様式３

論　文　内　容　の　要　旨

氏　名　（　吉岡　敏秀　）	
論文題名	Difference in representation of stereoscopic depth between visual areas MT and V4 in the macaque monkey （サル大脳皮質MT野とV4野における両眼性奥行き情報表現の相違）

論文内容の要旨

Binocular disparity is a powerful cue for stereopsis. The visual system represents binocular disparity in two different manners, i.e., correlation-based and match-based. In the correlation-based representation, cross-correlation between left-eye and right-eye images (binocular correlation) determines neural responses. In the match-based representation, the number of contrast-matched features between left-eye and right-eye images (binocular match) determines neural responses. Psychophysical evidence indicates that both representations directly contribute to stereopsis. Neurons in the primary visual cortex (V1) detect disparity by computing binocular correlation, whereas neurons in higher visual areas such as areas V4 and IT represent disparity in a match-based manner. Given that neural activities in V1 are not directly related to subjects' depth judgement, an area (or areas) higher in the visual hierarchy should have correlation-based response profiles. However, an evidence for correlation-based representation in areas other than V1 remains elusive.

To test whether an area beyond V1 has correlation-based response profiles, I recorded neural responses from area MT in the dorsal stream, a counterpart of V4 in the ventral stream, of two monkeys (*Macaca fuscata*) during a fixation task. I used dynamic random dot stereograms (RDSs) as visual stimuli. The RDSs consisted of a circular central patch and a surrounding annulus. The circular patch covered the receptive field of the recorded neuron. I systematically manipulated a proportion of random dot pairs whose luminance contrasts were reversed between the left-eye and right-eye images. Binocular disparity and the proportion of contrast-reversed dot pairs were randomly changed from trial to trial for the center patch, whereas the surrounding annulus always had 0 disparity and 100% binocular correlation (100% binocular match). This graded anti-correlation technique changed binocular match and correlation in a dissociable manner, allowing characterization of representation of the neurons under study.

When binocular correlation was decreased from 100% to 0% (binocular match was decreased from 100% to 50%), MT neurons weakened their disparity modulation as predicted from the correlation-based representation. With a further decrease in binocular correlation from 0% to -100% (binocular match was decreased from 50% to 0%), MT neurons behaved in a manner between correlation-based and match-based predictions; their disparity tuning curves were inverted relative to those obtained 100% correlated RDSs but had a tuning amplitude of less than one (ideal correlation-based representation should have a tuning amplitude of one). This was in sharp contrast to the response profiles of V4 neurons which showed no disparity modulation for -100% correlated RDSs (Abdolrahmani et al., 2016). Thus, responses of MT neurons inherited the characteristics of correlation-based representation in V1, whereas the responses of V4 neurons were match-based. Disparity representation was different between MT and V4. I further demonstrated that the disparity representations of MT neurons correlated with some other aspects of visual response properties. Neurons with asymmetric disparity tuning curves tended to respond in a more correlation-based manner, whereas those with symmetric disparity tuning curves followed match-based prediction. Neurons preferring high refresh rates had the correlation-based response profiles, whereas those preferring low refresh rates followed match-based prediction.

The present results provide the first unequivocal evidence for the existence of correlation-based signal in a visual area beyond V1. The difference in disparity representation between MT and V4 may be accounted for, at least partly, by the differences in the symmetry of the disparity tuning curve and the refresh rate preference.

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論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

本研究はサルの頭頂葉視覚経路のMT野における両眼視差情報の処理様式の解明を行った。両眼視差脳内処理には、両眼像の間の空間相関を表現した活動（両眼相関表現）と両眼像の間で一致した視覚特徴の間の視差だけを表現した活動（両眼対応計算）の二つがある。本研究は、段階的輝度反転ステレオグラムを用いて、MT野細胞がどちらの表現に近いか、また、腹側視覚経路のV4野と比較してどのような特徴を持つかを調べた。その結果、MT野細胞集団の性質は２つの表現の中間的な性質を示すものの、両眼相関表現に特有の性質を明白に持つことを示した。V4野細胞集団はほぼ完全に両眼対応を基にした活動であった。さらに、個々の細胞がどちらの表現に近い情報を伝えているかが、両眼視差チューニングのタイプと刺激更新頻度選択性と相関することを見出した。以上の結果は、２つの両眼視差表現が脳内の異なる領域でなされていることを示唆し、さらに両眼対応を算出する非線形処理の強弱が個々の細胞の時間応答特性と相関することを明らかにした。これらの結果は両眼立体視の神経機構の理解を大きく進めたものとして、博士号に値するものと判断する。