氏名	原（はら） 真一郎（しんいちろう）
博士の専攻分野の名称	博士（理学）
学位記番号	第 26271 号
学位授与年月日	平成25年3月25日
学位授与の要件	学位規則第4条第1項該当 生命機能研究科生命機能専攻
学位論文名	Neural correlates of the lightness constancy in the dorsal lateral geniculate nucleus (dLGN) and the retina of the cat （ネコ外側膝状体および網膜における明るさの恒常性と相関する神経活動）
論文審査委員	(主査) 教授 佐藤 宏道 (副査) 教授 北澤 茂　教授 八木 哲也　准教授 田村 弘

論文内容の要旨

Our visual system does not act as a photometer simply for measuring luminance of light. Rather it acts as an analyzer for estimating the reflectance of the surface (lightness), by which we can perceive constantly white surface of an object as white under various illuminant conditions (lightness constancy). The neural mechanisms of lightness have not been known yet. To examine how the lightness is represented in neuronal activity of early visual areas, I recorded the single-unit activity from the lateral geniculate nucleus (LGN) and the optic tract of anesthetized and paralyzed cats, and examined responses to the circular patch with uniform luminance (center stimulus) in the preferred polarity (increment of luminance for on-center cell and vice versa). The center stimulus was presented for 500 msec to the large area (10 deg in radius) covering both the cell's classical receptive field (CRF) and the proximal area outside the classical receptive field with or without a concurrent luminance change of the distal background area beyond center stimulus (background stimulus, BG stimulus). Forty three percent of LGN neurons responded significantly to the center stimulus, which were called as "surface-responsive neuron, SR neuron". Eighty three percent of the SR neurons showed luminance-dependent response. The response magnitude increased in proportion to the degree of the luminance change of center stimulus, in which the luminance-dependency was observed in late response but not in early response. The BG stimuli modulated the late response but not the early response.

To examine whether the BG-modulated (brightness-related) responses correspond to lightness, I calculated the ratio of the luminance between center stimulus and BG stimulus (C/BG ratio) as a reflectance of the center stimulus and examined the C/BG tuning of the responses obtained under 2 levels of center luminance. The C/BG ratio tuning curves of the late responses at difference center luminance were similar well each other, suggesting that the late responses of SR neurons represent lightness.

To know how intrageniculate GABAergic inhibition contributes to the formation of lightness-related response, I also recorded neuronal activity before, during, and after microiontophoretic administration of bicuculline methiodide (BIC), a specific $GABA_A$ receptor antagonist, and CGP52432 (CGP), a specific $GABA_B$ receptor antagonist. BIC with and without CGP increased spontaneous discharges and response magnitudes, but did not change the C/BG ratio tuning. These results suggest that lightness representation in the LGN emerges from excitatory inputs but not inhibitory inputs.

To examine the source of the excitatory inputs, I recorded from the single optic tract (OT) fibers under the same experimental conditions as LGN examinations. The OT fibers showed lightness-related responses with similar response properties as LGN neurons except that time course of center-stimulus-evoked spike response and BG-stimulus-evoked response modulation were earlier than that of LGN neurons. Therefore, I concluded that a certain population of LGN neurons represent not only luminance but also brightness and lightness, and those response properties are possibly inherited from those of RGCs.

論文審査の結果の要旨

我々は、照明環境が変わっても白いものは白く、灰色のものは灰色として知覚する。この「明度の恒常性」と呼ばれる現象は、私たちの視覚系が、物体表面で反射される局所的な光の強さ（輝度）そのものではなく、物体表面の反射率を推定して明度の知覚を生み出すことを示している。しかし、反射率推定の神経機構は未だに解明されていない。

本学位論文において申請者は、麻酔・非動化したネコの外側膝状体(LGN)ニューロンの神経活動を計測し、「明度の恒常性」の根拠となる反射率に相関する応答が存在するかどうかを検討した。その結果、多くのLGNニューロンが1）古典的受容野より大きな10度の一様輝度の刺激に反応すること、2）周辺刺激の明るさに応じて反応を変化させること、3）輝度ではなく反射率を反映した応答を示すこと、さらに4）その反応特性が網膜からの興奮性入力により形成されていることが明らかになった。

これらの結果は、網膜からの信号を元にして、外側膝状体ですでに反射率の推定が行われていることを示している。本学位論文は以上の通り、明度の恒常性を作り出す神経機構の解明に重要な貢献をした。よって、学位に値するものと認める。