Intention

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Understanding how the brain works in perceiving sensory input, controlling motor output and mediating cognitive functions is of fundamental importance both for basic science and for effective clinical treatment of neurological disorders.

Intention implies a measure of self-awareness and control which is goal directed and voluntary. However, while one may have the best of intentions, these do not necessarily translate into actions, and when they do, not necessarily into the most effective actions. Some of the reasons are alluded to in the letter I sent you that introduces this subject.

Intention may be a voluntary process with a measure of self-awareness. It can be mediated by both thought processes and emotions. In combination they affect their quality and the resulting actions. Objectives and purposes relate to intentions and how accurately, and appropriately, these are pinpointed in spacetime. They involve reach, grasp, manipulate and release mechanisms that operate to initiate functional triggers that direct thought and action. These, in turn, affect how accurately we move into the areas of regard so as to fixate, focus and fuse combined and goal-directed actions. The attention we pay, initially to our intentions, depends in large measure on their purpose, and on levels of motivation and abilities to concentrate.

From a clinical standpoint it is important to analyze the components of concentration in order to diagnose the reasons for poor concentration and ineffective, inappropriate, and inaccurate actions. Concentration relies on motivated interest, knowledge, and understanding, remembering, and motor control. Each of these constituents is energy related. Motivated interest finds and boosts energy, while understanding serves to use and conserve energy effectively. Remembering involves space and time sequences, staying on task, and the reasons for being there in the first place. Motor control requires energy and direction so that actions may be carried out effectively. A drunk may have every intention of walking past a police officer in a way that would hide his or her drunken state, but lack of motor control would expose the stumbling and irregular gait caused by the effects of excessive alcohol.

Intention, whether conscious or subconscious, relates an individual to his or her world with purpose and to achieve meaning. Initially, when developing a skill, there is an intentional and conscious focus, and concentration, on the details and sequence necessary to reach an effective level. In time, though, if the conscious processes are not relegated to sub-conscious levels, they get in the way of reaching higher skills levels.

The fact that consciousness need not enter into the description of intentionality opens new vistas in understanding brain functioning. Intention and attention in this context are top-down active processes, as well as reactive bottom-up processes to sensory stimuli and input. In Piagetian[1] terms the sensory consequences of actions enable individuals to assimilate and change, and accommodate so as to accept and survive changes in the environment. Our actions are driven both from without and within, but our intentional actions are directed by internally generated spacetime goals that affect us and other intentional beings.

Much of what one does and intends to do is based on intelligent rationalization, but one's emotions exert a major influence in each endeavor. As Freeman[2] notes (2000:92):

Our hearts pound, our palms sweat, and our stomachs churn when we face stressful situations that require us to do something, especially to avoid giving in to panic…The departure from a state of unflappable calm is aptly named: e(x)motion, meaning outward movement or intent. However, what may appear to call for rational intent, often gives way to spontaneous and illogical actions in defiance of our conscious and logical intent. They may be in apparent contradiction to sensory triggers that seem trivial, contrary, or insufficient to account for the intensity of the actions.

Perception may follow the impact of sensory bombardment, but that which is perceived is controlled by what is anticipated and prepared for, as well as from the degree of concurrence and agreement of all the input senses. "This appears to explain the global coordination, and unity of intentional action, and the perseverance of goal-directed states in the face of distractions and unexpected obstacles" (Freeman,2000:133)[2a]

It has been held that no conscious learning is possible without intention to learn, and yet there is no doubt that an individual who, inadvertently, places his/her hand on a hot plate, will reflexly recoil, and will learn from the incident not to do this again. Luria and la Yudovich[3] suggest that the best teacher is the environment, but that formal teaching is of value because: i) it helps to identify the detail necessary to master the subject of learning; ii) it builds and extends conceptual sequences; and iii) it accelerates the process of learning. It appears that both reflex and conscious learning constitute major life drives, that are built on human intentions. What one learns is the result of why, how, and to what, where, and when, we direct our intentions, and pay attention.

A challenging issue in cognitive neuroscience is to dissociate a variety of mental processes from one another in order to elucidate brain functions (Boussaoud;2001)[4]. Attention, in particular, has been a recurrent issue because of its strong links with perceptual, cognitive, and motor performances. Starting with a top-down model that relates cognitive control mechanisms in the brain neuroscientists have already established evidence of parts of the brain that operate or do not operate differentially with intentional, attentional, inattentional and neglect behaviors.

Intentional action is directed by an individual's goals within a spacetime framework, that is shared by other intentional individuals. Taken together, the sensory, motor and association cortices are implicated in a ring of interconnected neural tissue known as the limbic system. Electrodiagnostic and behavioral research[5] has been conducted to show that the limbic system is essential for all intentional actions including perception and most forms of learning. The three parts of the brain that have been described have reciprocal connections and appear to play a crucial role in the creation of intentional behavior. In each hemisphere the sensory cortex receives input, the motor cortex implements action and the hippocampus provides multisensory integration and orientation in spacetime.

Central executive top-down circuits that determine goal states seem to guide the body through complex sequences of action, and prime the sensory cortex to seek out and receive information that is anticipated and predicted to meet impending goal-directed actions. Intention is central to the concept of voluntary action.

Functional neuroimaging studies on humans have been shown to identify a region of right posterior superior temporal sulcus to respond to observed intentional actions (Saxe, Xiao, Kovacs, Perrett & Kanwisher, 2004)[6]. Intention is central to the concept of voluntary action. Experiments where individuals pay attention to their intentions rather than to their movement elicit prefrontal activity that is more strongly coupled with activity in the pre-supplementary motor area (pre-SMA) (Intention is central to the concept of voluntary action (Lau, Rogers, Haggard P,& Passingham, 2004.)[7]

Attention and motor preparation are two intimately linked processes, and the question is asked whether intention—the planning of action, can be separated from attention and differentiated neuroanatomically? Laboratory studies show that neurons that discharge in relation with attention or with motor preparation (or intention) exist in a variety of brain regions in the monkey, especially the prefrontal and premotor cortices. However, when examined more carefully, these two regions appear different in both the proportion of cells that respond during attention versus intention, and in the information coded in preparatory activity. This activity reflects sensory selection in the prefrontal cortex (spatial attention/memory), and/or selection in the premotor cortex. Two additional regions in the dorsal aspect of premotor cortex can be distinguished on the basis of their relative involvement in attention: a rostral (anterior) region, functionally close to prefrontal cortex, and a caudal one, which appears functionally close to motor cortex. Recent fMRI studies indicate that the functional specialization within the premotor cortex is similar in man to that found in the monkey (Boussard, 2003 583-91)[8].

Kampe, Frith, & Frith (2003)[9] show that successful communication between two people depends first on the recognition of the intention to communicate. Such intentions may be conveyed by signals directed at the self, such as calling a person's name or making eye contact. They used functional magnetic resonance imaging to show that the perception of these two signals, which differ in modality and sensory channel, activate common brain regions: the paracingulate cortex and temporal poles bilaterally. These regions are part of a network that has been consistently activated when people are asked to think about the mental states of others. Activation of this network is, however, independent of arousal as measured by changes in pupil diameter.

Downing, Bray, Rogers, & Childs (2004)[10] have used functional neuroimaging to show that certain classes of visual stimulus selectively activate focal regions of the visual cortex, that respond specifically to faces and the human body. Their results suggest that the visual system assigns attentional priority to types of stimuli that are represented in strongly selective cortical areas.

Russeler, Hennighausen , Munte, & Rosler F (2003)[11] investigated differences in sequential learning between subjects who were or were not informed of the presence of a repeating sequence (intentional or incidental group, respectively). Reaction times indicated that both groups learned the sequential regularities. Intentional learners showed a larger learning effect. Event-related brain potentials (ERPs) recorded during performance of the task showed differences in the intentional and incidental group performances that indicate different neural structures are involved in implicit and explicit serial learning.

Connolly, Goodale, Menon, & Munoz (2002)[12] used functional magnetic resonance imaging to study readiness and intention signals in frontal and parietal areas that have been implicated in planning saccadic eye movements-the frontal eye fields (FEF) and intraparietal sulcus (IPS). To track fMRI signal changes correlated with readiness to act, they used an event-related design with variable gap periods between disappearance of the fixation point and appearance of the target. To track changes associated with intention, subjects were instructed before the gap period to make either a pro-saccade (look at target) or an anti-saccade (look away from target). FEF activation increased during the gap period and was higher for anti- than for pro-saccade trials. No signal increases were observed during the gap period in the IPS. Their findings suggest that within the frontoparietal networks that control saccade generation, the human FEF, but not the IPS, is critically involved in preparatory set, coding both the readiness and intention to perform a particular movement.

A number of laboratories are studying relationships that derive from perception in action and the understanding of intention (Blakemore & Decety; 2001).[13] Movement and motor intention is the subject of a study by Toni, Thoenissen & Zilles (2001)[14]. Their study addressed the functional anatomy of movement representation. They used associative visuomotor tasks with instructed delays to elicit motor preparatory activity. In a first event-related fMRI experiment,they found that preparing to move according to arbitrary visuomotor associations relies not only on parietofrontal circuitry, but also on portions of the posterior superior temporal sulcus. In a separate behavioral experiment, they discarded the hypothesis that such activities were confounded by working memory processes. In a second imaging experiment, they were able to define the relative contributions of these parietal, premotor, and temporal areas to the preparatory process and their involvement in motor representations. They concluded that the posterior parietal cortex is interested in evaluating the potential motor significance of sensory stimuli, irrespectively of the likelihood of providing a motor intention response.

West and Alain (2000)[15] conducted an experiment to show that disruption of a neural system supporting goal-directed action gives rise to lapses of intention in healthy individuals and disorganized behavior in patients with prefrontal lesions. They provide evidence from behavioral studies to indicate that the occurrence of lapses in selective attention, working memory and prospective memory tasks is transient in nature. In their study, they used event-related brain potentials to demonstrate that lapses are associated with a slow wave over the frontal region that begins well before stimulus onset and lasts for several hundred milliseconds. The magnitude of this slow wave was modulated by task demands, indicating that attentional processes can be flexibly allocated in the service of goal-directed action. Together the findings of these experiments indicate that lapses result from a transient inability to bring to bear the goals of the individual upon the action selection system.

In summary, the current experiments demonstrate that lapses of intention are associated with a transient change in neural activity over the frontal region that begins well before stimulus onset. This slow wave inverted polarity from the fronto-polar to the fronto-central region consistent with the activity of a neural generator in the polar or dorsolateral prefrontal cortex. A P500 wave was observed for the ERPs associated with both correct responses on incongruent trials and intrusion errors, suggesting that inhibitory control processes were unaffected by lapses of intention. Together, these findings indicate that lapses of intention result from an inability to bring to bear the goals of the individual on the action selection system and not a failure of inhibitory control.

Fink, Marshall, Halligan, Frith , Driver, Frackowiak, & Dolan (1999)[16] discuss the neural consequences of conflict between intention and the senses. While this chapter and the title of this volume imply a separation between intention, attention, inattention and neglect, their integration is implicit in all functional and behavioral acts of daily living. Normal sensorimotor states involve the integration of feedforward intentions, actions and sensory feedbacks. Goal directed actions necessitate a mechanism that monitors sensorimotor inputs to ensure that motor outputs are congruent with current intentions. Such monitoring is usually implicit and automatic, except in the early learning stages, but becomes conscious whenever there is a mismatch between expected and realized sensorimotor states.

This chapter and those of Schriefers and Shelton form a basis for those that follow. Topdown intentional states determine what proceeds towards actions, and decides what bottom up sensory stimuli are received, attended to and acted upon. Such integrated functions embrace conscious and subconscious thoughts that apply to daily activities of living. Their connections ultimately provide a rationale for studying, understanding attention and inattention and treating memory loss, as well as other attentional deficits and neglect.

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