The Will of the Brain: Cerebral Correlates of Willful Acts

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Abstract

1. Current imaging techniques can depict physiological events in the brain which accompany sensory perception and motor activity, as well as speech. “Pure” mental events, unaccompanied by sensory input or motor/behavioral output, also induce different cerebral functional patterns related to inner representations of thoughts, ideas, visions, inner speech, etc.
2. Cognition, mental effort, and imagined volitional acts augment the activity in the frontal/prefrontal cerebral cortex. An augmentation in the cerebellum is also recorded. Temporally organized (serial) nerve cell activity takes place in these structures.
3. The prefrontal cortical activation accompanying volitional acts most likely corresponds to a willful mobilization of inner action programs which include representations of future events to be achieved by a goal-directed behavior.
4. Phylogenetically older parts of the cerebral cortex close to the midline (the cingulate gyrus) also participate in willful acts. Possibly they are involved in emotional/motivational (“value”) aspects of volition.
5. Abnormal volition (“sick will”) is encountered in organic dementia, Parkinson’s disease, depression, and schizophrenia. Such disorders are characterized by inactivity, lack of ambitions, and a reduced motor and verbal output. Patients in these groups often show a decreased activity in prefrontal cortical regions.
6. Individuals with subfrontal and mesial frontal lesions may develop so-called psychopathic behavior with abnormalities of volition, lack of impulse control, boredom susceptibility, sensation-seeking behavior, and abnormal risk-taking.

Introduction

The basic function of the central nervous system is to translate sensory impulses into an adequate behavior. According to William James (1890) a prerequisite for this translation is a “selection of stimuli and choice of response.” To the
neurophysiologist there are, schematically, two main types of “choice of response:” One type is “automatic,” reflexlike and directly stimulus-related. Such mainly non-conscious responses will not be considered here. The second type is coupled to a conscious attentional process, leading to a willed choice of a given response. This second alternative is combined with a suppression of other types of action.

The present review concerns regional cerebral functional (metabolic/circulatory) correlates to willful acts, as they can be measured by current brain imaging techniques. Indeed, there are also electrophysiological correlates of such acts in the brain, as shown clearly by Libet (1991), for example. Although his findings have several implications for the results reported below, they cannot be considered here.

The point of departure for the present review is an observation made nearly 20 years ago by Ingvar and Philipson (1977). Rhythmic, unilateral hand-clenching movements give rise to an activity peak in the contralateral hand area in the sensory-motor, rolandic region of the cerebral cortex. This finding confirmed the observations made by Olesen (1971). However, a willful conceptualization (inner representation) of the same rhythmic hand movement — without any motor activity — provided a different pattern, with mainly prefrontal cortical activation. This was the first direct evidence from brain imaging in conscious human beings that willful production of an internal representation of a movement (motor ideation) is accompanied by a frontal/prefrontal response located outside primary “executive” sensory-motor structures. Apparently, those parts of the cerebral cortex that program a given movement have a different location than the structures that control the execution of the actual movement.

In the present paper, emphasis is given to findings in normal subjects, but some observations in patients with various forms of “sick will” are also discussed.

**Brain Imaging Techniques**

The studies summarized below are based upon the principle of metabolic regulation of cerebral blood flow (Ingvar and Lassen 1975), i.e., that increased nerve cell activity in a circumscribed region of the brain is accompanied by a proportional increase of the metabolism, and of the regional cerebral blood flow (rCBF), in the same region. The opposite may also hold true, i.e., that diminished nerve cell activity lowers rCBF.

Originally, from the early 1960s and onwards, multiregional rCBF measurements were carried out following administration of an inert radioactive gas, 133 Xenon, dissolved in saline. Washout curves of 133 Xenon can be recorded externally over the brain, following either intra-arterial injection (Lassen and Ingvar 1961; Lassen et al. 1963, 1991; Ingvar and Lassen 1975) inhalation (Risberg 1980, 1986), or intravenous injection (Ryding 1986). The first studies were two-dimensional (2D), using multiple external detectors that depicted the distribution of function (rCBF) mainly in superficial cortical parts of the hemispheres. With these