Chapter 10
Cognitive Functions and Neuronal Mechanisms of Tactile Working Memory

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ABSTRACT

The concept of tactile working memory indicated that the system can actively maintain (maintenance) and flexibly manipulate (manipulation) tactile information received from the body surface. The cognitive processes consisted of providing for the interim integration, processing, disposal, and retrieval of information. In this review, we combined psychophysical and neurophysiological experiments to highlight some of the most important characteristics and the neural substrates of tactile working memory. In particular, these studies have addressed how neural codes are related to perception and working memory in tactile modality. Tactile information is stored by segregated neural networks that include not only the prefrontal and parietal cortex, but also the somatosensory areas where relatively early stages of perceptual processing are carried out and past and current sensory information are combined to drive higher cortical areas.

INTRODUCTION

The theoretical concept of working memory proposes that a limited capacity system maintains and stores information in the short term, and this system supports human thought processes by providing an interface between perception and long-term memory. Working memory was developed to extend the concept of short-term memory. Compared to short-term memory, working memory has two functions in that it can not only hold information "on line" over short intervals of time, but can also keep the information active while cognitive

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operations are performed on it. Working memory processing involves three critical phases. First, getting perceptual information into the short-term memory by the sensory registers (such as visual, auditory, tactile). Second, focusing attention on the necessary sensory information for the next action. Third, using the sensory information in working memory to generate some kind of output, and moving part of the information from working memory to long-term memory as new memory (Dijkerman et al., 2007).

Working memory is critically important in the human cognitive processing system, and failures in working memory are often responsible for learning disabilities. One of the basic assumptions is that practically there is interplay between working memory and perception. In previous research, the validity of these ideas has been fully assessed with regard to visual or auditory working memory modality. In comparison with visual or auditory working memory, far less research has been dedicated to tactile working memory (see, Figure 1). The lack of scientific attention directed to the topic of tactile perception might be due in part to the dominance of visual or auditory modality in humans. Moreover, there are practical problems related to stimulus presentation and response recording in the functional magnetic resonance imaging (fMRI) environment that the most recently developed forms of brain neuroimaging study (Kaas et al., 2007 ;Yu et al., 2011). Here, we will focus on discussing the cognitive neuroscience evidence about tactile working memory mechanisms.

In the present review, we first briefly summarize the extant psychophysical literature that has attempted to examine people's working memory for tactile information presented by means of the skin. Next, we highlight some of the physiological evidence in the domain of tactile perception, covering electrophysiological and neuroimaging studies on human and animal sensory systems. Finally, we conclude our review and point out some important features for tactile working memory research.

Figure 1. The number of publications in PubMed database that included visual, auditory, gustatory, olfactory, or tactile/haptic memory in the title (search date: September 22, 2011)