Representation of tactile features by the vibrissa system in awake behaving rats

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In the vibrissa system, the transformation of tactile features of objects into their neural representation consists of two main parts. The features are first transformed into a pattern of vibrissa deflections which are transduced into neural signals by mechanoreceptors embedded in the soft tissue surrounding the follicle. These deflections are then transformed into increasingly abstract neural representations at ascending levels of the somatosensory pathway. Surprisingly little is known about the first stage of this transformation. Here, we focused on the mechanics of vibrissa deflection. We used high-speed videography of awake behaving rats running on a linear track, on the sides of which various objects and textures had been placed so that the vibrissae would brush against them. We also developed a realistic finite-element model of a vibrissa. In both the recorded data and in the model, certain tactile features are well-represented by the motions of the base of the vibrissa. In general, the vibrissa motion appears to depend strongly and reproducibly on the macroscopic features of surface morphology, and not on microscopic features such as friction. In addition, we amassed a large database of vibrissa deflection patterns in the presence of various textures and characterized the corresponding statistical variations in vibrissa motion due to differences in the manner in which the vibrissae engage the surfaces. Variables such as running speed, distance from the head to the surface, and angle of contact have a variety of effects on the resulting vibrissa motion. In ongoing work, we are recording multiple single-unit extra-cellular activity in S1 cortex simultaneously with the high-speed video of vibrissa deflection. We hypothesize that utilizing vibrissa measurements as the stimulus input to the system will enable us to investigate how the neural pathway transforms and represents the features of tactile stimuli under various conditions. Finally, to determine the differences in neural representations in the anesthetized and awake states, we are comparing the measurements made in awake rats with measurements of neural activity made in anesthetized rats in which we present a reproduction of the awake-measured stimuli.

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