別紙４－１（課程博士（英文））

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Abstract（Doctor）

Title of Thesis	Color appearance of extreme fine stimuli: effect of optical and neural factors

Approx. 800 words

The colors of fine details are essential in our lives. For example, fabrics are made of various colored threads, and facial emotions are expressed by faint colors of the cheeks and lips. The importance of fine color details has increased in the era of high-resolution displays. It is known that a surrounding area influences the color appearance of a center area, and the influence becomes critical for detailed images. It is also known that the optical artifacts of the human eye, such as blurring and chromatic aberrations, degrade fine details and the colors of images. These neural and optical effects are integrated via the visual system and form our perception. Thus, it is important to differentiate these effects to understand how our color vision works.

This thesis focuses on the Monnier-Shevell illusion, which induces a significant color shift of a center stimulus according to two surrounding, spatially alternating complementary colors. The illusion is evident for S-cone colors (blue–yellow pairs) but not for L/M-cone colors (red-green pairs) for unknown reasons. It is thought that the effect works better for S-cone colors because the illusion is due to a synergistic effect of assimilation from the proximal colors and contrast from the distantly surrounding colors, and known spatial representation of colors in the early visual system is comparable for both S-cone and L/M-cone colors except for its spatial resolution. Here, I report a new spatial context of the Monnier-Shevell illusion, in which a thin gray line (test line) flanked with white lines (contour) appears reddish when surrounded by a uniform cyan. Psychological experiments and simulations excluded the possibility of the illusion being induced by optical artifacts. Experiment 2 showed that a chromatic (as opposed to an achromatic) contour modified color shifts, indicating linear summation of the color induction effect, chroma of the contour, and chroma of the test. In Experiment 3, I investigated the effect of line widths of the illusion and found that maximum effects for the L/M-cone colors were 0.9 and 1.9 min of visual angle for the contour and the test line. These widths corresponded to the width of a single photoreceptor and were eight times thinner than optimal widths for the S-cone colors. Observed differences of the optimal widths between two colors could reflect the known difference in spatial property between two colors.

Experiment 4 examined the effect of luminance contrast of the contour and found that a black contour instead of a white one diminished the illusory effect, indicating the importance of the white contour, and simple spatial organization along the chromatic axis failed to explain the illusion.

Simulation of the chromatic shift due to optical artifacts predicted the large chromatic shift at the retina; however, perceived color closely matched the actual chromaticity of the stimuli. This indicates that the human color system seems to provide veridical perception of color using some type of compensation, which could be attained through contrast enhancement from distant surroundings. This compensation works well for simple uniform backgrounds, but patterned backgrounds, such as our stimuli of flanking white contours and the original Monnier-Shevell illusion, induce an unexpectedly large color shift because the flanking white contours break the balance between the proximal assimilation and distant contrast effects. This interpretation suggests the Monnier-Shevell illusion is the side effect of removing chromatic shifts by the optical artifacts. This thesis describes the color appearances of fine stimuli and the effect of the complex spatial context. The neural mechanisms and models revealed here are useful for modern high-definition image-engineering applications.