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Change Blindness: A Review of Perception, Attention, and Memory in Visual Processing

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Abstract

Change blindness refers to the failure to detect significant changes in a visual scene when they coincide with a global visual transient, such as a saccade or a brief blank screen. This phenomenon highlights critical limitations in the healthy human perceptual system and underscores the distinction between sensation and perception. This review synthesizes current literature on change blindness, examining its underlying mechanisms in relation to perception, attention, memory, and top-down processing. We explore how visual representations are formed, maintained, and compared across disruptions, emphasizing the roles of working memory and attentional allocation. Additionally, the relationship between change blindness and inattentional blindness is discussed, with a focus on how attention modulates conscious perception. Findings from seminal studies, including those using gaze-contingent displays and dynamic stimuli, are integrated to illustrate how change blindness informs broader theories of visual cognition. The review concludes that change blindness is not merely a perceptual failure but a window into high-level cognitive processes, offering significant implications for understanding the architecture of visual awareness.

Keywords

Change blindness, visual perception, attention, memory, mental representation

1. Introduction and Phenomenon Definition

1.1. The Paradox of the Healthy Perceptual System

Perception results from a combination of both the sensory cascade and individual experience, effective in the normal (healthy) brain. However, a healthy perception system does not always respond to changes in the visual environment appropriately, failing even in the healthy brain. In this area of visual perception, change blindness is one example illustrating the tendency of failure of healthy perception system.

1.2. Defining Change Blindness: Failure During Visual Transients

Change blindness refers to the failure to see substantial changes in a visual scene that occurs simultaneously with a global visual transient. Such visual transients might be brief blank between presented scenes or blurs caused by eye movements between successive fixations [1].

1.3. Overconfidence in Change Detection Ability

Moreover, without truly precepting exact changes, people tend to overestimate their change-detection ability [2]. Change blindness is one crucial phenomenon towards understanding visual perception. It points to how the perceptual system processes information collected by sensation and the distinction between seeing and looking.

1.4. Change Blindness v.s. Inattentional Blindness: A Crucial Distinction

Notably, the factor of static stimuli and changing or dynamic stimuli is also one valuable factor analyzing change blindness and visual perception behind it. Change blindness has a

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relationship with inattentional blindness and allows further complicated study about one crucial factor: attention. Inattentional blindness is defined as a failure to notice an unexpected but fully-visible item when one is focusing on other targets, diverting attention to other aspects of one display [3]. Despite the similarities, change blindness, and inattentional blindness differs in etiologies and implications for visual perception, representation, and awareness.

1.5. Aims and Scope of This Review

This study is going to review the current literature on change blindness briefly; discuss change blindness in terms of perception, attention, memory, and top-down processing, and discuss its significance to visual perception; and further study change blindness concerning its relationship with inattentional blindness following attention.

2. Theoretical Origins and Experimental Foundations

2.1. Historical Roots: Coining the Term and Transsaccadic Integration

Change blindness was coined by Rensink, O'Regan, and Clark [4] as the surprising failure to detect significant visual changes to photographs when those changes are displayed during a brief visual disruption, related with subjects' change-detection ability. Much of change blindness's current literature originated in the study of transsaccadic integration, referring to the ability to combine information acquired by separate glances into a unified representation, and the preserving ability of visual system across saccadic eye movement to build and maintain a coherent representation of the outer world [3]. Much works regarding transsaccadic integration came from the study of eye movements on reading [5, 6], whose experiments involved changing stimuli and were related to change blindness.

2.2. The Grimes Experiment: A Milestone in Gaze-Contingent Display

The study of change blindness phenomenon by John Grimes [7] showed subjects photos on a gaze-contingent display and let subjects scanned the image, with the original image swapping with a changed version during a saccade. John Grimes' study found that subjects often failed to notice substantial changes during a saccade, inspiring researchers to study the change blindness phenomenon further. The one-shot tasks without a rich phenomenological experience of change blindness afterwards suggest a new aspect for testing the capacity of visual memory for scenes (mental representations) [8, 9, 10, 11].

2.3. Insights from Motion Picture Perception and Continuity Errors

Though much modern empirical study of change blindness has roots in the literature on visual integration, the motion perception inspired change blindness a lot, noticing that people often fail to notice continuity errors and mistakes in which an object or person unintentionally changes from one shot to another [12, 13, 14, 15].

2.4. Conditions for Detection: The Role of Attention and Motion Signals

Change detection succeeds when a change draws attention but often fails when it does not. Additionally, change blindness also occurs when the change occurs too slowly (i.e. by a gradual fade) to generate one perceptible motion signal [16]. It is also related to the commonly over-estimated change-detection ability study by Levin et al. [2], presenting subjects with changing stimuli and calculating subjects' low success rate. The high-level perceptual process, up-down processing, contributes a lot to change blindness as well. All factors mentioned above influence the change blindness a lot. The change blindness phenomenon also provides perception with a new viewing angle in turn and is vital for discussing high-level perception process further.

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3. The Cognitive Architecture of Change Blindness

3.1. A Multifactorial Cognitive Model: Perception, Memory, Attention

Change blindness refers to the failure to see substantial unintentional changes in a visual scene that coincide with a global visual transient [1], requiring perception, attention, memory, and top-down processing.

3.2. Sensation v.s. Perception: The Construction of Mental Representations

To detect changes in scenes of changing or dynamic stimuli, subjects must compare the pro-change image with the pre-change image (i.e. mental representations), involving top-down processing, memory, attention, and perception. Perception is different from sensation by integrating sensory information into advanced images and display these perceptual images to the consciousness (i.e. mental representation). When one subject is facing changing stimuli represented by change blindness experiments, his or her vision is conducted by his/her visual perception, which has managed and integrated sensory information into the mental representation. In other words, things one subject has seen are things processed by the subject had looked, affected by attention and awareness [17].

3.3. The Critical Roles of Memory Capacity and Attentional Distribution

In order to detect changes, comparison of the pre- and pro-change perceptual images is necessary, allowing enough capacity of memory (working memory). If one subject’s memory capacity is not big enough, it is difficult for him/her to detect changes because he/she cannot remember the pre-change image he/she saw before or compare the pre-change image with the pro-change image to find the change. Meanwhile, viewing a whole image requires differently distributed attention, resulting in some failed changes owing to the lack of attention. Change blindness involves perceptual processing, associated with individual differences in essential attention and perception abilities [3]. Detection of a change depends on many visual processes modulated by attention. Detection of one unexpected object also requires representations lies outside the focused attention.

3.4. The Physiological Basis: Foveal v.s. Peripheral Vision

In terms of perception psychology and top-down processing, change blindness has its relation with cones and rods in the visual system. Under daylight, vision mainly depends on cones, which distributed mainly on the fovea and little on peripheral. Cones are responsible for more detailed information, more sensitive to colour, and have more acuity, compared with less accurate rods distributed on peripheral. When focusing on one thing, the attended focus in the central vision is more detailed, while other non-focused parts are ambiguous. Additionally, attention is selective, and change detection performance follows the development of perception and attention skill, including executive functioning, verbal and visuospatial working memory, attentional breadth, and inhibition measures [18, 19].

3.5. The Side Effects of Top-Down Processing

To view the whole image, eye movement is required to try to see more details, involving top-down processing. However, top-down processing may draw side effects. When one subject is attended to one particular spot, his/her prefrontal lobe tends to dominate attention to this scene and turn the ability to manage surroundings and other factors into the automatic state. Top-down processing tends to distort one’s memory when his/her memory is inattentional with limited memory capacity.

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4. Explanatory Frameworks and Related Phenomena

4.1. The Corollary Discharge Theory and Eye Movements

Change blindness is related with motion perception because early studies in motion picture perception experiments noticed that people often fail to notice continuity errors and mistakes in which an object or person unintentionally changes from one shot to another [12, 13, 14, 15]. With knowledge of motion perception, corollary discharge theory finds that motion perception depends on three signals: image movement signal (IMS), motor signal (MS), and corollary discharge signal (CDS). According to the points mentioned above, when subjects are viewing dynamic stimuli, they are supposed to have saccadic eye movement to master the whole image and produce and compare the pre- and pro-change representations. The eye movement involved sends CDS to the comparator to the brain to produce and compare the representations. As for the stimuli is dynamic or changing rather than static, it is more difficult for subjects to detect the change, and the difference between CDS and IMS tend to be less aware. Referring to top-down processing, inadequate attention, and limited memory capacity, the perception of the pro-change image tends to keep static with the pre-change mental representation, failing to detect the change represented and perceiving the pro-change scene the same as the pre-change.

4.2. Mechanistic Differences: Change Blindness and Inattentional Blindness

Change blindness has a relationship with inattentional blindness and allows further complicated study about one crucial factor: attention. Many people, including expert psychologists, do not always distinguish change blindness from inattentional blindness because both phenomena refer to a failure to perceive certain perceptual event that appears in a scene [3]. However, change blindness, and inattentional blindness are different. Change blindness requires two images: the visual state pre- and pro-change, having no intentionally stimuli or task; while inattentional blindness requires only one scene but with target stimulus.

4.3. The Centrality of Attention: Enhancing Encoding and Representation

Inattentional blindness has its mechanism of cognitive psychology, involving working memory capacity, perceptual load, and most importantly, attention [20, 21, 22, 23]. With knowledge of inattentional blindness, change blindness allows further complicated study on the topic of attention. To detect a change, subjects must compare the pre- and pro-change representations, making all characteristics which affect the richness of the representation or the tendency to compare representations valuable. Attention is significant in this process. According to current researches, devoting more attention to encode the changing item is supposed and does similarly improve the change-detection ability [24, 25, 26]. Additional encoding time can increase the fidelity of memory representations of the pre-change image and in turn, improve the observer’s change-detection ability by providing a more detailed memory representation.

4.4. The Influence of Semantic Meaning and Perceptual Load

Attention contributes to better representations and hence contributes to better pre- and pro-change items comparison. Semantic meanings also serve as an essential factor affecting change blindness. Familiar scenes can reduce the perceptual load and decrease the rate of change blindness [27]. Visual perception system needs attention and memory to organize and manage sensory information. Deficient attention affects visual perception in terms of central vision and “static” information conveyed by cones and rods. Notably, represented stimuli of change blindness experiments display changing or dynamic stimuli instead of static stimuli, which increases the perceptual load and involves up-down processing. Dynamic stimuli representing unexpected changes challenges the observer’s attention ability and memory capacity to compare pre- and pro-change mental representations. Moreover, with up-down processing,

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subjects tend to ignore the unexpected change for the high-level perceptual organizing and still perceive the scene before, failing to detect the change.

5. Synthesis and Conclusion: Change Blindness as a Window into High-Level Perception

In conclusion, change blindness is a significant phenomenon for understanding perception, especially for digesting high-level perceptual process. Perception is different from sensation and perception integrates sensory information in the high-level perceptual process. In order to detect change blindness, subjects should compare mental representations of pre- and pro-change images and figure out the change, involving perception, memory, attention, and top-down processing. The functions of rods and cones and central vision explain the foundation mechanism of blurred mental representations, resulting in some unexpected changed spots perceived keeping static owing to lacking attention. As for the changes are unexpected, subjects must view the whole image, which requires eye movement, involving corollary discharge theory in motion perception. The corollary discharge theory implicates that CDS will be sent to the brain before the eye movement. According to top-down processing, subjects tend to ignore the unexpected changes when they are concentrated to one particular scene or keep thinking from a high viewpoint. Change detection success requires mental representation comparison, making memory capacity a crucial factor. The more capable the memory is, the more easily one can detect the unexpected change. Related to inattentional blindness, change blindness allows further complicated study towards attention. In accordance with the top-down processing and memory capacity knowledge, attention affects visual perception and have effects on the high-level perceptual organization, resulting in change blindness phenomenon. Change blindness offers a new significant research topic for perception and shows the importance of the relationship between attention and perception.

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