論 文 の 内 容 の 要 旨

論文題目　Visual distortion with dynamic visual stimuli
（動的刺激による視知覚の歪みに関する研究）

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Humans survive in an environment of which things keep changing dynamically all the time. Vision, being the sense that humans rely on the most, has a limit in processing capabilities and is susceptible to various illusions. Chapter 1 provides an overview of the main topic of this thesis—visual distortions in dynamic situations. This chapter introduces three specific visual distortions that are examined in detail in the subsequent chapters. The attentional repulsion effect concerns that when a transient cue that captures spatial attention is presented just before the appearance of a target object, the perceived position of the target is shifted away from the cued position; similarly, if a cue is presented just after the target presentation, the target appears to be attracted toward the cued position, despite that the cue is presented at a moment later than the target (the attentional attraction effect). In the flash-lag effect (FLE), the position of a briefly-flashed stationary object is perceived to lag behind a nearby moving object. Although both of them are physically at aligned positions, the moving object appears to be at a position ahead of where it actually is along its motion trajectory. In object substitution masking, objects are masked by other objects and become invisible when they appear at close spatiotemporal positions. The information about the masked object is replaced by new objects before adequate processing has been done to allow the masked object to be consciously perceived. All these examples represent visual distortions that occur in high-speed dynamic presentation of visual stimuli. The three following chapters examine each of these three classes of visual distortions

using a psychophysical approach and discuss the implications on human visual processing in dynamic situations.

Chapter 2 examines whether visual awareness is necessary for capturing spatial attention and eliciting the attentional repulsion and attraction effects. Observers judged whether the two vertical bars of a briefly-presented vernier target (which is either temporally preceded by or followed by two cue discs that capture attention) were horizontally aligned, in two conditions where the cues were visible or rendered invisible by backward visual masking. Strong repulsion and attraction effects occurred in the cue-visible condition, which was consistent with previous findings; in the cue-invisible condition, the distortion effects also occurred in the same expected directions although somewhat weakened. In a separate task where observers judged the position of the masked cue instead of the target bar positions, observers could not reliably identify the cue position, showing that the attentional capture in the cue-invisible condition was operating without visual awareness. In the second experiment, observers performed the target bar position judgment and the cue position judgment simultaneously in each trial. The direction of the position distortion effects was found to depend on the physical position, rather than the observer-reported position, of the cue. This further supported that the attentional capture by invisible cues does not necessitate conscious visual awareness.

Chapter 3 examines the role of motion continuity in modulating the FLE. Previous studies have shown that a sudden change to the moving object at the time of the flash presentation can eliminate the FLE. This study examined whether the FLE would be eliminated when a sudden color change is embedded in a sequence of color alternations in a moving object. Observers viewed a moving disc, the color of which did not change at all, changed only once when another stationary object flashed, or alternated regularly (in the first experiment) or randomly (in the second experiment) between two colors as it moved before the flash presentation. Although the magnitude was reduced compared to the no-change condition, the FLE observed with the moving object that changed its color during the motion was significantly stronger than that in the one-change condition. In the third experiment, the object color alternated between two but unexpectedly changed to a new color when the flash appeared. The elimination of FLE in such condition was comparable to the one-change condition, suggesting that the unexpected change restored the salience of the moving object at the time of flash presentation, which spared the observer from perceiving the FLE. These results imply that, without an unexpected event, rapid changes in the surface feature of the moving object partially degrade the maintenance of object identity information, but this does not preclude the visual system in registering the existence of only one object in the motion stream.

Chapter 4 reports a new illusion of numerosity underestimation in dynamic visual displays. Numerosity estimation of a large number of objects in a static visual display is possible even

with a short duration; this chapter examines the numerosity estimation of visual objects in dynamic displays and the effect of object similarity on numerosity estimation. In the basic paradigm, two streams of dots were presented and observers indicated which of them contained more dots. The streams consisting of dots with the same color were judged to contain fewer dots than the streams with different colors. This underestimation effect for identical visual items disappeared when the presentation rate was slow (the first experiment) or when static displays were used (the second experiment). In the subsequent experiments, in addition to the numerosity judgment task, observers performed another attention-demanding task at the fixation. The task difficulty influenced the observers' precision in performing the numerosity judgment task, but the underestimation effect remained evident irrespective of task difficulty. These results suggest that identical or similar visual objects presented in succession may induce substitution masking among themselves, leading to an illusion of being less numerous overall, and that exploiting attentional resources does not eliminate such underestimation effect.

Chapter 5 summarizes the main findings and implications drawn from the series of studies reported in this thesis regarding the processing of dynamic visual information by the human visual system. The thesis is concluded with the remark that psychophysical experiments can provide clues and directions to supplement neuroscientific studies, to bring about new understanding of information processing in the brain.