様式３

論　文　内　容　の　要　旨

氏　名　（　青木俊太郎　）	
論文題名	Binocular cross-correlation computation produces depth perception in a relative frame of reference (両眼相関計算は相対的参照枠に奥行き知覚を形成する)

論文内容の要旨

Binocular disparity, a cue for depth perception, is encoded based on interocular cross-correlation of visual images and solution of the stereo correspondence problem. The correlation computation produces reversed depth perception in a binocularly anti-correlated random dot stereogram (aRDS) when an adjacent depth reference of a correlated RDS (cRDS) is presented. Removal of the depth reference abolishes reversed depth perception, suggesting that the correlation computation forms depth in a frame relative to the reference plane (a relative frame of reference) but not in a frame centered at a fixation point (an absolute frame of reference). Neural representation of correlation-based disparity signal, however, encodes disparity of a visual feature from the fixation point (absolute disparity) rather than relative disparity between two objects. Neurophysiological evidence thus predicts that correlation computation forms depth in an absolute frame of reference.

To resolve these discrepancies, I psychophysically tested the frame of reference in which reversed depth perception in aRDSs takes place. When viewing an aRDS disk with zero absolute disparity surrounded by a cRDS annulus with non-zero (crossed or uncrossed) disparity, subjects perceived reversed depth. Since the absolute disparity of the center disk was zero, this result cannot be explained by reversal of depth in an absolute frame of reference. When RDSs without disparity (uncorrelated RDSs) were surrounded by cRDSs with non-zero disparity, subjects did not perceive reversed depth. Hence, relative disparity between aRDSs and cRDSs is essential for the reversed depth perception. The reversed depth perception occurred when aRDSs with zero absolute disparity was presented briefly (94 ms). When disparities of both the center aRDS and the surround cRDS were manipulated, subjects' depth perception was reversed from the depth of the surround but not from the fixation depth. The reversed depth perception also arose for cRDSs surrounded by aRDSs. Combination of correlation-based absolute disparity detectors produced sensitivity to relative disparity that supported reversed depth perception in a relative frame of reference.

The results indicate that reversed depth perception in aRDSs occurs in a relative, rather than an absolute, frame of reference. I conclude that correlation-based representation produces perception of stereoscopic depth in a relative frame of reference. I suggest that correlation computation generates representation of relative depth in the brain.

様式７

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

両眼立体視において、脳は左右眼に投影された像の間の空間相関を計算する過程（相関計算）と、さらに両眼像間の対応を計算する過程（対応計算）を行い、その両方の出力の重み付け和が奥行き知覚を決定する。左右眼において輝度を反転した逆相関ランダムドットステレオグラムを見ると奥行きが幾何学的に定義される両眼視差とは逆転して見えることが、相関計算が直接的に奥行き知覚に根拠とされている。青木俊太郎氏は、ヒトを被験者にたくみな心理物理学的実験を行い、この時逆転するのは相対視差に基づく奥行きであって、絶対視差に基づく奥行きではないことを示した。さらに、両眼相関を表現している細胞が相対視差を算出するモデルを考案し、この心理物理学的知見を理論的に説明することに成功した。これらの成果は、従来、サルを用いた研究から考えられてきた「相関計算を行う神経システムは絶対視差を伝えており、対応計算を行う計算システムが相対視差の算出を担う」という考え方に変更を迫るものであり、両眼立体視の脳内機構の理解を進めたものとして評価できる。博士号学位を授与するに値すると判断する。