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Neurophysiological Speculations on Zen Enlightenment

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Inhibitory mechanisms play a major role in the organization and function of the nervous system. A variety of inhibitory mechanisms heighten contrast and focus attention in sensory processing. Similarly, the precision of motor activity is controlled by a number of inhibitory mechanisms that limit action in time and space. A review of the literature on Zen suggests that Zen meditation involves a deliberate enhancement of some of those inhibitory mechanisms by psychological means. This intuitive application of basic principles of brain function could account for the successful application of Zen concepts and techniques to the martial arts as well as the creative and performing arts.

Buddhism, and particularly the Zen school, had a profound influence on Japanese culture (Suzuki, 1959). It had an especially sizable impact on all forms of artistic expression, inspiring the martial arts as much as the creative and performing arts. More recently, it has also been proposed that Zen principles and concepts can be successfully applied to psychotherapy (Akishige, 1977a; Hirai, 1989).

Throughout its long history Zen has inspired countless philosophical and metaphysical studies, but only a few attempts at scientific investigation. The scientific research that has been conducted has sought to elucidate the neurophysiological basis of Zen practices by investigating the changes in EEG and EMG activity and in respiratory function during Zazen [Zen meditation] (Akishige, 1977a, 1977b; Hirai, 1989). Can modern neurophysiology provide any deeper insights into Zen? A better understanding of its neurophysiological basis would of considerable practical, as well as theoretical, interest since it is claimed that Zen meditation has a great potential for improving physical and mental well-being. This paper will therefore review the relevant neuro-

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physiological and Zen literature in the hopes of furthering our understanding of the neurophysiology of Zen enlightenment.

Review of Neurophysiological Literature

Many nerve cells in the central nervous system are spontaneously active, and information is transmitted by modulating this activity through inhibitory mechanisms (Roberts, 1976). Moreover, our perceptions of the world around us are mediated not only by the excitation of the appropriate nerve cells, but also by the inhibition of neighboring neurons, whose silence supplies contrast and sharpens the image (Kandel, 1985). The nervous system also has the capacity to decide a priori which stimuli it will respond to by a variety of inhibitory pathways descending from the brain to the brain stem and spinal cord.

Such inhibitory control and editing of the information coming into the nervous system continues at every step of the transmission from the periphery up to the cerebral cortex. The normal response of neurons in the somatosensory cortex to stimulation of only a very specific part of the skin is determined by inhibition of inputs from other areas. These neurons respond to stimulation of a much larger area of skin when such inhibitory mechanisms are blocked pharmacologically (Dykes, Landry, Metherate, and Hicks, 1984). The visual system has an even higher degree of complex organization, with nerve cells responding very discretely to only highly specific stimuli. This specificity of response is also mediated by inhibitory mechanisms since neurons in the visual system respond indiscriminately when the inhibition is blocked (Sillito, 1986).

The nervous system furthermore has the capacity to learn to ignore confusing inputs, such as the image from a poorly functioning "lazy" eye, since clear monocular vision is preferable to fuzzy binocular vision. This phenomenon can be produced experimentally by rearing kittens monocularly deprived of vision by lid suture. When the eye is opened it is no longer capable of driving neurons in the visual cortex unless the inhibitory control of these neurons is blocked (Burchfiel and Duffy, 1981).

The parts of the nervous system involved in motor activity are similarly under the control of a variety of inhibitory mechanisms which determine the extent and duration of the muscle activity required to accomplish the desired action. There is feedback inhibition of the motoneurons which innervate skeletal muscles by Renshaw cells and reciprocal inhibition of muscles having opposing actions at the same joint. The output of the Purkinje cells in the cerebellum, which monitors and adjusts all voluntary motor activity, is entirely inhibitory. Furthermore, it has been suggested that most of our actions are mediated by preprogrammed circuits which are held in check by tonic inhibitory mechanisms until they are required. They are then

unleashed by inhibiting the tonic inhibition that had been restraining them (Roberts, 1976). Learning to ride a bicycle, for example, involves practicing the appropriate movements until they become a set of reflexes that can be executed automatically. Indeed, attempts at conscious intervention become counterproductive once that point has been reached. There is no surer way to fall off the bicycle, after one has learned to ride one, than to try to think of what one is doing.

As these examples indicate, inhibitory processes play a fundamental role in the organization and functioning of the nervous system, governing both how we perceive the world around us and how we respond to it. In view of the nature of Zen meditation practices (see next section) it is also noteworthy that inhibitory pathways in the central nervous system require more repetitive stimulation than excitatory ones (Shibuya, Fromm, and Terrence, 1987).

Review of Zen Literature

The word Zen is the Japanese version of the Chinese word *ch'an*, which in turn was derived from the Sanskrit word *dhyāna*. *Dhyāna* is usually translated as meditation, but really denotes the practice of mental concentration and heightening of consciousness by the exclusion of extraneous thoughts so as to approach the plane of *mushin* (no–mind) and attain enlightenment (Akishige, 1977a).

The control of the mind required for successful meditation is started by observing a code of discipline and restraint of the senses, so as to achieve a calm mind that is unconcerned with externals (Goleman, 1988). An attitude of "not gaining anything" (Suzuki, 1970) or "no–contrivance" (Taniguchi, 1977) is considered to be an essential pre-requisite. Distraction is further minimized by carrying Zen meditation out in a room that is not too bright and provides a quiet environment (Hirai, 1989). The meditation exercises then restrict and constrain the flow of thought by counting breaths (*sūsokukan*), and watching the breath flowing in and out past the tip of the nostril or the movements of the abdomen as the air flows in and out of the lungs (Benson, 1980; Hirai, 1989; Matsumoto, 1977; Thich Nhat Hanh, 1987).

As meditation deepens, according to some accounts, there is a progressive separation of internal and external objects from the field of consciousness. This process has been divided into nine stages, with the first four considered to be meditation on the world of form or material states and stages five to nine to be meditation on the world of no–form or formless states (Akishige, 1977b; Goleman, 1988). Zen considers stage four to be the ideal and strenuously avoids the progressive cessation of consciousness characteristic of the higher stages (Akishige, 1977b). Accordingly, perception of external stimuli persists during Zazen (Hirai, 1989; Taniguchi, 1977), in agreement with the notion that Zen

meditation strives for an optimal state of awareness rather than the trance-like isolation from internal and external input characteristic of stages five to nine.

Metabolism decreases by about 20% during Zazen and this decrease appears to be due to a decrease in the cerebral metabolic rate (Hirai, 1989; Nagashima, Ikawa, and Akishige, 1977). Concomitantly, the respiratory rate decreases (Ando, 1977; Hirai, 1989; Matsumoto, 1977). The changes in the galvanic skin reflex and in plethysmograph recordings elicited by acoustic stimuli are also decreased (Taniguchi, 1977).

The EEG pattern changes from beta to alpha during Zazen even when the eyes are kept open, beginning in the frontal and temporal regions (Hirai, 1989; Yamaoka, 1977a, 1977b). As meditation progresses, the alpha activity increases in amplitude and slows in frequency until it is replaced by rhythmical theta trains in the final stages of Zen meditation. The EEG changes can be divided into four stages (Hirai, 1989, which probably correspond to the first four of the nine stages of meditation described in some Buddhist texts. Furthermore, no habituation occurs to repeated noise stimuli. Each stimulus causes approximately the same alteration in the EEG pattern, suggesting that the ability to respond accurately to stimuli is retained during Zazen.

Discussion

Zen meditation appears to involve a deliberate enhancement of some of the inhibitory mechanisms that are fundamental to the organization of brain function. The importance attached to concentrating on the continual activity of breathing as a meditative technique (Benson, 1980; Hirai, 1989; Matsumoto, 1977; Thich Nhat Hanh, 1987) is particularly noteworthy since inhibitory mechanisms in the central nervous system are elicited more readily by repetitive stimulation (Shibuya et al., 1987). Focussing attention on the breath flowing in and out through the nostrils or on the movements of the abdomen as the air flows in and out of the lungs provides a continuing repetitive sensory experience as well as avoiding the diversion of attention by distracting thoughts. The increase in inhibition of cerebral activity is manifested by a decreased metabolic rate, reduced respiratory rate and change in the EEG pattern from beta to alpha activity even when the eyes are open.

Since inhibition of irrelevant and distracting input is a basic feature of information processing in the nervous system, it is not surprising that awareness of stimuli persists during Zazen and that it may even be enhanced. As demonstrated by Hirai (1989), the response to auditory stimuli persists regardless of the number of repetitions. Thus, Zazen has been described as "relaxed awareness accompanied by steady responsiveness" (Hirai, 1989, p. 74) with the sensory system appearing to be in a "highly dynamic equilibrium compared to other situations" (Taniguchi, 1977, p. 303).

Zen's intuitive application of basic principles of nervous system function could help to account for its success and its resultant profound influence on Japanese culture. Perhaps at least part of Zen's appeal has been the realization that it provides a practical and workable technique for accentuating our perception of the world around us and for enhancing our ability to respond to it, leading to such concepts as *ma* in the creative and performing arts and *mushin* in the martial arts.

The character for *ma* shows the sun in the middle of an open gate and in Chinese refers to space, but in Japanese it signifies time as well (Komparu, 1983). Thus it summarizes well the fact that nothing highlights and dramatizes a subject or an action as much as surrounding emptiness. The rocks in the garden at Ryoanji in Kyoto are made more impressive and seem to come alive because of the empty space around them. Many Japanese paintings also make extensive use of negative space—large sections left blank or only vaguely defined. In his essays on the aesthetic principles underlying Noh theater, Zeami states that "what [the actor] does *not* do is of interest" (Komparu, 1983, p. 73) and describes the ability to create moments of "no action" as the most important secret of a successful actor (Keene, 1960). Similarly, Rikyu declared that "the art of *cha-no-yu* [tea ceremony] consists in nothing else but boiling water, making tea, and sipping it" (cited in Suzuki, 1959, p. 280). The emotional impact of the tea ceremony derives in large measure from the elimination of all nonessentials, thus featuring and accentuating the actions of the tea master.

The concept of *mushin* expresses the perception that the last and most perfect stage in the martial arts is reached after the technique has been mastered to the point that it is performed reflexively. Ultimate mastery is then achieved by letting the mind go from itself so that the appropriate actions can occur intuitively and instantaneously. *Mushin* thus represents the capacity for enacting the most efficient and immediate responses: those that have been rehearsed into reflexes that can be called forth unconsciously at the right instant by releasing them from the inhibitory control that holds them in abeyance when they are not required. Swordsmanship (Sato, 1986; Suzuki, 1959; Takuan, 1986), Zen archery (Herrigel, 1953) and Aikido (Stevens, 1984), to name just a few examples, all appear to embody this practical application of Zen. Interestingly, similar ideas are now being proposed in American sports, and the player is instructed play "out of his/her mind" and to just "let it happen" (Gallwey, 1974).

In any event, it appears that both our perceptions and our actions are to a large degree shaped and influenced by inhibitory mechanisms in the brain, and that these mechanisms in turn can be influenced and modified by psychological means. Viewed in this perspective, a variety of Japanese cultural phenomena, such as Zen practices, aesthetic concepts, and martial arts techniques, can

be seen to have a physiological basis. That is not to say that these phenomena developed historically in this way, but that the neurophysiological basis proposed in this paper offers a Western explanation of why they are so effective.

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