# Single neuron and population analysis of visual motion direction : effect of uncertaincy.

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## Introduction

Studying the **internal representation** of natural features in the primary visual cortex (V1), like direction or spatial frequency, is crucial to understand how we perceive the external world. Research on 2D motion direction in **non-human primates** in particular when displaying **naturalist-like stimuli** like Motion-Clouds reveals substantial diversity and multiple mechanisms within the neuronal population [1]. The aim of this project is to examine how a large population of V1 neurons encodes stimulus direction and how this representation is modulated by the uncertainty.

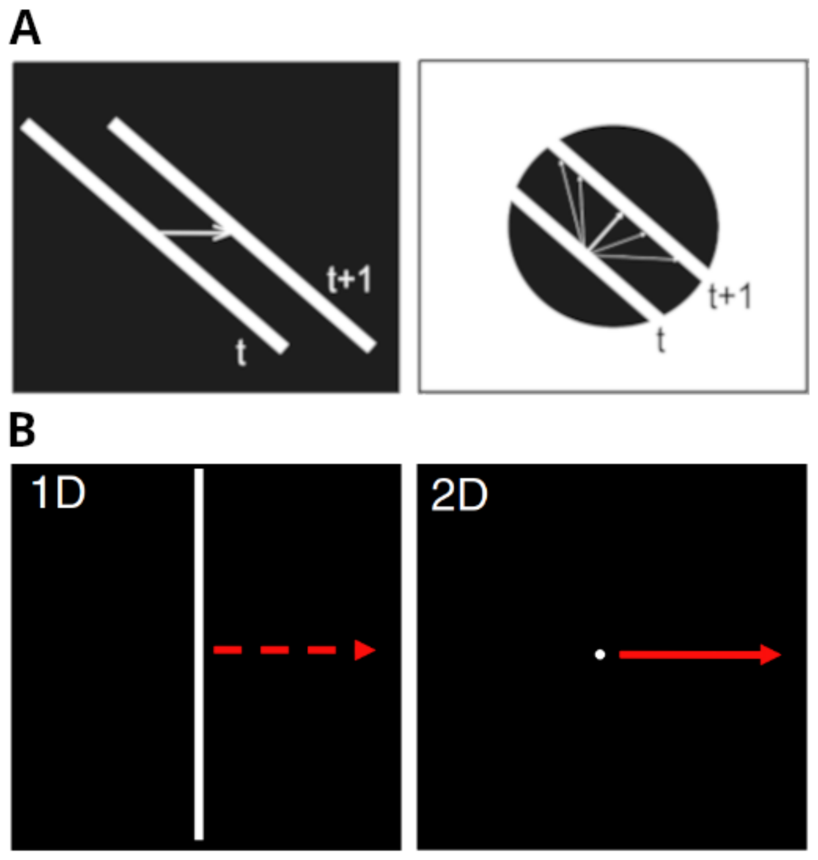
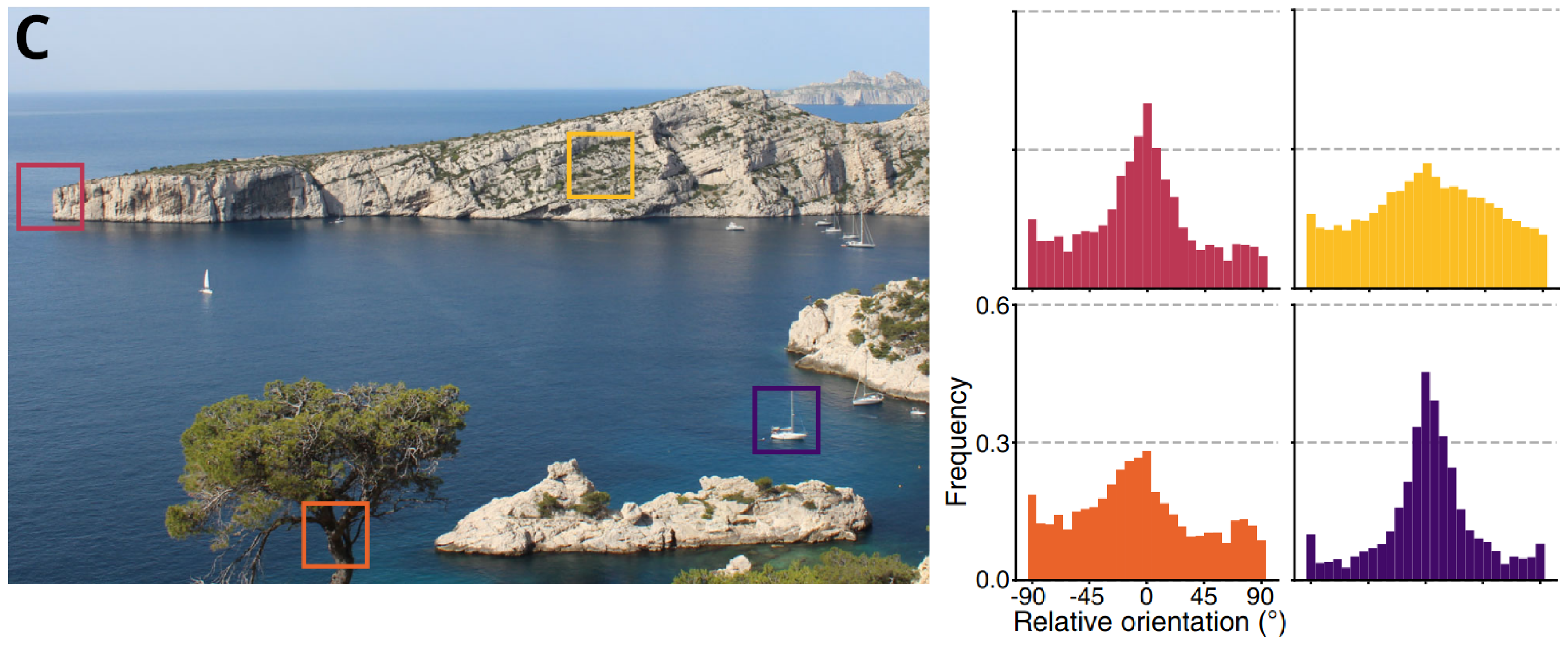



Figure 1: **A.** The aperture problem. **B.** 1D vs 2D visual information. **C.** Orientation distribution of natural patches. (**A** and **B** are adapted from [2])




## Method

Neuronal recordings were made in V1 of one marmoset monkey using the Neuropixel technology during 2D motion presentation in twelve directions ($\theta$) from $0°$ to $330°$, four levels of orientation bandwidth ($B_\theta$; $0°$, $15°$, $30°$ and $45°$) and four levels of spatial frequency bandwidth ($B_{sf}$; $0.01$, $0.175$, $0.7$ and $2.8$ cpd). A Motion-Clouds [3] is obtained by assigning a random phase to its corresponding Fourier envelope and computing the inverse Fourier transform.

The decoding method based on [4] defines the likelihood function of the stimulus direction as an equivalent to the sum of the likelihood functions of each neuron, which is equivalent to summing the agreement functions of each neuron weighted by the activity of each neuron during stimulus presentation.

If we take $W_i$ as the tuning curve of neuron $i$ and $A_i^s$ as the activity induced by simulus $s$. Then, $L_i^s$ and $L^s$ are respectively the likelihood function for a particular trial of the neuron $i$ and the population.

$$\log L^s(\theta) = \sum_{i=0}^{N} \log L_i^s(\theta) = \sum_{i=0}^{N} A_i^s(\theta) \log W_i(\theta)$$

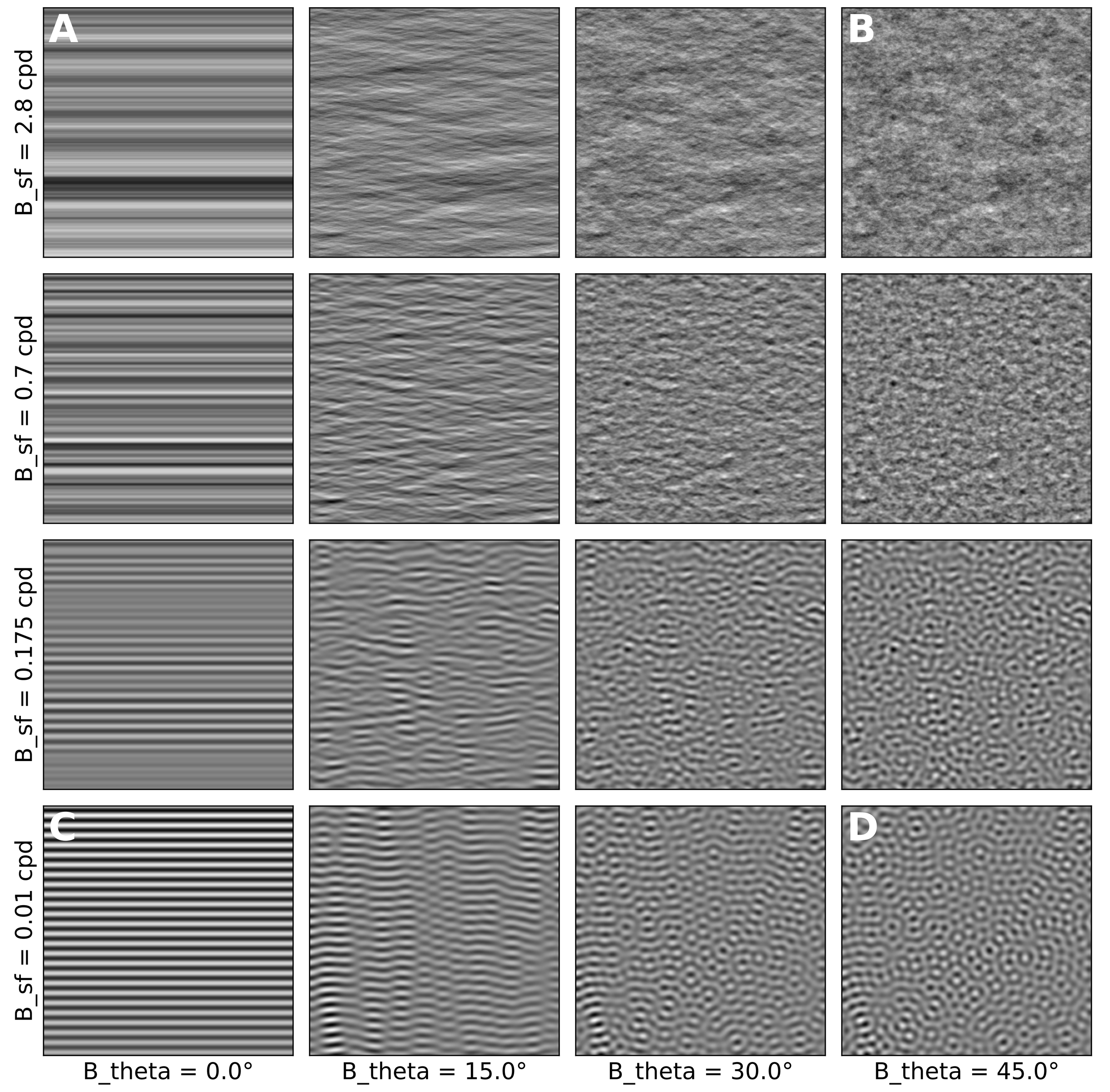



Figure 2: Motion-Clouds examples from sinusoidal grating (**C**) to pink noise (**B**), 2D noise (**A**) and 1D noise (**D**).

## Results : single neuron analysis

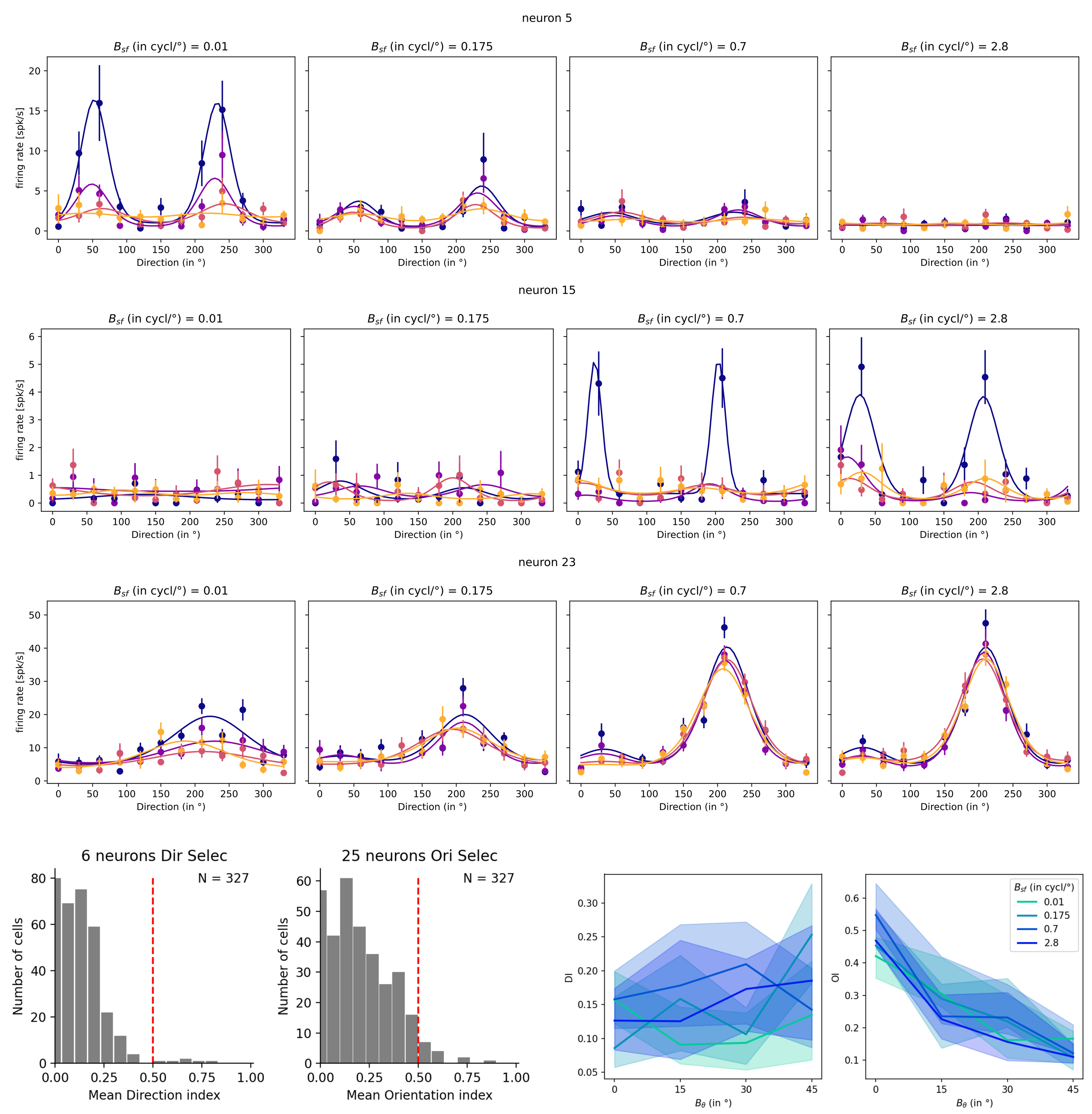



Figure 3: Representative fitted tuning curves for different orientation and spatial frequency bandwidths. Distribution and modulation of orientation and direction selectivity indices (OI, DI) across bandwidth conditions.

## Results : population decoding

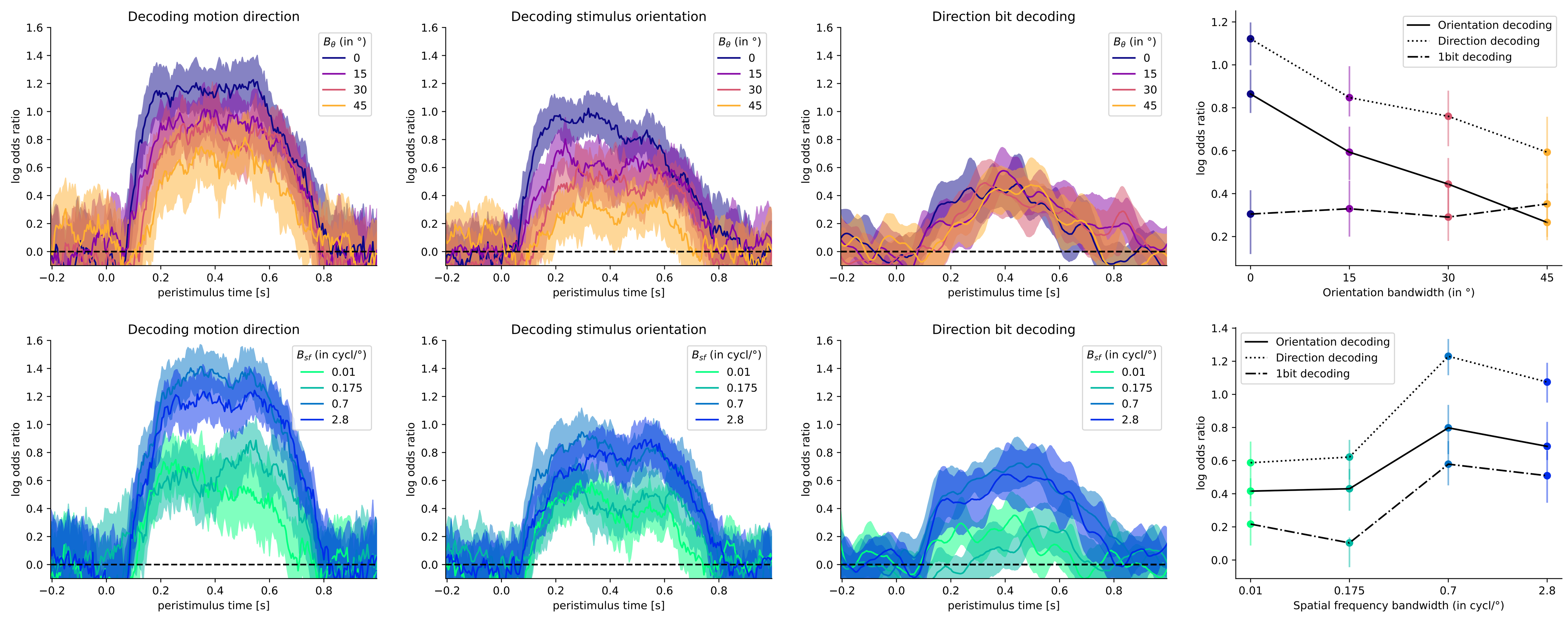



Figure 4: Direction ($\phi$), orientation ($\theta$) and direction bit decoding for different orientation and spatial frequency bandwidths ($B_\theta$, $B_{sf}$).

## Perspectives

Coupling decoding method and Motion-Clouds allow us to study how V1 population responses encode orientation and direction information by tiltrating the precision level in orientation and spatial frequency domains. In this context, MotionPlaids could offer an interesting next step to study how the brain combines oriented motion components, helping to disentangle orientation and direction contributions to population activity and to better understand how motion ambiguity is resolved in V1.

## References

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