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A psychoanatomical investigation of the blanking phenomenon

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Abstract

One cannot detect a white disk located at least 15° from fixation in an intersection of gray alleys that define a grid of black squares. A psychophysical examination of the anatomical locus of this "blanking phenomenon" is reported here. Stimuli were presented dichoptically; disk threshold was measured with fixed-step staircases. Three dichoptic experiments were developed employing different stimuli. Simple dichoptic presentations implied both pre- and post-fusion contributions. One follow-up experiment verified pre-fusion contributions, while another implicated post-fusion mechanisms. These results indicate that the blanking phenomenon has contributions from multiple sites in the visual system.

Keywords: Illusion; Brightness; Psychoanatomy; Blanking phenomenon; Visual disappearance

1. Introduction

Psychophysical examination of visual phenomena has yielded extensive information regarding the structure and function of the human visual system. Recently, the psychophysical analysis of a visual illusion termed the "blanking phenomenon" has been reported (McAnany & Levine, 2002, 2003, 2004). The blanking phenomenon is elicited by black squares on a medium gray background, arranged such that the squares delineate a set of intersecting orthogonal gray "alleys." If a disk lighter than the background alley-gray is centered in an intersection approximately 15° or more from fixation, the disk is not perceived. Fixating on the lower grid of Fig. 1 provides a demonstration of the blanking phenomenon. When fixation is appropriately distant from the upper grid, the light disk disappears. Conversely, disks darker than the background alley-gray remain visible; when fixating the upper grid in Fig. 1, the dark disk in the lower grid remains visible.

Conditions under which the blanking phenomenon occurs and factors affecting the efficacy of the illusion have been examined (McAnany & Levine, 2002, 2003, 2004). For example, the blanking phenomenon is evident for a light disk presented with a reduced grid consisting of an intersection delineated by just four black squares (McAnany & Levine, 2002, 2003, 2004). While the inverse arrangement of four or more white squares surrounding a dark disk on the same background alley-gray also elicits the blanking phenomenon, it is somewhat less effective.

The phenomenon develops immediately and is present with trial durations less than 250 ms. With longer presentations, the effect persists for as long as fixation is approximately maintained. If fixation is appropriately far from the disk (approximately 15° or greater), small saccades do not disrupt the phenomenon (this can be verified with Fig. 1). Additionally, the disk must be centered in an intersection for blanking to occur, as a disk centered as little as one disk radius from the center of the intersection is visible. Finally, the onset and offset of the grid and disk must be simultaneous; if the grid and disk are presented asynchronously, the effect is disrupted. Thus, the blanking phenomenon is a novel form

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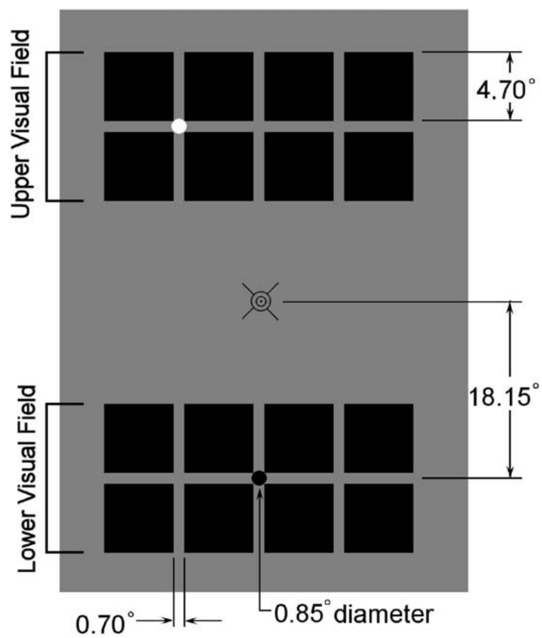

Fig. 1. Demonstration of the blanking phenomenon and stimulus dimensions. The disk appeared 18.15° above or below fixation, and the disk could be darker or lighter than the background alley-gray. Both arrangements are depicted simultaneously in this schematic, but during a trial only the upper or lower configuration (4 columns × 2 rows, and a single disk) was presented.

of visual disappearance that is not dependent on adaptation, motion, or masking.

Other than the aforementioned rudimentary characteristics, little else is known regarding the mechanisms underlying the blanking phenomenon. In an effort to gain a greater understanding of the effect, this study examines the anatomical and physiological underpinnings of the blanking phenomenon as inferred through psychophysical examination. We employ a strategy that uses the site of binocular fusion as a marker for localizing events that occur proximal or distal to that reference point (the psychoanatomical approach: Blake, 1995).

Experiment I was designed to parse the anatomical contributions to the blanking phenomenon from pre- and post-fusion sites. In experiment I, a light disk was presented to one eye and the grid of black squares was presented to the other eye. Disk contrast threshold was measured to determine the efficacy of the blanking phenomenon. Results of experiment I imply both pre- and post-fusion contributions to the blanking phenomenon.

Experiment II was designed to specifically reveal pre-fusion contributions by comparing contrast thresholds from two different conditions. In the "same-polarity" condition, neither eye received a stimulus that would induce blanking, while in the "opposite-polarity" condition each eye received a stimulus that would induce blanking. As will be discussed in Section 4.2, these two conditions were created to appear identical to high-level (post-fusion) cortical processing centers while being readily discriminable by lower-level (pre-fusion) areas. If the contrast thresholds are different between these two conditions, a pre-fusion contribution to the blanking phenomenon can be inferred, as only the pre-fusion peripheral paths should have the ability to differentiate between the same- and opposite-polarity conditions.

Experiment III was designed to verify post-fusion contributions to the blanking phenomenon. In experiment III, a light disk appeared to be centered in an intersection of black squares; however, the disk was presented in a different plane than the grid (disparity condition). The contrast threshold in the disparity condition was compared to that obtained when disks appearing in both eyes were shifted in the same direction by the same amount as in the disparity condition (offset condition). If the blanking phenomenon is greater in the disparity condition than in the offset condition, a post-fusion contribution can be inferred since neither eye alone can distinguish between these two conditions.

2. Methods

2.1. Subjects

The authors (males 24 and 60 years of age) and one volunteer naive to the intent of the research (female 24 years of age) participated in all three experiments (subjects 1, 2, and 3, respectively). All subjects had normal or corrected-to-normal visual acuity and normal stereopsis. The experimental protocol and process of consent were approved by the University of Illinois at Chicago Institutional Review Board.

2.2. Apparatus and calibrations

A chin-rest supported the subject's head, which was located 32 cm from a computer monitor in a dark room. The total path length from the subject's eyes to the monitor was 37 cm. Stimuli were generated by an IBM Pentium III computer running Windows 98 and were displayed on the screen of an EIZO 19 in. FlexScan FX•D7 monitor (1024 × 768 pixels, 85 Hz refresh rate). One component of the stimulus, chosen at random, was presented on one half of the computer monitor, and the remaining component was presented simultaneously on the other half of the same monitor. A first-surface mirror stereoscope permitted fusion of the images on the two halves (see Fig. 2A for a schematic of the stereoscope).

The shape of the subject's horopter was taken into account to ensure proper alignment and fusion of the stimuli appearing in the left and right eyes. Alignment was