refresh) at the field center after a delay from the onset of the conditioning field. The subsequent trial began 2 s following the observer response. Thresholds were gathered for 20 test delays, systematically sampled from -306 ms to 1396.6 ms, where negative values indicated that the test was presented before the pedestal onset. Four delays were interleaved in an experimental session. These were grouped so that the thresholds determined in the dark and pedestal periods were measured in different sessions.

In a control experiment, we compared detection thresholds interleaving reddish and EES staircases. The reddish and greenish stimuli were used in the main experiment. A multiple-judgment task was used to measure thresholds for detection and chromatic identification in four separate staircases for the reddish and greenish stimuli. After each trial, the observer used game pad (Gravis 4211) switches to indicate one of three choices: “reddish”, “greenish”, or “not seen.” Four thresholds were measured, detection and identification of the reddish test pulses, and detection and identification of the greenish test pulses. Thus, 16 staircases were run concurrently in each experimental session. For the measurement of detection thresholds, the staircase followed a yes-no reversal rule, and both the reddish and greenish responses were treated as yes. For the measurement of chromatic identification thresholds, a 3-correct-1-incorrect reversal rule was used, and only the accurate identification of the direction of chromatic change was taken as a correct response.

**Results**

We first established chromaticities that yielded similar detection thresholds in the dark and on the pedestal for the greenish and reddish stimuli. We next evaluated whether the chromatic detection data were representative of detection of a chromatically neutral stimulus. Figure 5 compares threshold detection data for an EES stimulus and the chromatically reddish stimulus (no chromatic identification staircases were run for these conditions). There are no systematic differences between thresholds for the EES and chromatic stimuli.

The data of the main experiment are displayed in Figure 6. Open symbols show the detection results and closed symbols show the hue identification results; both are color coded by stimulus chromaticity. The tasks yielded similar data for both observers. Following onset of the pedestal, thresholds rose abruptly. Thresholds were highest about 50-100 ms following onset and showed a slight recovery. Thresholds declined abruptly at stimulus offset and reached baseline within 200 ms. The detection
data were more sensitive than the identification data in the dark with an average difference of 0.45 log unit. The detection data were consistently more sensitive (about 0.08 log unit), though they had overlapping standard deviations. The black lines show a fit of an exponential equation to the recovery data. The time constant for recovery was 87 ms for JP and 125 ms for IY and was similar for both detection and hue identification. This time course is slower than for recovery from a contrast pedestal in Experiment 1 (e. 25 ms) but much faster than recovery from a bleaching light (e. 120 s).

Figure 6. The time course of thresholds measured on a 506-ms, 68-td achromatic pedestal. The panels show data of two observers. Thresholds are shown for detection and hue identification for a pair of chromatic test lights, biased to appear slightly reddish or greenish. Detection thresholds are indicated by open symbols; hue identification thresholds are shown by closed symbols. Red squares indicate the reddish biased test chromaticity and green circles indicate the greenish biased test chromaticity. The solid lines are exponential fits to the recovery data.

Figure 5. The time course of thresholds measured on a 506-ms, 68-td achromatic pedestal. The panels show data of two observers. Thresholds are shown for detection for a test light metameric to the EES (black symbols) and a chromatic test light that appeared slightly “reddish” (red symbols). The solid lines are exponential fits to the recovery data.

Discussion

In Experiment 2, we were interested in distinguishing pathway activity in the Crawford paradigm and compared detection data with hue identification data in concurrently run detection/identification tasks. The hue identification task provided an index of PC-pathway sensitivity since there is no evidence of the MC-pathway
providing a redness-greenness code. We employed stimuli with subtle chromaticity differences; larger or smaller chromaticity differences between the greenish and reddish stimuli would have resulted in higher or lower estimated PC-pathway sensitivities. Additionally, the different decision rules used to govern staircase reversals for the two tasks affected the relative sensitivities to a small degree. Thus, while we expected the hue identification function to characterize the time course of PC-mediated detection, it could not offer a guide to absolute sensitivity.

We interpret the detection data in the dark as reflecting MC-pathway mediation (the data in Figure 5 showed that detection was the same for one of the chromatic stimuli and an achromatic appearing stimulus). There was a $0.4\log$ unit cone photochromatic interval. At pedestal onset and offset, we saw no overshoots as would be expected of the MC-pathway and demonstrated in Experiment 1. This result leads us to conclude that thresholds within +/- 25 ms of onset and offset were mediated by the PC-pathway.

Based on earlier work, we expected that the MC-pathway might be more sensitive during the mid-period of the 68-td pedestal; for a similarly sized stimulus, observer IY showed an $\sim 0.1\log$ unit MC-pathway advantage (Smith et al., 2001; we do not have corresponding data for observer JP). However, the parallel threshold functions from the beginning to the end of the pedestal are consistent with PC-pathway mediation of these detection data. The data with which we defined relative PC- and MC-pathway sensitivities (Pokorny & Smith, 1997; Smith et al., 2001) were gathered with gaps between the discrimination stimuli. Separating stimuli impairs luminance discrimination (Boynton, Hayhoe, & MacLeod, 1977; Sharpe & Wyszecki, 1976), but it is not possible from these studies to identify the pathway mediating the discriminations.

The data showed a conspicuous difference from Crawford's classic data; there was no overshoot at pedestal onset/offset. This is likely due to the lower retinal illuminance of the pedestal. Our pedestal was about 10-fold lower than Crawford's lowest conditioning field. The rapid overshoot in the usual Crawford experiment probably represents contrast saturation in both the PC- and MC-pathways.

The exponential recovery functions we fit to the sensitivity recovery at pedestal offset for the two experiments have different interpretations. For the Pedestal-\(\Delta\)-Pedestal Paradigm, the very small step in pedestal retinal illuminance is insufficient to result in a substantial sensitivity change due to sensitivity regulation. This is evident from the small differences in thresholds measured prior to the pedestal and after the pedestal had been presented for 500 msec. Thus the 25-msec time constant represents the recovery from contrast saturation. For the Crawford paradigm, there is a substantial change in sensitivity during the pedestal. Here, the $\sim 100$-msec time constant represents the time course of recovery of the mechanism involved in sensitivity regulation.

Acknowledgments

National Eye Institute Research Grant EY00901 supported this research. Publication was supported in part by an unrestricted grant to the Department of Ophthalmology and Visual Science from Research to Prevent Blindness. We thank our observers HK, LS, and IY for their patience, and Linda Glennie for programming assistance. Commercial relationships: none.

Footnote

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