Configuration effects on texture transparency

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Abstract—This study examined the factors producing the perception of transparency between overlaid regions composed of Gabor micro-patterns as functions of their spatial frequency, separation of overlaid regions, and types of orientation modulation. The results showed that the likelihood of perceiving transparency was high both when (1) the difference in Gabor spatial frequency between regions was large, and (2) the region boundary, which was formed by short-range orientation differences in the Gabor micro-patterns, clearly emerged. We conclude that texture transparency appears to result from an interaction between a boundary-detection mechanism defining the shape of each region and a surface-detection mechanism assigning the boundary.

Keywords: Texture segregation; perceptual transparency; boundary assignment.

1. INTRODUCTION

The visual system can recover three-dimensional geometrical relationships between visual objects by using various cues. For example, we often encounter situations where one object occludes another. If the occluding object is transparent with some transmittance, the occluded object is also visible. This situation is often called perceptual transparency, and it has been argued that luminance and contrast conditions are required for such perceptual transparency (Metelli, 1974; Beck et al., 1984; Adelson, 1993; Singh and Anderson, 2002a, b). It has been further suggested that perceptual transparency is a cue for pop-out phenomena (Mitsudo, 2003). Therefore, it is possible that the representation of transparency is generated at a relatively early level of visual processing (Watanabe and Cavanagh, 1992).

Recently, Watanabe and Cavanagh (1996) demonstrated a novel perception of transparency. In their study, observers perceived transparency strongly when a display contained two overlapping regions, in which each region was composed of different kinds of texture, as shown in Fig. 1. Watanabe and Cavanagh also

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reported that the impression of transparency varied with the junction between the texture elements. The impression of transparency increased when there was no junction between the texture elements and decreased when the junctions were $x$- or $t$-junctions. As a result, the overlapping parts of the two textures containing these junctions appeared to separate from their non-overlapping parts, producing a distinct third region. Therefore, they suggested that perceptual grouping of similar texture elements, that do not make a junction, may induce the perception of transparency from the texture. They designated the appearance of this phenomena ‘texture laciness’. This perception of transparency from texture may occur even when there are no luminance or contrast conditions involved, as previously suggested by Metelli (1974). In this paper, we call the perception of transparency caused by texture cues ‘texture transparency’.

Kingdom and Keeble (2000) showed that spatial frequency differences facilitate the segregation of layered textures (see also Kingdom et al., 2001). They used two layered orientation-modulation gratings (OMG) as stimuli. When a spatial frequency difference was introduced into the Gabor micro-patterns making up the two superimposed, but out of phase, OMGs, the amplitude detection thresholds declined significantly. Although they did not directly measure the impression of transparency, one can gain the impression of transparency when observing their stimuli where the spatial frequency difference between the two OMGs is large. Therefore, we suggest that the spatial frequency difference between surfaces may be a factor in texture transparency.

The general goal of this study was to clarify the factors producing texture transparency. We had two aims. First, we aimed to clarify the effect of spatial frequency differences on texture transparency. While Kingdom and Keeble (2000) showed that, even without any spatial frequency differences between their superimposed out-of-phase OMGs, the modulation could be detected (albeit with elevation thresholds), Watanabe and Cavanagh (1996) showed that the impression of transparency was significantly reduced in superimposed textures of identical elements in terms