様　式　Ｃ－１９、Ｆ－１９、Ｚ－１９　（共通）

科研費
KAKENHI

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平成　２７　年　　６　月　１０　日現在

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研究課題名（英文）Priors and visual perception

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研究成果の概要（和文）：我々が受け取る視覚情報は多くの場合曖昧で不確かである。有力な学説によると、我々は既存の知識を使って感覚証拠の曖昧さを解消している。この科研費課題は、ベイズ推定を考察し、視覚情報処理における事前知識（Priors）の脳内メカニズムの解明を目指した。機能的MRI、数理分析、及び行動実験においては、物体の動きが遅い場合に事前知識を使用するという結果を得た。また、事前知識によって物体の位置関係が効率よく脳に伝達されることで被験者の課題成績が向上するという仕組みも調べた。さらに、被験者は事前知識と感覚証拠を統合して意思決定を行っているわけではなく、２つを切り替えている、という発見も得ることが出来た。

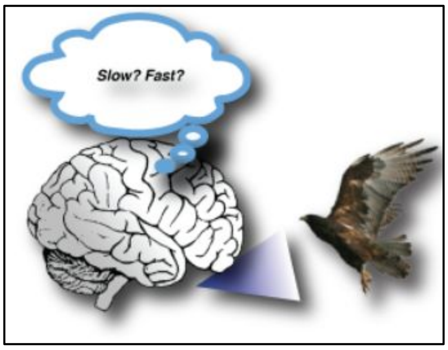
研究成果の概要（英文）：Often our visual sense gives us only ambiguous or uncertain information about the world. A powerful set of theories suggest that we should use prior knowledge to disambiguate such sensory evidence. This Kakenhi was geared towards understanding the representations of such prior information on visual processing. We chose to study this framework of Bayesian inference in the visual system for which there is considerable knowledge about the basic neural circuitry that represents sensory responses. Using functional imaging, computational analyses and behavioral measurement we found a representation of visual motion that incorporates a prior for slow movement. We have also examined how prior cues indicating the relevance of particular locations can enhance behavioral performance by efficient selection of sensory signals. Finally, we have uncovered evidence for a behavioral switching heuristics in which subjects switch between priors and evidence rather than integrate the two.

研究分野：神経科学

キーワード：事前知識　Priors　fMRI　Attention　Vision　 Perception

１．研究開始当初の背景

Often sensory evidence is ambiguous and we need to make perceptual decisions based on prior information. For example, seeing a bird flying on a foggy day may be difficult and you may want to use prior information about the likely speed of birds in deciding how fast it is actually moving (figure 1).



Theory tells us that the optimal way to do this is to use Bayesian inference in which sensory evidence and priors are formalized as probability distributions which are multiplied to give you a posterior distributions. The best guess comes from a properly computed posterior which incorporates appropriately the uncertainty of sensory information and priors. This appealing and intuitive theoretical framework is thought to govern many human decision making behaviors from sensory inferences to more complex cognitive functions like understanding language and finding structure in the world. However, little is known about how such theoretic computations might actually be performed in the human brain and this Kakenhi project is aimed at understanding neural mechanisms that might implement Bayesian inference.

２．研究の目的

One area of focus for the Kakenhi project was to examine the process involved in estimating the speed of motion of simple stimuli. We focused on this area because there are theoretical models and a wealth of psychophysical data suggesting that speed estimation may be an example of Bayesian inference. In particular, when stimuli are of low contrast and are therefore hard to see, the sensory evidence about their speed is weak. Human subjects are then biased towards seeing these stimuli as moving slowly. Theoretical work has interpreted this as a prior for slow motion in that it suggests that the bias towards slow is a prior that is invoked when sensory evidence is weak. The strength of this theoretical work is that it explains a whole host of different, otherwise seemingly disparate motion related phenomenon like what direction an ambiguous one-dimensional motion appears to move in (called the aperture problem), various perceptions of plaid stimuli and the directions that a moving rhombus appears to move in as you vary its dimensions and contrast. We therefore aimed to understand how and where this bias for slow appears in human cortical processing.

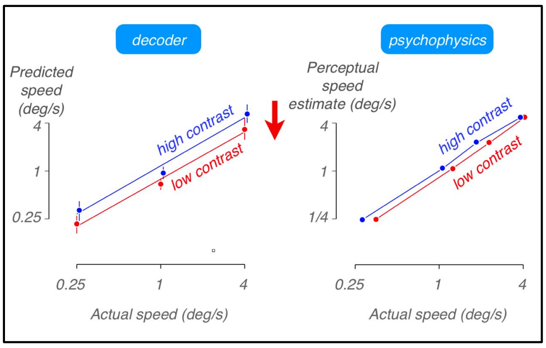
３．研究の方法

We used psychophysical methods to establish the general phenomenon of a bias for slow in speed perception. To do this, we had subjects view a control stimulus and another stimulus at different speed and contrast and asked them to vary the speed of the other stimulus until it perceptually matched the control. Using this procedure we were able to establish that subjects showed a prior for slow.

We also made use of function imaging measurements using magnetic resonance imaging (fMRI) and decoding techniques. We showed human subjects different stimuli moving at different speeds and contrasts and then measured the pattern of fMRI response in topographically determined visual areas. We used standard retinotopic procedures to determine these topographic areas. Using machine learning techniques (LARS-lasso regression), we built regression models that predicted the speed of stimuli using voxel responses. These techniques build sparse regressions models in which weights on most voxels are zero and ones with actual information about the speed of stimuli are weighted appropriately. We then examined the prediction of these models on cross-validated data to see how they would preform. Would they predict for lower contrast the veridical speed of the target, or would they predict the perceptual speed which incorporates the slow speed prior.

４．研究成果

We found that we were able to predict the speed of targets human subjects had viewed in the magnet. This is a finding by itself since the representation of speed is not simple but thought to be distributed and it was not clear from the onset that the coarse resolution of fMRI would give us access to these representations. We then tested what the representation looked like when the contrast was lowered (left side of figure) and found that it was decreased matching perceptual estimates (right side of figure).



Our results suggest that this bias for slow, if it is a prior for slow motion, is represented in the earliest part of the visual processing. This may be because it is a prior that is established over a long period of time (subjects show the prior when they are first tested and it is not learnt within the testing period).

５．主な発表論文等
（研究代表者、研究分担者及び連携研究者には下線）

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〔図書〕（計　0　件）

〔産業財産権〕
○出願状況（計　0　件）
名称：
発明者：
権利者：
種類：
番号：
出願年月日：
国内外の別：

○取得状況（計　0　件）
名称：
発明者：
権利者：
種類：
番号：
出願年月日：
取得年月日：
国内外の別：

〔その他〕
ホームページ等

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