

Uncertain decisions are strongly influenced by risk-attitude. In humans, risk-attitude is flexible and depends on contextual factors, such as whether the outcomes represent gains or losses, and the current wealth level. However, the neural mechanisms underlying these effects are not known. To investigate these questions, we designed a risk-based decision-making task, in which monkeys had to choose between a sure option with certain outcome and a gambling option with uncertain outcome with different explicitly indicated probabilities. Critically, the monkeys were trained to accept token as a secondary reinforcer. Across multiple trials, they had to accumulate six tokens to earn a standard fluid reward. This allowed us to test gamble options that resulted in a gain or loss of token and to test the effect of different token assets on the preference for the same gamble option.

Our behavioral results showed that the risk-attitude of the monkeys was both influenced by the gain/loss domain and by the currently accumulated token number. The monkeys showed an overall tendency of risk-seeking in both the gain and the loss domain. However, they displayed more preference for the gamble option when facing a risky gain than when facing a risky loss. In addition, we found an effect of token assets at the start of a trial on choice behavior. This effect varied in the gain and the loss domain. With increasing token assets, monkeys were prone to choose the gamble option less often in the gain domain, but more or equally often in the loss domain.

To study the neuronal mechanisms underlying this results, we recorded from neurons in the anterior insular cortex (AIC). We found that many AIC neurons encode the wealth level of the monkey, i.e. the token number at the start of trial. In addition, we found that many AIC neurons encode, whether the offers represented a gain or a loss. Some of them encoded the contextual difference between gain and loss in a binary manner. Other neurons represented a context-specific value signal. These neurons encoded the expected value of options in a parametrical manner, but asymmetrically, only in the gain or loss domain. These gain/loss context signals and wealth level signals were present before the decision was made. Furthermore, we found that trial-by-trial fluctuations of these token- and gain/loss-encoding neurons were significantly correlated with fluctuations in the monkey's risk-attitude.

In sum, our behavioral findings indicate that the monkey's choices depend heavily on their relative changes in wealth (gain or loss), as well as wealth level. Our neural data indicate an important role of AIC in monitoring contextual factors that influence risk attitudes.