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PATTERN TARGET ANALYSIS

PART I. A THEORY

PART II. A PSYCHOPHYSICAL EXPERIMENT

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P R E F A C E

The limiting range at which a nonuniformly luminous object, such as an aircraft or a ship, may be visually detected cannot ordinarily be calculated by conventional procedures since available visual threshold data relate only to uniformly luminous visual targets. Some special means for performing such calculations has long been sought. In 1945 the Tiffany Foundation, under its war-time O.S.R.D. contract, began an exploration of the problem by viewing illuminated ship models at variable distance against a separately illuminated unstructured background. [See p. 205-211, Tiffany Foundation report entitled "Visibility of Targets (Record of Research)," September 1945.] By varying the illuminance on the target, detection range curves were produced and compared with corresponding curves for uniformly luminous targets of like size and shape. These experiments were interrupted by the end of the war and the termination of the Tiffany contract before a solution to the "patterned-target" problem had been achieved, but speculations based on the fragmentary experimental results were included in Volume 2 of the Summary Technical Report of N.D.R.C. Division 16 (p. 128).

Dr. Morris and her staff at the Visibility Laboratory extended the war-time experimental approach to include studies of the visual detectability of separate pattern components and thereby achieved a successful solution to the patterned target visibility problem. The data for this study were collected and analysed and the theory described in this report was developed at the Visibility Laboratory during the period from August 1955 to December 1956. This basis for calculating visual detection ranges for nonuniform targets has been in routine use by the Laboratory since that time.

S. Q. Duntley
Director, Visibility Laboratory

ACKNOWLEDGEMENTS

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The author wishes also to thank Mrs. J. Gordon, who designed the movable contrast scale-rule for the dark-light methods of plotting and who aided in the analysis of the data; Mrs. L. Knapp who performed the mathematical calculations; Mr. C. Cutchshaw, who served as experimental assistant; and H. Harper, C. Day, and E. Parker who gave their services as experienced psychophysical observers.

PATTERN TARGET ANALYSIS

by A. Morris

An important objective in visibility research is to be able to examine a visual target, analyze its various characteristics and, from a physical description, accurately predict at what range it can be detected or recognized. The primary problem in making this type of prediction is basically one of deciding what the qualities of the effective stimulus are to the human eye. It is quite possible that not all of the inherent target area and not all of the contrast with its background will be utilized by the eye. Some areas will integrate with others, some corners will round off and not contribute to the total area, and some zones of high contrast may compete or inhibit the "seeing" of adjacent areas. What, then, are the target components to be specified and what are the proper data to use for a visibility range prediction? It is possible to measure the target and describe its inherent physical characteristics. We can also specify the luminance of the background and the illumination incident upon the target surface. Through controlled experiments we can determine the actual distance at which the target is first seen and we can evaluate the sensitivity of the observer's eye under the experimental conditions. But the question still exists — what is the perceived visual stimulus which provides the basis for the observer's positive response?

At present we are able to handle quite effectively the simple uniform target. The results of many experiments have shown that, for a simple target, the observed detection range can be accurately predicted from extensive basic visual threshold data for uniform circular targets[1]. As the target departs from a circle, there are experimentally determined correction factors for form or shape which may be applied.[2] The question which now arises is: "How do we handle the complex patterned target?"

By definition, patterned visual stimuli are made up of elements of various contrast with their background and, to complicate the picture further, these elements are seldom of equal size. The detection or discrimination of any element in the configuration essentially depends upon the combination of contrast and size; that is, a large low contrast object or target area may have the same detection range as a very small, high contrast one. "Recognition" of a patterned visual stimulus is basically the cumulative discrimination of sufficient details or elements of the target to provide a basis for naming or classifying it.

Descriptive data collected during relatively simple psychophysical experiments furnishes insight into the problems of detection and recognition. Upon close examination one finds that the elements or zones within the patterned targets are visually separable in terms of their contrast with their background. The patterned target may be crudely laid off into separable zones, each of which may be physically specified in terms of area and apparent contrast. By observing the targets from far to near, from minimum detection to full recognition, and by carefully describing the appearance of the target

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1. Blackwell, H. R., "Contrast Thresholds of the Human Eye," Journal of the Optical Society of America, 1946, 36, 624-643
2. Blackwell, H. R., "The Effects of Target Size and Shape on Visual Detection, IV," Project MICHIGAN Report #2144-335-T, February 1959.

at various distances, informative data may be achieved.[3] Each individual target will be seen to go through its own peculiar sequence of developmental phases. When first detected, any target will be a small spot or smudge which is either lighter or darker than the background behind it. The maximal cue is that element or zone of the target which can be seen at greatest range because of the combination or its size and contrast. As one gets closer to the target, more and more details are visible and finally at close range sufficient features are discriminated and the target can be "recognized." The highly trained person may be able to discriminate the cues in a somewhat less distinct form through frequent experience with these particular patterns, and he will probably react faster and more confidently, but he still must see the essential elements for recognition.

"Recognition" usually occurs when the observer perceives some distinctive inherent characteristic associated with that particular target. This characteristic is one of the zones or elements in the pattern and its detection range can be predicted from its inherent specifications in the same manner as the maximal cue for primary detection.

The "critical element" for recognition of any specific target is difficult to establish. There is an infinite variety of targets to be considered and the visual appearance or pattern presented by any one target will change radically as illumination conditions and/or observing aspects are varied. The apparent configuration will also change as the target moves or re-orients itself relative to the source of illumination. In

3. SIO Visibility Laboratory Report No. 56-10, "Underwater Television for the Identification of Mine-Like Objects," May 1956, (Confidential)

addition, the background of training and experience which provides the associations necessary for recognition is certainly not the same for all observers. However, for certain targets it is possible to distinguish outstanding elements which serve as recognition cues in the majority of cases, and which can be used for recognition indices.

Our approach to pattern target analysis has been to observe targets under various luminance conditions, to record detection ranges and descriptions of the target's appearance, and to quantify carefully the many parameters existing in the experimental situation. The range at which the targets should be seen can be predicted from their physical characteristics and basic visual threshold data. Using a transparent overlay these visibility prediction curves may be superimposed over a plot of the observed data. By shifting the prediction curves right and left for contrast correction, and up and down for size correction, we can obtain best agreement between the two sets of data. By studying the necessary corrections we can analyze the targets or target elements and determine the essential differences between the "real" physical target and the effective visual stimulus or "apparent" target.

The theory presented in Part I of this paper was derived through the analysis of data collected in the controlled psychophysical experiment described in Part II.

PART I. A THEORY

Basic Threshold Curve

In order to handle patterned targets that contain light and dark areas a new method of plotting the typical threshold curve as devised. To illustrate: take a simple split-field target of two equal areas with one area white and the other area quite dark. The visual threshold for either half of the target, independently observed against a uniform background, would fall on the standard visual threshold curves such as defined by Blackwell and many others, see Figure 1. As target contrast is increased, the required angular size for perceiving the target decreases. At the background luminance level illustrated, it has been shown that the same curve holds for targets that are lighter or darker than the background; i.e., positive or negative contrast.

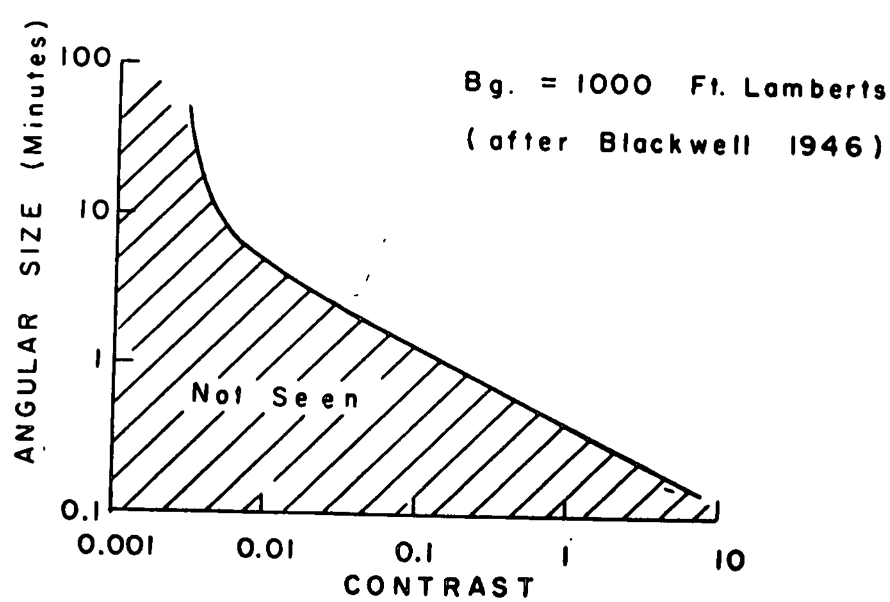

Figure 1

"Dark-Light" Plot of Basic Curve

By plotting threshold size versus the luminance ratio of target-to-background instead of contrast ratio, we can illustrate both darker and lighter visual stimuli on a continuum as in Figure 2. Note that in this and the subsequent figures negative contrast targets, or ones that are darker than their background, will be plotted with a bold line; lighter or positive contrast targets with a dashed line.

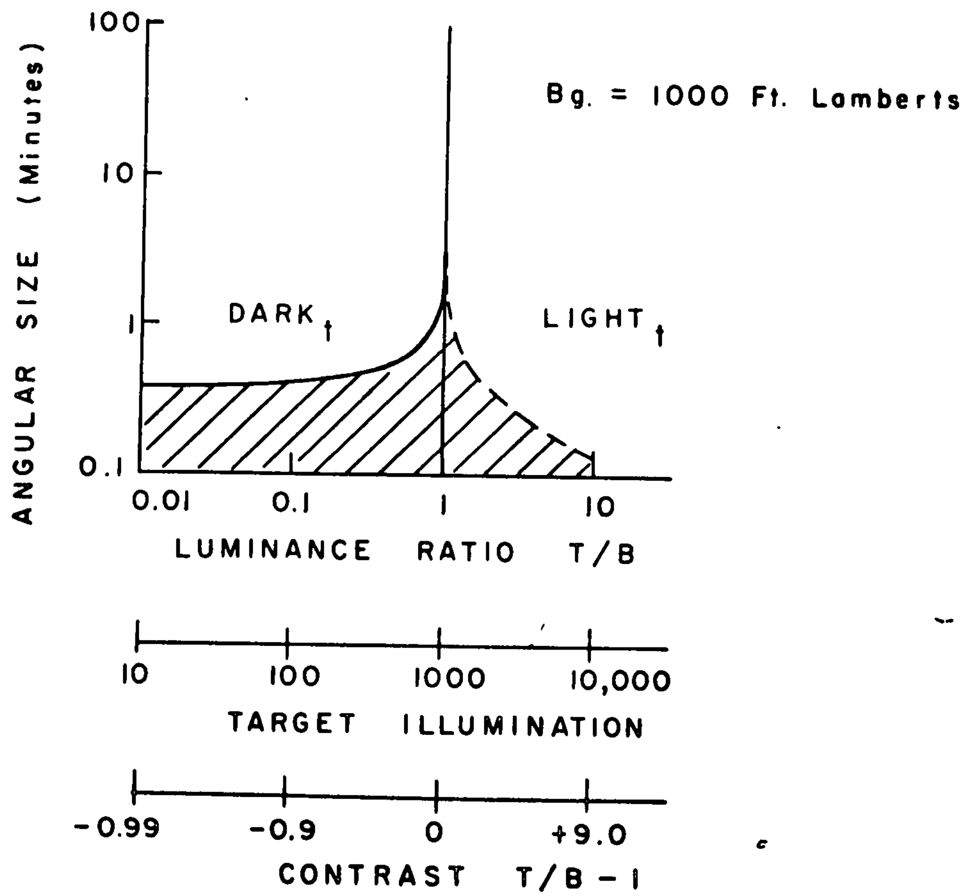

Figure 2

When the luminance of the target equals that of the background the ratio is 1.0, contrast is zero, and the target matches its background. With a good match it will not be visible no matter how large its size unless irregular edges or imperfections show. Increasing the luminance ratio above 1.0 produces a target lighter than its background and as the ratio or contrast increases the threshold size decreases. This arm of the curve is the standard visual threshold curve (Figure 1) for the positive contrast targets. Reducing the target to background luminance ratios below 1.0 will produce targets that are darker than their background. Threshold size decreases as before until the negative contrast of -1.00 is approached at which point the target can get no darker and the curve is asymptotic. At any one luminance ratio the target will be visible if the area subtended at the eye meets or exceeds the size threshold for the contrast value achieved. Progressing across this scale the threshold target would be described by the observer successively as "very dark," "dark," "grey," "faint grey," "match," "faint light spot," "light," "lighter," "very light."

If the background luminance level is held constant and a specific target is observed under various levels of target illumination, E, the dark-light threshold curve will be plotted on a scale such as the second one of Figure 2. The third scale of the figure shows the equivalent contrast values derived from the luminance ratio scale by using the formula:

$$\text{Contrast} = (\text{target}/\text{background}) - 1.$$

These three scales may be used effectively by means of correction factors and a movable ruler.

Assuming infinite meteorological range it is possible to add a range scale to the basic graph through the use of actual target dimensions and a conversion graph such as Figure 3. One procedure for handling non-circular targets is to measure the projected area with a planimeter, to determine the circle of equivalent area and to plot target size data in terms of the angular subtense of the diameter or square area of that circle.[4] Through this technique or through the use of various "form factors" which have been experimentally determined,[5] the whole target, as well as the various separable components in the pattern of the target, may be measured and specified. Then, given the conversion factors, the target size in minutes visual angle may be determined for any specific range.

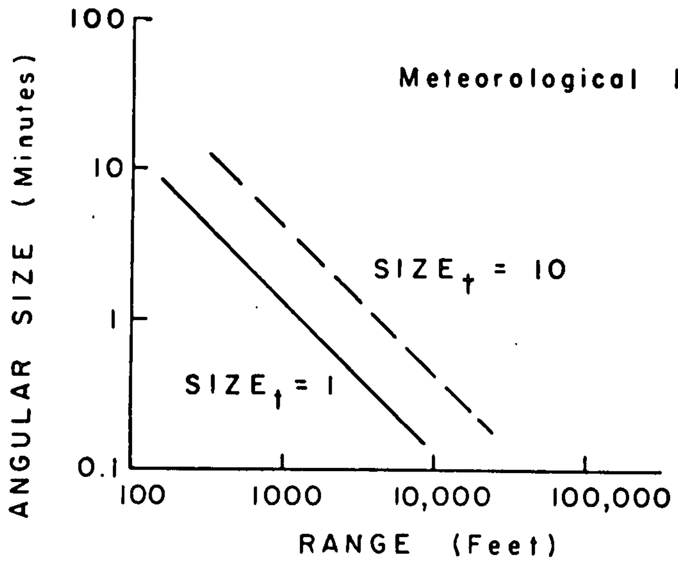

Figure 3

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4 Beck, L. H., "An Experimental Study of a 13.3 x 125 x 2.40 Monocular Telescope," unofficial Project MICHIGAN report #2144-793-M, 1 July 1955.

5 Kristofferson, A. B., and Blackwell, H. R., "Effects of Target Size and Shape on Visual Detection, I. Continuous Foveal Target at Moderate Background Luminance," Project MICHIGAN report 2144-279-T, September 1958.

Effect of Changing Size

Two targets or target areas of different size, the area of one being ten times the area of the other may be plotted in the dark-light threshold curve and would appear as in Figure 4. The size threshold data for these two targets, measured in terms of angular subtense would of course be two superimposed curves. Using the physical dimensions of the targets and converting as in the previous figure the threshold curves may now be plotted in terms of detection range or distance from observer when first seen. Obviously the larger target is detected farther out than the smaller one, however, they both obey the contrast threshold requirements in the standard form. The size change can be thought of as a simple shift of the basic curve up and down the range axis, as long as there is no contrast attenuation due to limited meteorological range.[6]

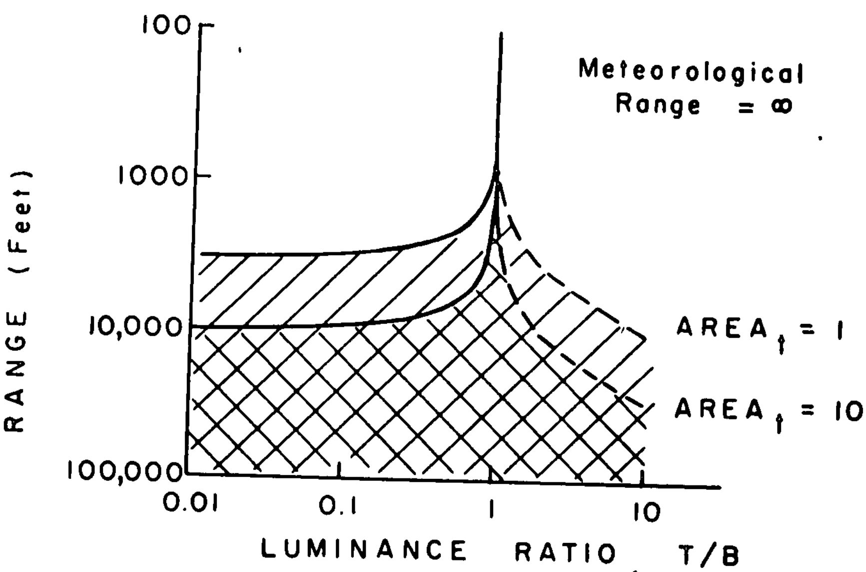


Figure 4

[6] Duntley, S. Q., "The Visibility of Distant Objects," J.O.S.A. Vol. 38, pp 237-249, 1948.

Effect of Changing Surface Reflectance

When observed against a fixed background luminance at various target illumination levels a simple uniform target of perfect reflectance, (100%), would match the background when target illumination equals background luminance. The illumination incident upon the target multiplied by the reflectance of the target equals target luminance. When target luminance and background luminance are equal, contrast is zero.

$$E \times Refl_t = B_t \qquad B_t/B_g - 1 = \text{contrast}$$

Observed under the same luminance conditions a similar uniform target of equal size, but with surface reflectance of 10%, must be illuminated by ten times more luminance flux to match the background and would result in a simple shift to the right of the basic size threshold curve as shown in Figure 5. As before, the size threshold follows the standard form once the shift or correction adjustment for target reflectance has been made.

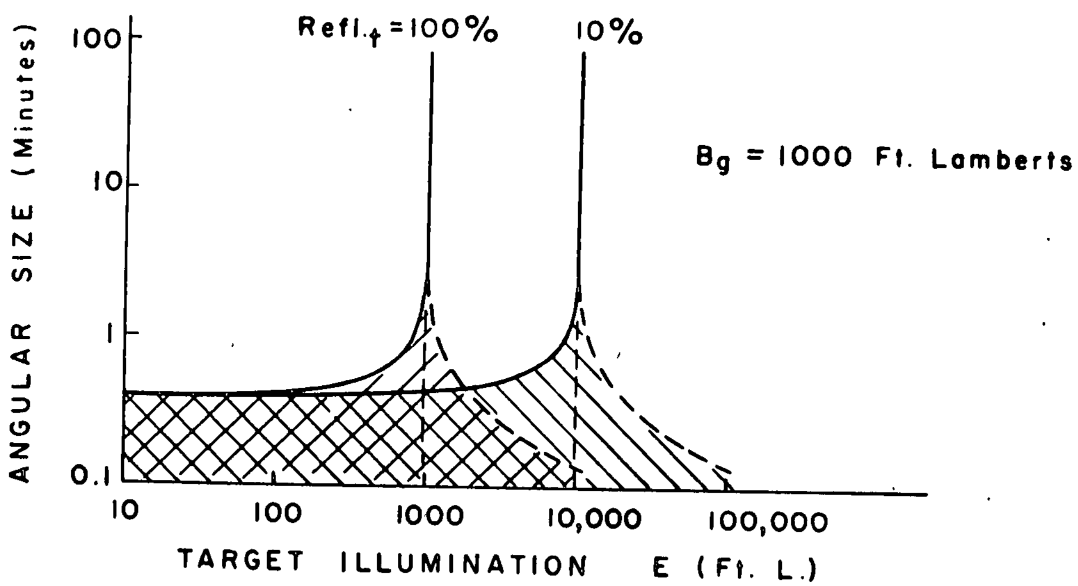


Figure 5

Target Areas of Various Size and Contrast

As previously defined, the patterned visual target is made up of areas or elements of various contrasts and sizes. Figure 6 shows a two-part target having one area which is large and of low positive contrast; the other area is small and has high negative contrast with the background. From such a plot of the visual threshold curves one can determine which element will be the primary detection cue or be first seen at greatest range, and at what range the second element will be discernible. It must be assumed that the pattern targets dealt with in this analysis are not point sources, but are sufficiently large so that the various elements could be discriminated if other threshold requirements were met.

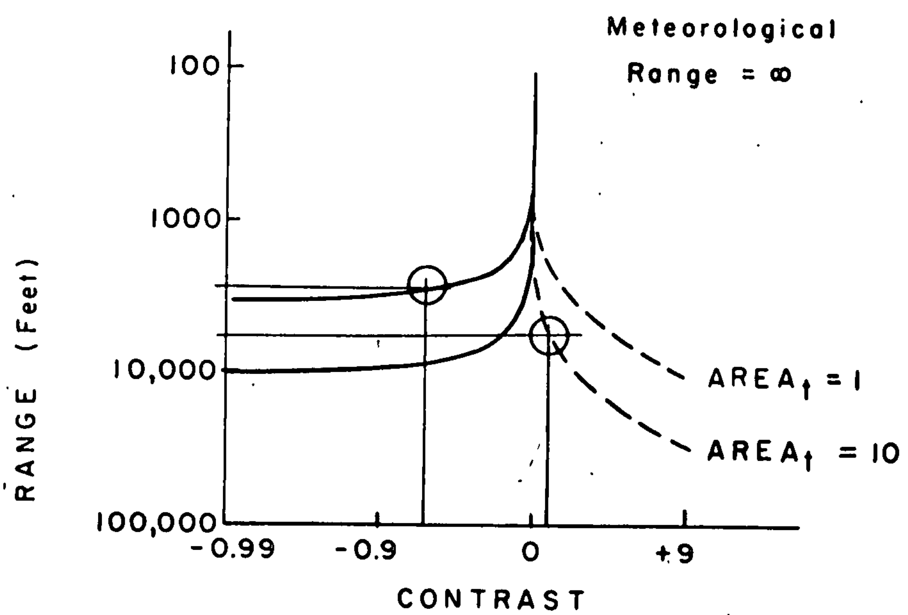


Figure 6

Criteria for "Patterned" Targets

To carry the example further, let the target be painted or be a photograph with an inherent pattern of two clearly separable zones with surface reflectances of 80% and 20% for the small and large (10X) areas respectively. Observed against constant background luminance level the detection range threshold for the pattern may be determined as a function of the level of target illumination, Figure 7 below.

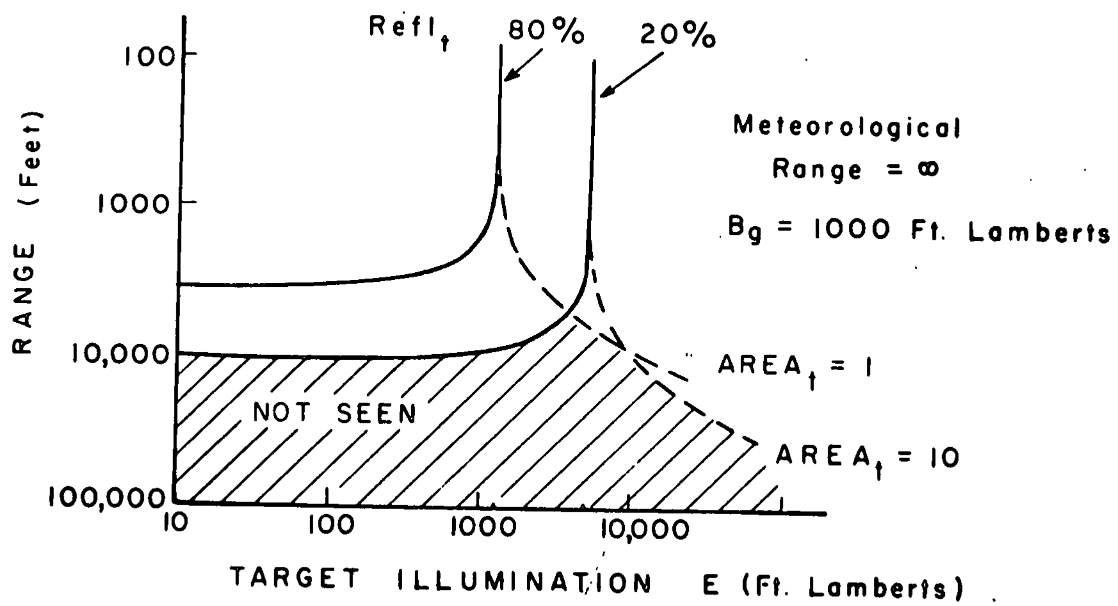


Figure 7

As seen in Figure 7 the first detection at low target illumination values (100 ft L) will be made at 10,000 feet range, and the effective stimulus is the large 20% reflecting area which will appear darker than the background. At this same E value the second area will become visible at closer range and will also appear darker than the background. At E value 1250 ft L, the large 20% reflecting area will again be first detected, but at slightly shorter range due to reduced contrast, while the 80% reflecting small area will match the background and will not be seen even at close range. By increasing the incident light, the large dark area is still first seen and at shorter range; the small 80% area will again be seen at closer range but this time will appear lighter than the background. A point will be reached where both areas are equally visible and, when the target is detected it will be described as "dark and light." At E value 5000 the 20% reflecting large area will match the background; the primary and only detection cue is the 80% smaller area and will be seen as lighter than the background. At still higher E values both target areas are receiving sufficient illumination so as to be lighter than the background, and their detection range will depend upon their inherent size.

An important point in pattern target analysis has just been demonstrated. The "patterned" target illustrated in Figure 7, when considered as a whole, was detectable throughout the gamut of various target illumination levels. At no time did the whole target disappear or match the background. There was always one or the other component available as a visible stimulus. Through the use of the dark-light threshold curve we can simultaneously handle positive and negative contrast targets or target areas. We are able to see on one graph the various lights and darks of a patterned target as well as demonstrate the shifting appearance of a target relative to its background due to varying luminance conditions. It should be pointed out that this method of plotting also minimizes the very low contrast data which are difficult to specify except under the strictest laboratory controls.

Against the fixed background level the uniform target was found to match the background when the product of its inherent reflectance and the incident illumination equalled the background luminance. An intermediate target, one with slight or fine pattern that would be difficult to divide into separable zones, the various areas and reflectances will blend or integrate visually and, when subjected to the procedure described above, will match or nearly match the background at some target illumination level. For all intents and purposes this type of target may be called "uniform" with a reflectance value which includes an integration of the various area in the configuration.

With the above technique an operational definition of a "patterned" target has been developed: Call a target "patterned" if it has distinguishable areas of various size and reflectance such that, as a whole, the target cannot be brought to zero contrast with a uniform background through adjustment of target illumination.

As stated previously in this paper, the theory presented here has been derived from the analysis of visual threshold data collected in psychophysical experiments using uniform and patterned targets. The observed ranges were plotted and treated as the "true" or "real" answers. The standard prediction curves, plotted to handle both dark and light targets or target components (as in Figure 2), were superimposed and adjusted for best fit. For uniform targets the observed data could be exactly fitted by a single prediction curve, once the shifts had been made to correct for target area or target reflectance. However, such was not the case with the observed data for patterned target stimuli. When plotted, the curves did not appear similar to the single "dark-light" prediction curve, and could in no way be made to fit it by any type of shifting. Recognizing that the pattern was composed of areas of various size and reflectance, each of which would require their own correction factors, multiple prediction curves were used, one for each of the visually separable areas of the inherent pattern configuration. Excellent agreement could be found between the observed threshold ranges and the composite prediction curve such as Figure 7. Hence, the following generalization: The various components of a patterned target may be treated as if they were several independent targets with superimposed threshold curves alternately taking precedence, one over the other.

Summary

In brief, the main aspects of this theory of pattern target analysis, based on experimental psychophysical data, are:

1. Patterned visual targets have elements or zones that are visually separable in terms of their area and contrast.

2. The visibility of specific targets, or the component elements of a patterned target, depends upon the inherent physical characteristics plus the luminance conditions under which they are observed.

3. The discernible elements in the patterned target may be considered as several independent targets simultaneously viewed, each with its own detection range.

4. The maximal cue for primary detection is that target element which can be seen at greatest range because of its particular size and contrast with the background.

5. "Recognition" of a patterned visual stimulus is basically the cumulative discrimination of sufficient details or elements of the target to provide a basis for naming or classifying it.

6. If, for some targets, a "critical element for recognition" may be defined; then, from the physical characteristics of this element, the visibility range for recognition may be predicted.

7. An operational definition of a "patterned" as opposed to a "uniform" visual target has been developed and can be stated as: define a target as "patterned" if it has distinguishable areas of various size and reflectance such that, as a whole, the target cannot be brought to match a uniform background through adjustment of illumination incident upon the target.

PART II.

A PSYCHOPHYSICAL EXPERIMENT

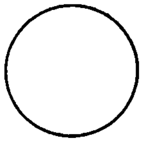
Problem: To determine the visual detection threshold for targets of various shapes and internal pattern configurations as observed under various luminance conditions and, from descriptions of the appearance of these targets, to define the effective visual stimulus.

Apparatus: The target detection range was a 62-foot-long dark tunnel with an evenly illuminated 8-foot-square white background screen at one end, subtending a visual angle of 7.25 degrees. The observers, seated at the other end of the tunnel, moved the target carriage with a hand-operated windlass. The target carriage was an open frame on wheels with invisible cross-hairs for suspending the target. When mounted, the target appeared suspended against the background. The carriage also carried the target illuminators and controls. The distance from observer to target was indicated by a pointer on the carriage and a scale on the floor. The experimental brightness levels were achieved by means of two pairs of illuminators (photo-slide projectors). Two of the projectors, situated one on either side at the end of the tunnel, illuminated the background screen. They were matched in flux and produced even illumination over the white background area. The second pair of projectors, illuminating the target, were mounted on either side of the carriage at the same height as the target. Their flux was also equated and adjusted to give even illumination over the target area. By positioning the target projectors at a sharp angle relative to the target surface, the visual field was unobstructed, and stray light was absorbed by the black walls of the tunnel. The four illuminators were run on regulated voltage and their basic flux level adjusted and maintained by variacs and voltmeters. To achieve the desired experimental brightness levels, each projector was equipped with a series of mounted neutral density filters for coarse adjustment, and a pair of polaroid filters, one of which could be rotated, were used for fine adjustment of the brightness levels. The transmission characteristics of all the filters was carefully determined photometrically within the projection system, as well as photoelectrically outside of the projection system. The brightness levels were measured and maintained by regular use of a Macbeth illuminometer, which had been carefully and periodically calibrated on the photometric bench against NBS standard lamps.

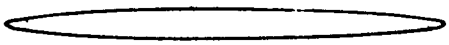
The targets used in the experiment were all of equal area, and consisted of a circle, an ellipse, a silhouette, and various mounted photographs of uniform and patterned targets, as shown in Figure 8.

Psychophysical Procedure: Using the standard psychophysical method of limits, a series of threshold distance settings were made as follows: For half the series, the target was placed at a position where it was clearly "visible", and then moved out by the observer at a constant rate of speed until it "disappeared." The carriage was stopped, and the distance recorded. In alternate trials of the series, the target was placed out at a position where it was definitely "not visible," and moved in until the observer reported it as "visible," and again the distance was recorded. For each target two observers made at least five "in" settings and five "out" settings. The average value is plotted in the figures. The observers' descriptions of the appearance of the targets at detection thresholds were also recorded. The exposure time was of relatively long duration, around a half minute per observation.

WHITE TARGETS:



CIRCLE (diameter 0.689 inch)



ELLIPSE (length:width = 10:1)

SILHOUETTE OF PLANE
(length = 1.99 inches)

PHOTOGRAPHIC TARGETS:

SIDE VIEW OF PLANE

"UNIFORM PATTERN"
(plane heading into sun)

"DARK-LIGHT PATTERN"
(plane headed across sun, sun behind observer)
AREA - Body:Tail = 5:1

Figure 8. Targets of Equal Area
(0.373 square inches)

Experimental Procedure: In the process of establishing the illumination levels, a large white test plaque with the same surface reflectance characteristics as the white targets (white photographic paper), was placed in the target location. By adjusting the target illumination level and by making careful photometric measurements and visual checks, the target luminance or apparent brightness was matched to the background luminance. Having established this match point the target illumination level was then varied by means of adding or subtracting filters to ac'ieve values above and below the match point, i.e., target appearance of "lighter than" and "darker than" the backgrounds. At any one background level, the various target illumination settings were duplicated with the white and with the "patterned" photographic targets. Since the targets were all the same total area, the differences in detection threshold would be due exclusively to a change in surface reflectance or inherent pattern. For any one session, the observer was dark adapted to a specific background luminance level which was held constant, and detection ranges were measured for all targets under various levels of incident illumination.

Results: Threshold data for background level 0.002 foot lamberts are presented in the next three figures. In each case the Tiffany prediction curve, plotted in the "dark-light" style described in Part I of this report, has been adjusted for best fit to the observed data. In superimposing these curves certain restrictions had to be met: Those targets that were described by the observers as "lighter" than the background must fall on the positive contrast arm of the standard dark-light reference curve, and the threshold points for the "darker" targets must fall on the negative arm. The "match" point, if such is described, must coincide with the area of zero contrast in the dark-light plot. After the accepted adjustments have been made to correct for differences between the two experiments, it can be seen that the Tiffany curve fits the observed data of this study very well. Figure 9 presents the size thresholds for the three white targets of equal area; the circle, the ellipse, and plane silhouette. Differences in shape are not evident in these measurements.

Data for the fourth target, the "uniform pattern" photograph of the size view of a plane, are plotted in Figure 10. Typical observer descriptions are recorded across the top of the illustration. Observing the same restrictions as above, the prediction curve fits the data as before, except that the target matched the background at a higher level of target illumination, which was sufficient to compensate for the difference in surface reflectance. For all intents and purposes this "patterned" target can be considered uniform and perceptually integrated. The white targets are made of unexposed white photographic paper, identical in surface characteristics to the patterned targets. When the patterned photograph is substituted for the white targets and observed under identical luminance conditions and experimental control by the same observers, the change in the size threshold can only be due to the "pattern" of the photograph. By increasing the target illumination and determining the point of "match-to-background" we have derived a visually integrated or summated reflectance, in this case around 35%. Using this value, the actual target area, and standard prediction curves, we can predict the detection threshold for <u>this</u> target observed under other luminance conditions.

Referring to the illustration of targets, Figure 8, the bottom photographic target can be seen to have distinct and clear, visually separable zones of dark and light. The data for this target are presented in Figure 11. Since the area of the <u>effective</u> visual target was not known, each particular detection range measurement has been subjected to three size conversion factors; one for the area of the total target, one for the area of the dark body and one for the area of the light tail zone. (The area of the body is five times that of the tail.) Each observed threshold, then, has been plotted three times. As can be seen, no match point was achieved for this target, a fact confirmed by the observer's descriptions noted across the top of the figure. At no time did the entire target disappear, or match its background. The threshold ranges cannot be fitted by the superposition of a single Tiffany prediction curve. However, obeying the restrictions mentioned above, these data points can be fitted by two Tiffany curves; one for each of the visually separable components in the pattern configuration.

Having established the correction of our data to Tiffany through the use of the white targets, the prediction curve can now be slipped right and left to diagnose what portion of the target was detected and described by the observer at the recorded range. For primary detection, we are interested in the component of the target that will be predicted to greatest range or smallest angular size.

If possible, we must first find a continuous series of judgments that will fit along one appropriate arm of the prediction curve. Begin at the left of the figure, at the lower target illumination values. The target was described as "darker than the background." It is impossible to get these first three range measurements on the negative arm of the curve, when converted to the area of the tail. These points have been crossed out to indicate that they are not possible. However, these three measurements will fit on the negative arm of the prediction curve when converted to the area of the body. At the right of the figure, i.e., higher target illumination levels, the top five thresholds, converted to the area of the tail and described as "lighter than the background," may be fitted continuously on the positive arm of the curve when it is shifted to compensate for higher reflectance of tail. If the first position of the prediction curve is correct for the "darker" target, the body area will approach zero contrast at these higher levels and match or nearly match the background, leaving only the tail area as stimulus for detection. As indicated on the figure, the two middle threshold observations were described as both "dark and light," with the light area first visible at the far distance, and the darker area coming in at nearer range. This cross-over zone description confirms the positioning of the two curves and would have been predicted from them once their correct location had been set by other data.

Similar data and results for background luminance of 0.01 foot-Lambert are presented in Figures 12, 13, and 14.

Considered as a thorough psychophysical experiment the author would be the first to agree that the data given herein are sparse; they are presented primarily as demonstration of the theory developed from the analysis of these and other data. The methods and hypothesis for the prediction of visual detection thresholds has been applied successfully to other uniform and patterned targets of various shapes, observed against background luminances ranging from 10^{-4} foot-Lamberts up to full daylight levels.

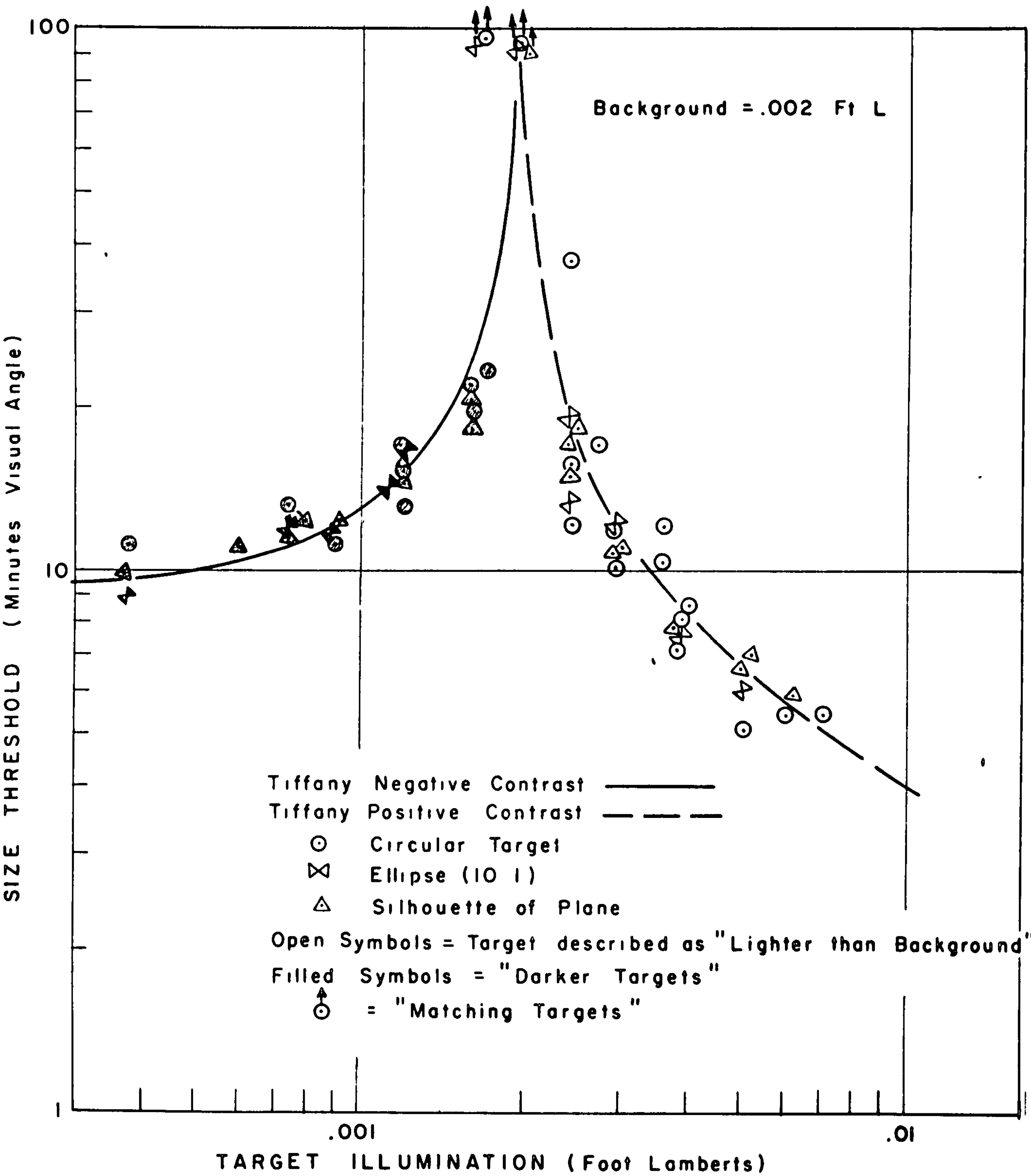


Figure 9. Threshold data for three white targets compared to Tiffany prediction curves. Background = .002 Ft. L.

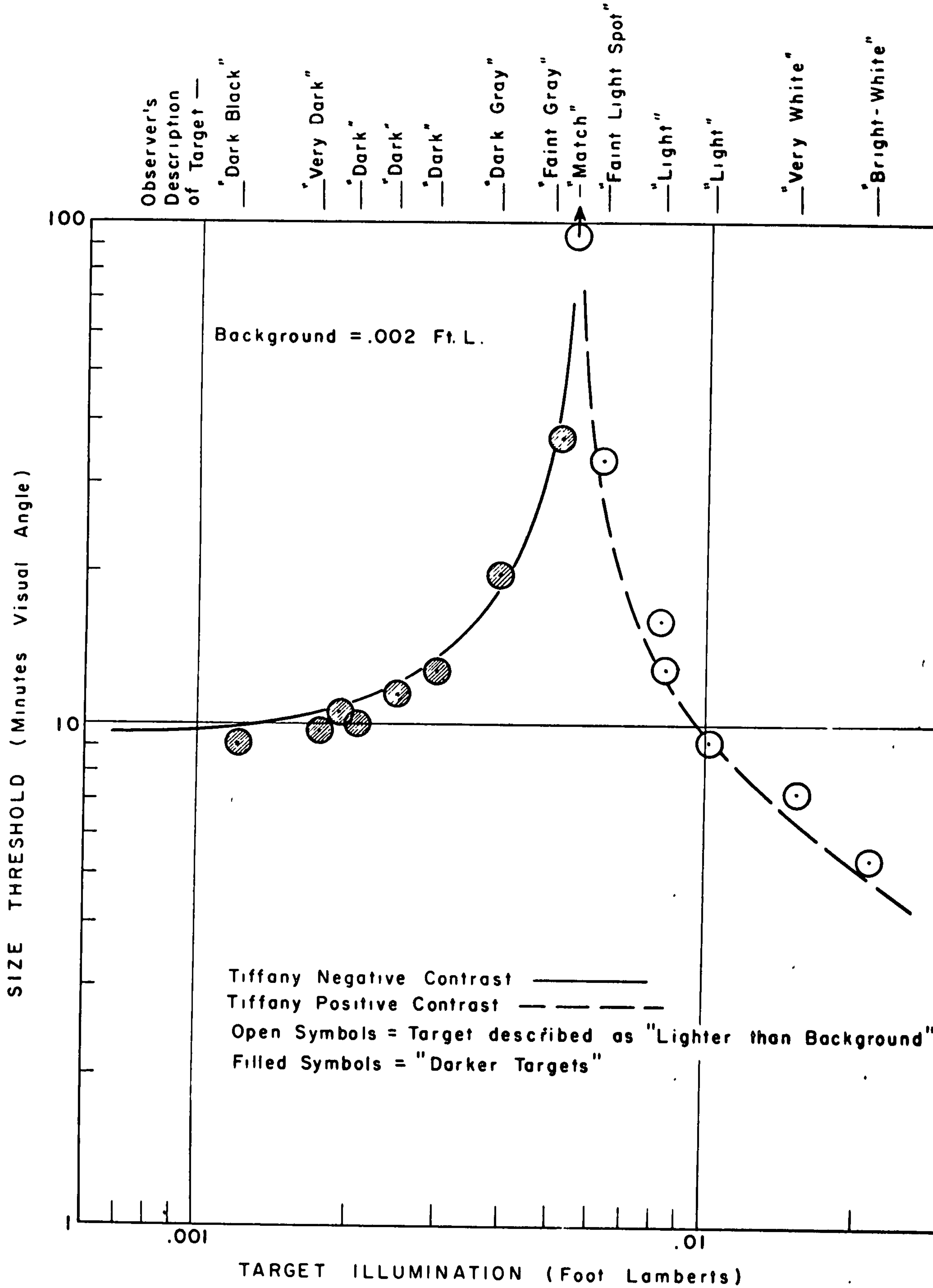


Figure 10. Threshold data for the "uniform pattern" target.
Background = .002 Ft. L.

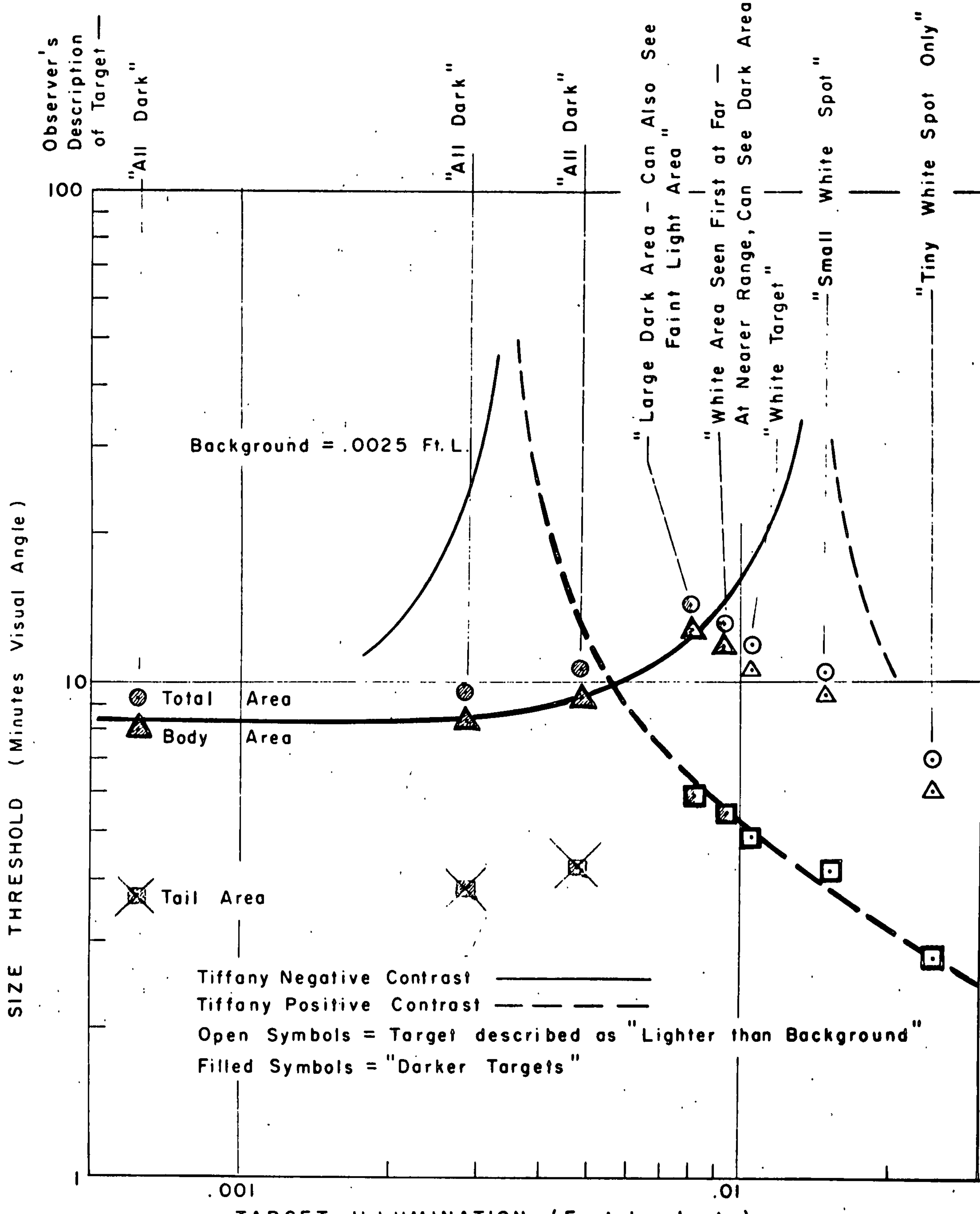


Figure 11. Threshold data for the "dark-light pattern" target. Background = .0025 Ft. L.

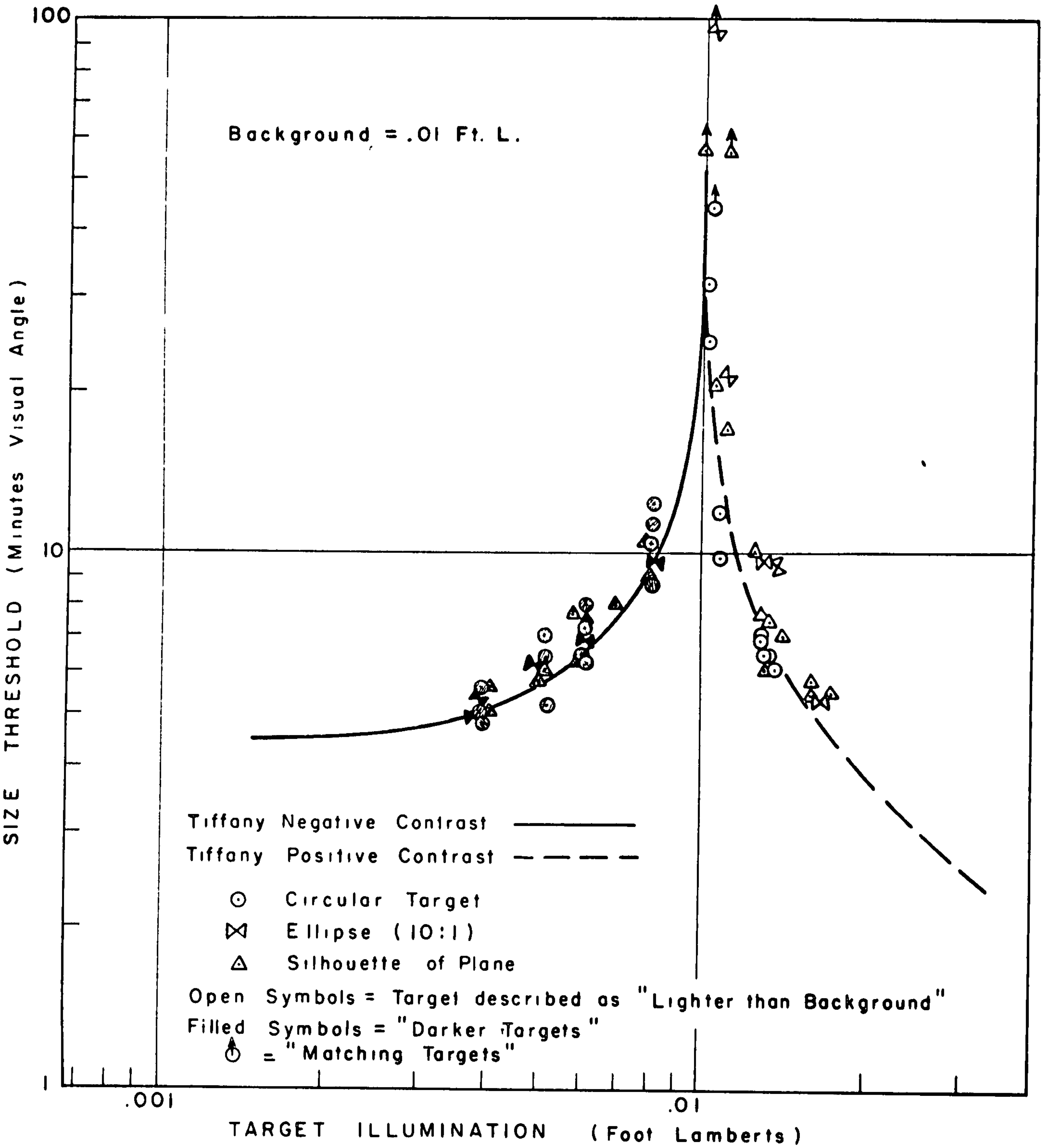


Figure 12. Threshold data for three white targets compared to Tiffany prediction curves. Background = .01 Ft. L.

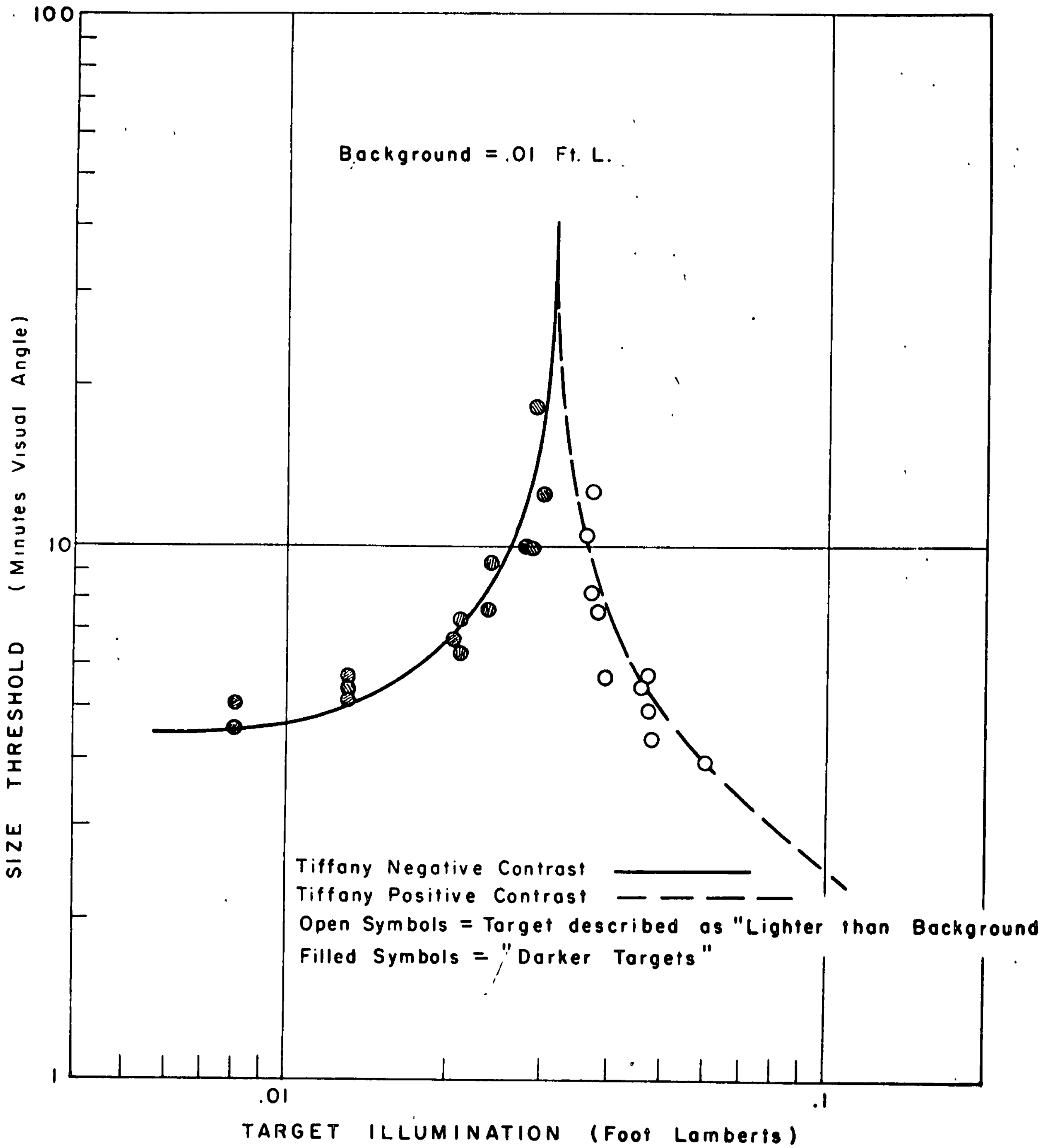


Figure 13. Threshold data for the "uniform pattern" target. Background = .01 Ft. L.

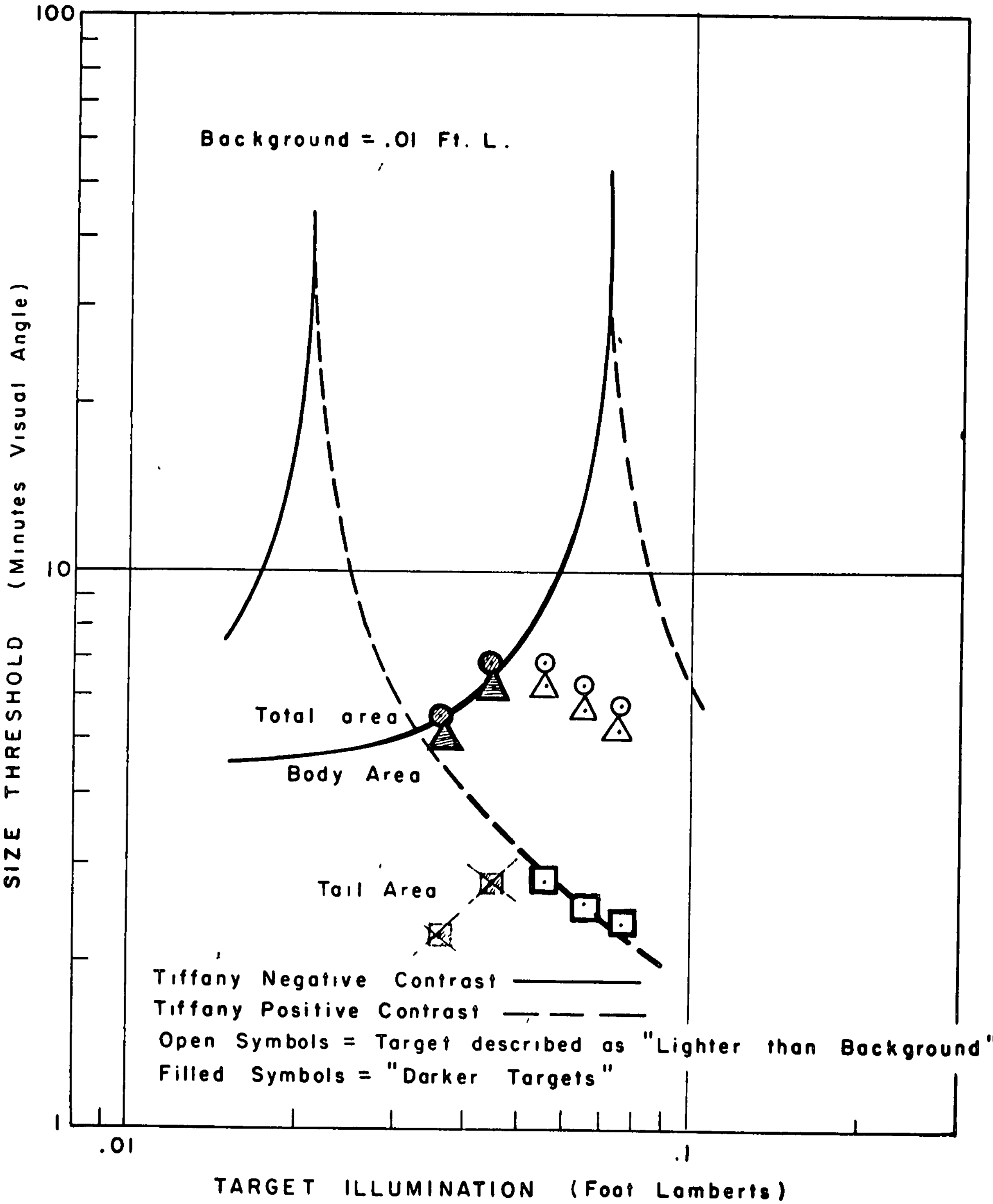


Figure 14. Threshold data for the "dark-light pattern" target. Background = .01 Ft. L.