Symmetry and constancy in the perception of negative and positive luminance contrast

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The perception of suprathreshold luminance contrast was investigated by forced-choice psychophysical procedures that were designed to define contrast equivalence relations. Observers compared the perceived contrast of rectangular bars that were presented for 500 msec at 3.9 deg on opposite sides of the fovea. The results show a nearly symmetrical relation between the perception of negative and positive contrast that is largely invariant over four decades of background luminance. Thus, for any fixed background luminance, equal absolute contrasts evoke approximately equal perceived contrasts. Symmetry also held with variations in the width, the eccentricity, and the focus of the bars. Symmetry was investigated further by determining equivalent contrast relations for negative contrasts as a function of background luminance and by contrast scaling. These results show evidence for nearly perfect contrast constancy for targets of low to moderate contrast and departures from constancy for high-contrast targets. These new findings on negative contrast, symmetry, and contrast constancy are discussed in relation to underlying mechanisms for contrast perception and classic experiments on brightness and lightness constancy.

1. INTRODUCTION

Negative luminance contrast conveys a wealth of information in such varied forms as typescript, backlit objects, shadows, and the myriad of objects that reflect less light than their backgrounds. Nevertheless, the perception of negative luminance contrast has not been studied as intensively as that of positive luminance contrast. Thresholds for the detection of decremental stimuli only tap the beginning point of the suprathreshold realm of negative contrast and the associated perceptual continuum that runs from the light gray to deep black. In this paper we explore this suprathreshold realm by obtaining some measurements of the relation between luminance contrast and *perceived contrast*. We define perceived contrast as the *perceived difference* between a target and its background.

Previous measurements that seem most germane to the perception of suprathreshold negative contrast come primarily from studies of simultaneous brightness contrast or brightness constancy in which observers either matched or scaled the brightness of targets appearing on backgrounds of higher luminance.[1–11] In this paper we take a somewhat different approach by having observers judge contrast rather than brightness in experiments that are expressly designed to yield contrast equivalence relations.

We start with the premise that observers can judge the relative magnitude of *perceived contrast* independently of the contrast sign. We find that such judgments are relatively easy to make and yield orderly psychometric functions when forced-choice procedures are used. From these functions we have determined *perceptual equivalence relations* between negative and positive luminance contrasts. We then extend the approach to determine perceptual equivalence relations for negative luminance contrasts over a wide range of background luminance. Taken together, our data provide evidence for two properties of contrast perception—symmetry and contrast constancy—that have implications for the underlying mechanisms of contrast vision and for aspects of classic experiments on brightness and lightness constancy.

2. METHODS

Apparatus

Vertical bars were generated on a Joyce Electronics cathode-ray-tube (CRT) under computer control, as described in detail previously.[12] The screen subtended 8 deg vertically and 13.6 deg horizontally. Luminance was calibrated with a UDT 80× photometer. Adaptation level was varied by placing precisely calibrated neutral-density filters in front of the observer's eye and making fine adjustments in CRT luminance to achieve the exact level desired.

In auxilliary experiments, an optical system containing interference filters (~11-nm bandwidth) and a xenon source was used to generate stimuli for spectral sensitivity measurements. A beam splitter was arranged so that the spectral stimuli appeared as increments on the CRT screen.

Procedure

Contrast Equivalence for Negative and Positive Contrasts

Observers monocularly viewed the display schematized in Fig. 1A while maintaining fixation at the center (F). A spatial two-alternative forced-choice procedure was used to assess the perceived contrast of negative and positive contrast bars. On each trial, a standard bar with negative contrast was presented for 500 msec on one side of the fixation mark and a comparison bar with positive contrast was presented simultaneously on the other side. The bars were 1.4 deg × 8 deg (width × height), and their inner edges were 3.2 deg lateral of the fixation mark. The observer was required to press a button to indicate which bar had the greater perceived contrast. After a response, a delay occurred so that about 3 sec

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