Shabtai Barash

Armenuhi Melikyan
Xiaolan Wang
Wenchao Xu
Mingsha Zhang

Bridging body and mind: Neuronal signals, eye movements, brain architectures

Department of Neurobiology

Tel. 972 8 934 3744 **Fax.** 972 8 934 4131
E-mail: shabtai.barash@weizmann.ac.il

Body and mind

The fundamental problem driving our research is that of understanding the relationship of body and mind. Our approach is based on the conviction that the realities revealed by the concepts and tools of contemporary neuroscience begin to transform this ancient problem into specific, experimentally testable questions.

Saccadic eye movements

Saccades are the brief jumps of the eyes that keep taking place, two to three times each second, while we look. Saccades are essential for vision because they direct the thin line of high-acuity sight toward the locations of interest. Most saccades necessitate intricate cognitive operations, such as selection of one target among several candidates.

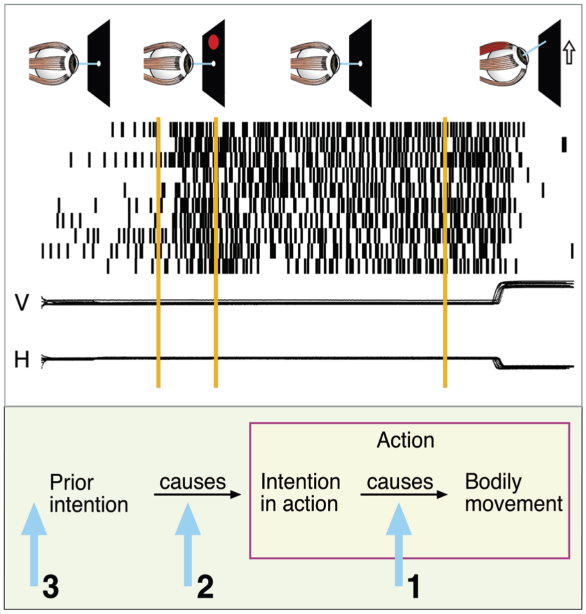

Fig. 1 Top, signals of a neuron reflecting intention in memory-saccades. Bottom, black and red: scheme of intentions by the philosopher John Searle (Intentionality, 1983). Blue: our recent investigations. 1, Nature 2000a, J Neurosci 1999; 2, Nature 2000b; 3, in process.

Saccades are very pertinent to the study of brain-mind relationship. Gateways to the stream of visual awareness, the pattern of saccades to some degree reflects the contents of thoughts. Saccade-like eye-movements are a signature of dreams. Saccades play a key role in interpersonal communication. A network of areas in highest-level association cortex is involved in the management and analysis of saccades. Understanding how these areas interact toward a saccade is significant for understanding how these cortical areas support the mind in general.

We investigate saccades on three levels. First, as part of vision; second, as movements, requiring plastic calibration; third, as intentional actions. Here we illustrate the latter.

Intentions

Intentions are plans for action. Intentions are subjective, private to their beholder. Intentions emerge and eventually are actuated or cancelled; in between, intentions are kept in memory. Intentions are, beyond doubt, fundamental mental entities.

We study intentions to make saccades. Fig. 1 (top) illustrates a memory-saccade. The cartoons of task stages are aligned in time with the actual records of spikes and eye-movements, shown below. The monkey intends to make a saccade, but withholds the saccade during a 1-second memory interval. While the monkey is performing, we record the signals generated by single neurons in specific brain locations. Neurons are the elements of information processing in the brain; their signals are encoded as a series of spikes. The black notches in Fig. 1 show the signals of a single parietal cortex neuron. Each line is a trial (a repetition); each notch represents a spike. An increased spike rate is sustained throughout the presumed lifetime of the monkey's intention. The actual relationship of such activity to intentions is a subject of extensive discussions. We have recently made contributions to this issue.

Fig. 1 (bottom) illustrates this using a scheme of intentions by the celebrated philosopher John Searle (Intentionality: an essay in the philosophy of mind, 1983). The superimposed blue arrows illustrate our three of research directions.

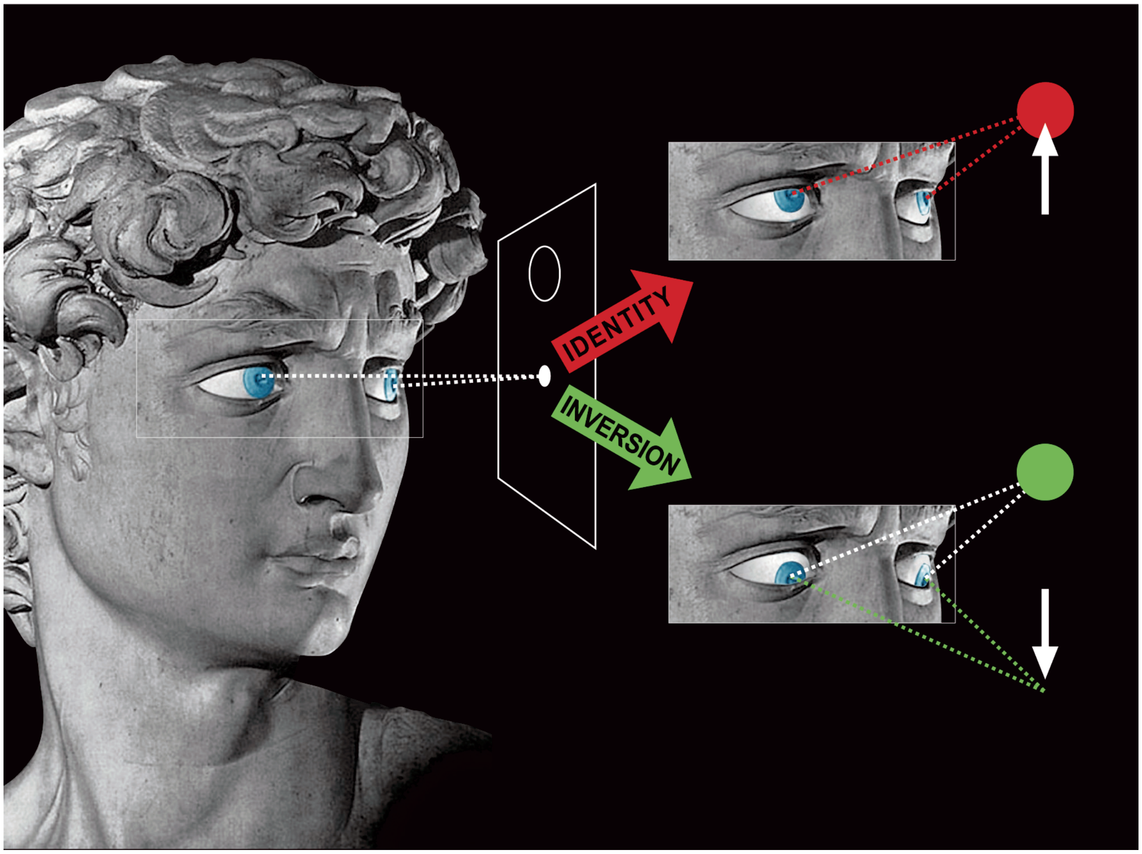

Fig. 2 *Illustration of the sensorimotor transformations required for the task we use to study context-contingent neuronal switching (Nature 2000b).*

Context-contingent neuronal switching

In contrast to light-sensitive bacteria, which always migrate toward the source of light, we may respond to the same stimulus in many different ways, depending on context. Fig. 2 illustrates the procedure of studying this context-contingent neuronal switching. We recently discovered a paradoxical signal in parietal cortex neurons involved in context-contingent switching (Zhang and Barash 2000). Surprisingly, our paradoxical signal complements another paradoxical signal discovered seven years ago in prefrontal cortex. We are now studying the implications of the two paradoxical signals for understanding the functional interaction of parietal and prefrontal association cortices towards context-contingent switching.

Selected Publications

Barash, S., A. Melikyan, A. Sivakov, and M. Tauber (1998) Shift of visual fixation dependent on background illumination. J. Neurophysiol. 79, 2766-2781.

Thier, P., T. Haarmeier, S. Treue, and S. Barash (1999) Absence of a common functional denominator of visual disturbances in cerebellar disease. Brain 122, 2133-2146.

Barash, S., A. Melikyan, A. Sivakov, M. Zhang, M. Glickstein, and P. Their (1999) Saccadic dysmetria and adaptation after lesions of the cerebellar cortex. J. Neurosci. 19, 10931-10939.

Thier, P., P. W. Dicke, R. Haas, and S. Barash (2000) Encoding of movement time by populations of cerebellar Purkinje cells. Nature 405, 72-76.

Zhang, M., and S. Barash (2000) Neuronal switching of sensorimotor transformations for antisaccades. Nature 408, 971-975.

Barash, S., (2001) Interaction of parietal and prefrontal cortices: possible implications of paradoxical saccadic activities (In process).

Barash, S., X. Wang, M. Zhang, A. Melikyan, M. Tauber (2001) Emerging intentions revealed by area LIP neuronal activity in free-choice memory-saccades (In process).

Acknowledgements

Current support includes grants from the Human Frontier Science Program (HFSP) and the Israel Science Foundation (ISF).