Tactile information processing in the brain and the effects of spinal cord injuries

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Abstract: Brain receives information about the surroundings via sense organs. Receptors in the sense organs act as detectors of energy (light, sound, pressure) or chemicals (for taste and smell). Different receptors are sensitive to different features of inputs, such as specific frequencies of light. This improves sensitivity and resolution across a wide range of the signal magnitude. Receptors of different animal species have evolved to enable detection of aspects of the environment that are essential for its survival. Information from the receptors is transmitted to the brain in the form of binary electrical pulses called action potentials. Frequency and timing of action potentials provides information about the intensity and temporal dynamics of the input signal. Other features of the signal, for example, frequency of the touch and its location on the body are coded by specificity of the circuits connecting specific receptors to the specific parts of the brain.

Sensory inputs are processed in a network of neurons, the brain cells. Neuron is an information processing unit that connects with other neurons to form progressively larger information processing nodes. Connections between neurons are both parallel and serial, with converging and diverging inputs and outputs. Information flow through these nodes is regulated by feedforward and feedback connections, which permit, amplify or inhibit flow of information. From these one or two-dimensional segregated inputs, brain, the network of neurons, creates a rich multidimensional percept of the world around us. Brain also filters the information so that only relevant parts of multitude of inputs become salient for conscious perception, i.e. attention, learning, memory formation, and reaction.

The sense of touch along with the knowledge about body position and muscle tension is processed in the somatosensory system. Mechanoreceptors in the skin convey information about touch to different processing centres in the brain. Besides creating the tactile percept this information is used to control movements. My laboratory is interested in understanding how tactile information from the hand, the primary touch organ for humans and other primates, is processed in the brain to help create a unified percept of the object being manipulated. In the brain inputs from different fingers are organized in the form a map of the hand such that neurons receiving information from adjacent regions of the skin are located next to each other. We have recorded neuronal activity in the brain in response to touch on different parts of the hand. The results show that information from different digits is initially kept largely segregated in the primary somatosensory area of the brain. However, neurons also respond to touch on other digits, in a manner that reflects behavioural use of the hand. Such network properties presumably enable integration of information across different fingers.

In a second set of experiments we have determined how lack of inputs from the skin to the hand due to spinal cord injuries affects neuronal responses. Our results show that the part of the brain that received information from receptors in the hand, start responding to touch on other parts of the body, the face, suggesting the brain circuitry is a built in a manner that is highly flexible or plastic.