Dead skin encodes the perception of microscale textures

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Abstract

Dynamic touch provides us with greater resolving power than our eyes do, making the finger pad an instrument of choice for the perception of fine textures and materials. Recently, researchers have discovered that humans can tactually discriminate sinusoidal gratings that are one to two orders of magnitude smaller than a single skin cell. In this study, we present a psychophysical evaluation demonstrating that humans can discriminate microscopic periodic features not only by their size but also by their direction. To explain this remarkable ability, we investigated the concurrence of multiple phenomena, including adhesive and interlocking frictions as well as cutaneous viscoelastic stiffening. Through high-fidelity tribological measurements, we obtained evidence that the keratinized outermost skin layer, known as the stratum corneum, undergoes a frequency-driven phase transition. This arises from the numerous consecutive interactions that occur when sliding against microscale features. We formulated a novel dynamic model of microscale contacts to capture this effect. It unveils the mechanism by which skin cells transition from a soft, rubbery state to a rigid, glassy state, resulting in significant variations in adhesive friction. These findings establish the basis of a pre-neuronal mechanical coding of microscale rugosity. Consequently, the viscoelastic properties of our outermost skin layer may contribute to our ability to identify natural materials like wood, owing to their fractal roughness.

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