Key Issues in Sensory Augmentation Workshop, March 25th to 27th, University of Sussex

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In recent years, the question how the brain acquires perceptual abilities has moved into the center of interest. In early sensory areas, many properties of neurons can be understood as forming statistically optimal representations of natural stimuli, resulting from activity dependent plasticity shaping sensory systems during development. Recently, enactive theories of perception propose that this scheme does not only apply to processing of sensory input but to perception as such: The perceptual quality of sensory signals is determined by learned knowledge of systematic changes of afferent signals resulting from behavior and interaction with the environment. This concept of sensorimotor contingencies gained experimental support by studies on sensory substitution.

In a first pilot study, we pursued this line of thought and created new sensorimotor contingencies, and, hence, the basis to learn a new quality of perception. Adult subjects received orientation information, obtained by a magnetic compass, via vibrotactile stimulation around the waist. We demonstrated that it is possible to influence physiological reflexes and the quality of perception by introducing novel sensorimotor contingencies, giving evidence to the role of sensorimotor contingencies in perceptual awareness. In a further study we also tested the usefulness of sensory enhancement with this haptic compass for a congenitally blind subject.

In the near future, we aim to study the substrate of newly acquired sensorimotor contingencies with physiological techniques. Sensory augmentation provides the opportunity to compare the sensory apparatus before and after learning of a new sensory stimulation, and thus to isolate the neuronal processes related to (a new) sensory experience without bias. The integration of the sensory information into behavior is quantified in an orientation task in a walkable virtual environment. Learning and the physiological substrate of perceptual changes are characterized by EEG and fMRI measurements, respectively. Changes in subjective experience are documented and correlated with psychophysical and physiological measures.
Action-based theories predict that behavioral and perceptual mastery of the novel sensory information requires physiological integration of the new signal beyond primary sensory areas, i.e. in higher-level perceptual and motor areas that enact and code the sensorimotor relations provided by the augmentation device. Hence, sensory enhancement presents the opportunity to relate the neural substrate of sensorimotor contingencies, their influence on behavioral performance and conscious perception.