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ORIGINAL PAPERS

Brain Function: Free Energy, Predictive Processing and Active Inference

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Abstract *A potential new theory of brain function based on Bayesian inference could be that the brain is a predictive processing system that generates internal models of the world to make predictions about future sensory inputs. According to this theory, the brain generates internal models based on prior beliefs and past experiences, which are used to make predictions about future sensory inputs. In summary, the free energy principle focuses on minimizing the difference between the predicted and actual sensory inputs using a hierarchical generative model, while the predictive processing theory focuses on generating and updating internal models to make predictions about future sensory inputs.*

Key words: Bayesian inference, free energy principle, sensory inputs, brain function, predictive processing.

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Introduction

One theory of brain function that is based on Bayesian inference is the free energy principle, which proposes that the brain seeks to minimize the difference between its internal model of the world and the sensory inputs it receives [1]. This process is thought to be implemented by performing Bayesian inference, which involves updating prior beliefs based on new evidence in a probabilistic manner.
However, a potential new theory of brain function based on Bayesian inference could be that the brain is a predictive processing system that generates internal models of the world to make predictions about future sensory inputs. These

models are constantly being updated based on new sensory inputs, and the brain seeks to minimize the prediction error, or the difference between the predicted and actual sensory inputs. This process is also implemented through Bayesian inference but emphasizes the role of prediction and active inference in guiding behavior.

1.Bayesian inference in the brain processing

According to this theory, the brain generates internal models based on prior beliefs and past experiences, which are used to make predictions about future sensory inputs. These predictions are compared to actual sensory inputs, and any discrepancies are used to update the model's parameters. The brain also actively seeks out information that can help reduce prediction error, such as by moving the eyes or body to explore the environment and gather new sensory inputs.

One potential advantage of this theory is that it emphasizes the importance of active exploration and information seeking in the learning process, which could have important implications for educational and therapeutic interventions. Additionally, this theory could provide a framework for understanding the role of different brain regions in generating and updating internal models and could help guide the development of new computational models of brain function.

The predictive processing theory of brain function based on Bayesian inference can be formulated mathematically using the principles of Bayesian probability theory and signal processing [2]. In this framework, the brain seeks to minimize the prediction error, which is the difference between the predicted sensory input and the actual sensory input.

More specifically, the brain generates internal models of the world, which are represented as probability distributions over possible sensory inputs. The model generates predictions by calculating the expected value of the sensory input given the internal state of the model. This prediction is compared to the actual sensory input, and the difference between the two is called the prediction error.

The prediction error is then used to update the internal model, which is done using Bayes' rule. Bayes' rule states that the posterior probability distribution over the internal state of the model given the new sensory input is proportional to the likelihood of the sensory input given the internal state of the model multiplied by the prior probability distribution over the internal state of the model. This process is known as Bayesian inference.

The mathematical expression for Bayesian inference is:

$$P\,(S|O) = \frac{P(O|S) \times P(S)}{P(O)} \qquad (1)$$

where:

P(S|O) is the posterior probability distribution over the internal state of the model given the new sensory input;

P(O|S) is the likelihood of the sensory input given the internal state of the model;
P(S) is the prior probability distribution over the internal state of the model;
P(O) is the marginal probability distribution over the sensory input.

This expression shows how the prior probability distribution over the internal state of the model is updated based on the new sensory input, and how the updated posterior probability distribution can be used to generate new predictions and guide behavior.

Overall, the predictive processing theory of brain function based on Bayesian inference can be expressed mathematically using the principles of Bayesian probability theory and signal processing. This framework highlights the importance of prediction and active inference in guiding behavior and provides a mathematical basis for understanding how the brain generates and updates internal models of the world.

The free energy principle is a theory of brain function that is based on the idea of minimizing the free energy of the internal model of the world. Free energy is a measure of the difference between the predicted sensory inputs and the actual sensory inputs, and the brain seeks to minimize this difference by updating the internal model in a probabilistic manner. This process is implemented using a hierarchical generative model that generates predictions about sensory inputs based on the internal model of the world, and the brain seeks to minimize the prediction error, or the difference between the predicted and actual sensory inputs, by updating the internal model.

The predictive processing theory, on the other hand, is a theory of brain function that is based on the idea of generating and updating internal models of the world to make predictions about future sensory inputs. The brain generates these models based on prior beliefs and past experiences, and these models are constantly being updated based on new sensory inputs. The brain seeks to minimize the prediction error, or the difference between the predicted and actual sensory inputs, by updating the model's parameters in a probabilistic manner.

Conclusions

In summary, the free energy principle focuses on minimizing the difference between the predicted and actual sensory inputs using a hierarchical generative model, while the predictive processing theory focuses on generating.

R E F E R E N C E S

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