The Frontal Lobes: Key to Moral Thinking

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Our work in the operating room focuses almost exclusively on pathophysiology and surgical anatomy. The operating room team acts primarily in response to something gone wrong and attempts to gain or regain maximal function with minimum morbidity given the unique structure of the anatomy presented. It is perhaps too easy to forget the nature of the normative function of the structures with which we work. When the structure in question is the brain, in particular the frontal lobes of the brain, this takes on peculiar significance. The importance of the frontal lobes cannot be overstated without difficulty. Stuss and Benson[1] suggest that the study of the frontal lobes is no less than the study of the qualities that define the human being as human. To the degree that this statement is true, the frontal lobes are worthy of some awe and respect as we approach them surgically. This article will reintroduce you to a specific area of the brain, the frontal lobes. A discussion of moral thinking will best illustrate the distinctive human defining character of the frontal lobes.

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A brief review of the anatomy of the frontal lobes will precede a selective but more extensive review of the literature concerned with frontal lobe function. Following that, a unique presentation of the functional neuropsychology of the frontal lobes will help with the thorough assimilation of these complex functions. To begin, a philosophical description of the character of moral thinking provides a basis for what must be accounted for in order to claim that the frontal lobes are essential to this neuropsychologic function. A concise, point by point correlation of frontal lobe function including the philosophical requirement will demonstrate why the frontal lobes may be characterized as the locus of moral thinking.

Basic Anatomy of the Frontal Lobes

The external delineation of the frontal lobes can be described by reviewing the anatomic markers on three surfaces: lateral, medial, and inferior.[1-3] Lateral surface markers may be best known to most surgical technologists. The frontal lobes constitute the brain area anterior to the central (Rolandic) sulcus and superior the the lateral (Sylvian) fissure (Figure 1). From this view, the relative size of the frontal lobes in

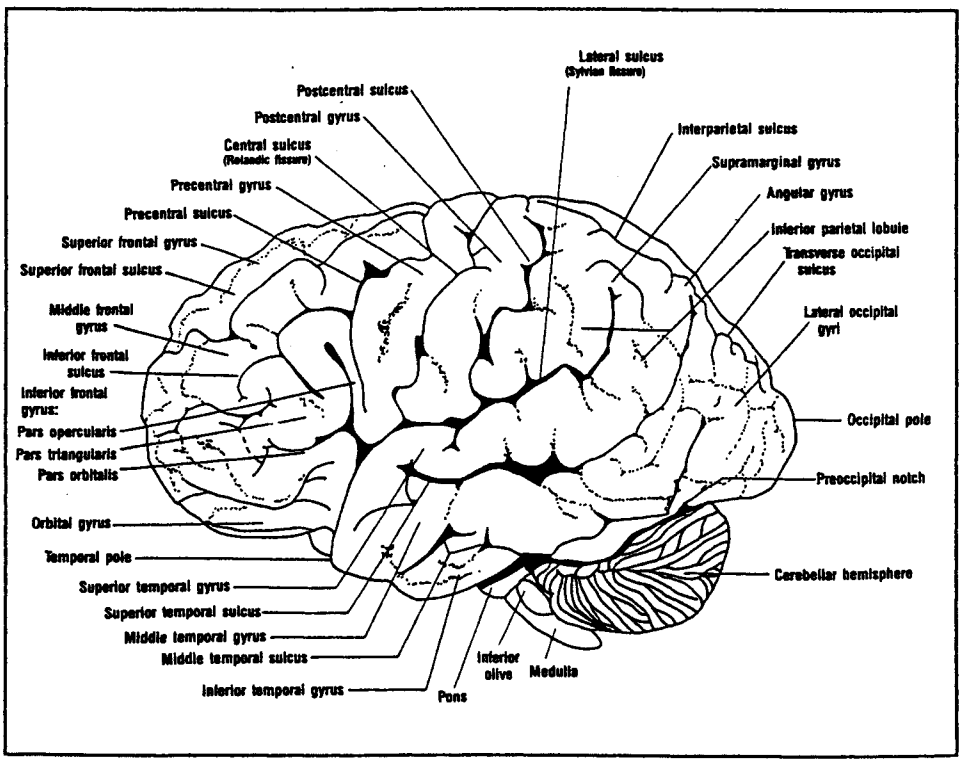

Figure 1. Lateral surface of the brain. (Adapted from DeArmond et al.[2])

human beings is remarkable. On the medial surface, the frontal lobes lie anterior to an imaginary vertical line drawn from the medial aspect of the central sulcus to the level of the corpus callosum. The frontal lobes surround the corpus callosum from this view (Figure 2). Inferiorly, the temporal poles form the lateral-posterior borders while the medial is formed by an imaginary horizontal line drawn at the level of the optic chiasm (Figure 3).

A surface view inadequately represents the complexity of the brain. While detailed anatomic and neurophysiologic descriptions of the cortical and subcortical connections are beyond the scope of this article, the surgical technologist should be aware of the richness of these connections. Cortical-to-cortical projections exist from the visual, auditory, somatosensory, and olfactory cortex and to the temporal, posterior sensory, and limbic cortex, plus intrafrontal projections. Subcortical projections also are present. Projections are made to and from the hypothalamus, amygdala, hippocampus, and thalamus and to the septum, striatum, subthalamic region, and mesencephalon.[1-3] The neuropsychologic descriptions of function discussed later demand this rich interaction between the frontal lobes and the other organized systems of the brain.

The frontal cortex itself is normally divided into three regions: the precentral, prefrontal, and limbic cortex. Several areas serve well-known functions and should be familiar to every technologist: the precentral gyrus, the premotor cortex, Broca's area, and the prefrontal cortex (Figure 1).

The precentral gyrus is the primary motor area and includes the anterior wall of the central sulcus, laterally, and the anterior portion of the paracentral lobule, medially. Most commonly, the primary motor area is responsible for the contraction of muscles on the contralateral side of the body. Given cortical areas correspond to particular muscular groups and are commonly represented by a graphic homunculus. Many of the nerve fibers originating in the precentral gyrus travel in the

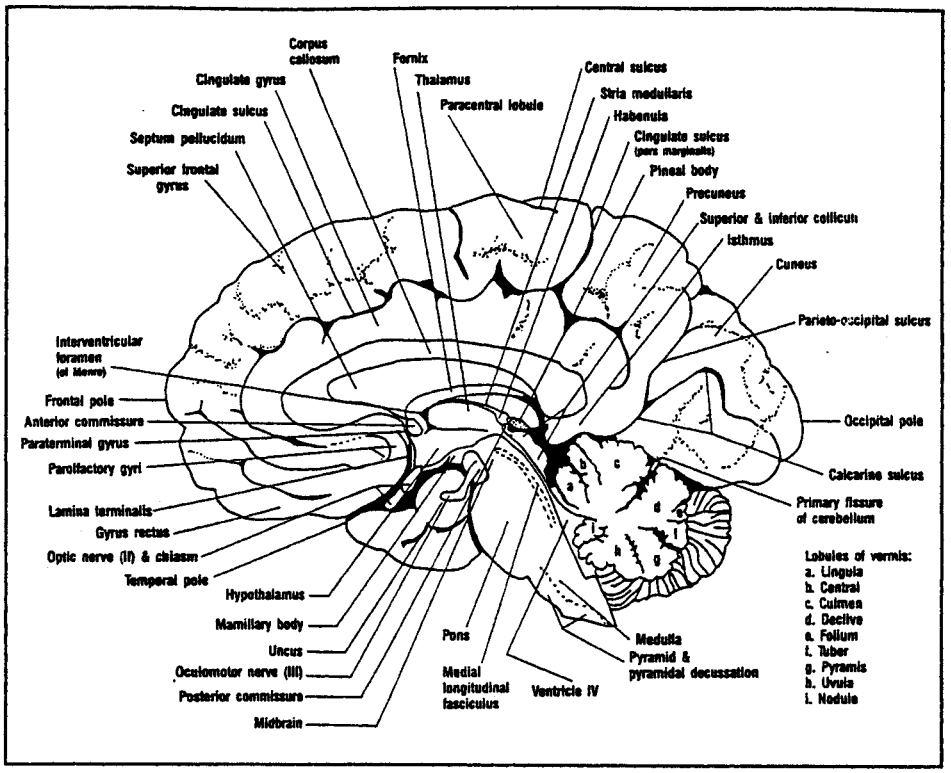

Figure 2. Medial surface of the brain. (Adapted from DeArmond et al.[2])

corticospinal tract, the only connection between the cerebrum and spinal cord made up of long fibers.[4] Most of the fibers decussate at the lower end of the medulla accounting for the contralateral lateral relationship between cortex and muscle group. Lesions in the primary motor area often result in contralateral paralysis.

The premotor area lies anterior to the primary motor area on both medial and lateral surfaces. The premotor areas contributes to motor function through the corticospinal tract directly, through a contribution of nerve fibers, and indirectly, through its interaction with the primary motor area. The premotor area is involved primarily with programs for motor routines used in skilled voluntary action. The relationship between the premotor and primary motor area is easily explained: the primary motor area executes a given action at the direction of the premotor area. Lesions in this area produce a type of apraxia, the impaired performance of a learned movement.

Broca's motor speech area is located in the left hemisphere with rare exception. The motor speech area is found in the opercula and triangular portions of the inferior frontal gyrus. A second, nonfrontal language area called Wernicke's receptive speech area also has specialized language functions. Broca's and Wernicke's areas communicate through the arcuate fasciculus. Lesions in the two areas characteristically produce different aphasias. Broca's aphasia is classified as a conduction aphasia. Patients are generally characterized by nonfluent aphasic output, relatively intact language comprehension, and a repetition disorder.[3]

The prefrontal or association cortex is that cortex which does not produce a motor response when stimulated. It is only well developed in primates, particularly in humans. The prefrontal cortex has numerous interconnections with other lobes and the dorsomedial thalamic nucleus. These pathways provide the prefrontal cortex with access to contemporary sensory experience, memories of past experiences, and affective reactions to pre-

sent experiences. The prefrontal area plans and monitors behavior. Lesions here produce a wide variety of disturbances, some of which are described in the subsequent section. The prefrontal cortex is the area most important to moral thinking and thus will be discussed in further detail.

A Brief Review of Literature

Literature concerned with frontal lobe activity is voluminous, so while this review may be incomplete, it represents a good selection of some of the most respected researchers in the area. Although current knowledge of the frontal lobe activity remains incomplete, significant gains have been made in the past half century. The foundation of this review is Stuss and Benson's *The Frontal Lobes*[1] and Heilman and Valenstein's *Clinical Neuropsychology*.[3]

To provide an honest review while making sense of the history of brain research, one must recognize that the traditional approach focused attention on questions of localization. For example, "Can functions be localized in the frontal lobes?" Care should be taken not to oversimplify when asking questions. In modern neuroscience, the question should not be posed as "Is anatomic area A directly and solely responsible for function 1?" The brain is clearly too complex for a simple answer.[1,3,5-7] The question should instead be, "Is the particular function of a given anatomic area necessary for the integrity of a complex function?" In response to that question, Stuss and Benson[1] concluded that while behavioral function can not be localized to any specific area of the frontal lobes, behavioral changes following damage to specific areas are consistent enough to suggest lawful behavior represented by organized and integrated functional systems. The role of the frontal lobes generally involves the functions of anticipation, establishment of goals, planning for goal attainment, and acting upon and evaluating the plan. Some believe the concept of an executive function describes frontal lobe activity.[1,8-11] The effect of the executive function is profound. According to Stuss and Benson,[1] the very qualities that make a human being human can be attributed to this function. Nervous system activities may be carried out by more posterior systems, but without frontal lobe participation these activities tend to be reflexlike and stereotypical. Likewise, while the intelligence we refer to as IQ is not a frontal lobe function, the frontal lobes play a significant role in determining the integrated use of intelligence. There is a clear sense that the conscious ego is a frontal lobe phenomenon, specifically confined in the prefrontal cortex. Calvin[7] has described prefrontal activity as including "abstract and creative thinking, fluency of thought and language, affective responses and the capacity for emotional attachments, social judgment, volition and drive, and selective attention." The executive role may be summarized with the following: While frontal lobe function may not be necessary for storage, memory, or execution of an act, it is necessary for the selection of the particular action to be carried out in a given time and space.

The frontal lobes can be said to function as the executive of brain activity.

From the perspective of a literature review and personal research, Stuss and Benson[1] offer a hierarchy of brain function. Self-awareness, the highest attribute of the frontal lobes, is necessary for fully integrated anticipation, goal selection, preplanning, and monitoring. These functions influence drive and sequencing, which in turn influence attention, alertness, visual-spatial processing, autonomic and emotional activity, memory, sensory perception, language function, motor function, and general cognition. Relative to general cognition, the frontal lobes are more actively involved in processing new information than old information.[1,12]

Broadly speaking, the frontal

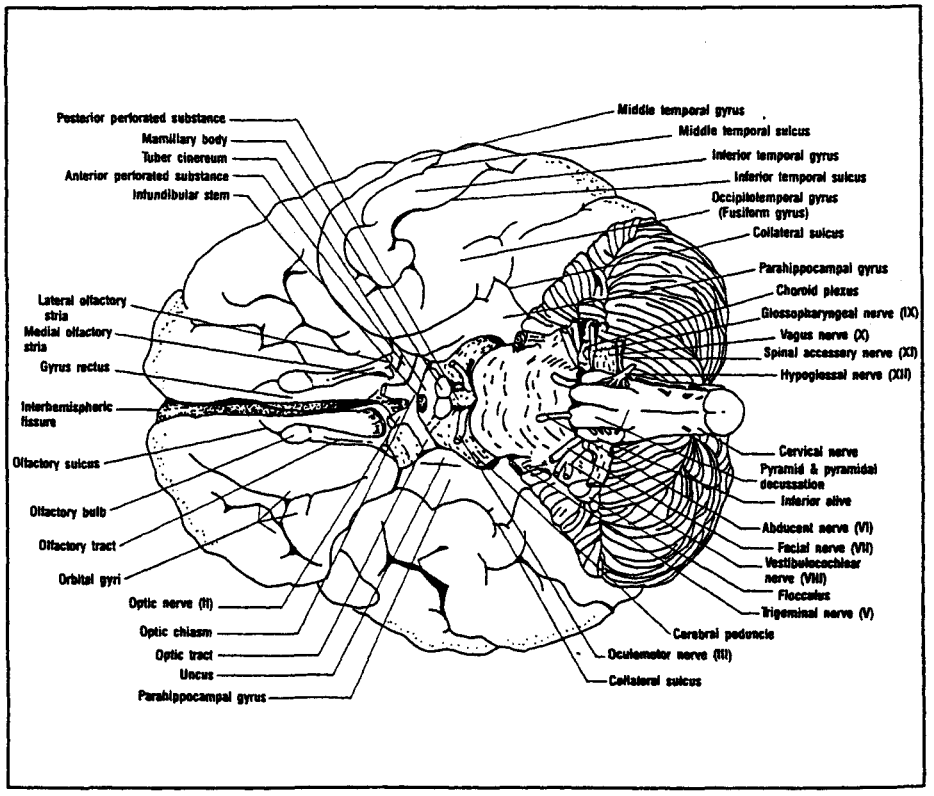

Figure 3. Inferior surface of the brain. (Adapted from DeArmond et al.[2])

lobes can be said to function as the executive of brain activity. Primarily inhibitory in nature, the executive function limits or controls (similar to an editor) other brain functions. Properly functioning, the frontal lobes, particularly the prefrontal area, are the locus of self-awareness or self-consciousness. It seems fair to say that the mental functions considered to be most definitive of the human being are those associated with the frontal lobes.

The richness of these frontal lobe functions invites interdisciplinary reflection from both the fields of philosophy and psychology. My own theoretical and research interests in the area of moral development[13-15] raise many questions. One that illustrates the importance of frontal lobe activity is whether the functional activities of the frontal lobes in human beings correlate to the psychologic and philosophical components of moral thinking known as practical reasoning. While both psychologic and philosophical aspects are noteworthy, the ensuing discussion will focus on the philosophical standpoint. A sound philosophical statement of the nature of practical reasoning, allowing for an evolutionary perspective, complex psychologic dynamics, and social competency skills, will help illustrate.

Frontal lobe lesions produce cognitive impairments to the successful function of memory.

Thomas Aquinas: An Ethical Anthropology

The great medieval philosopher and theologian Thomas Aquinas was a careful observer of human beings and a profound thinker. In his work on moral philosophy, he describes the characteristics necessary for adequate moral thinking and behavior. While we need not adopt his metaphysics or theology, his ethical anthropology precisely and adequately describes the type of mental activity necessary for moral thinking and behavior.[16] The work of Joseph Pieper[17] further clarifies Aquinas' ethical anthropology.

Familiarization with the concept of *prudence* as the "mold and mother of the other cardinal virtues, justice, fortitude, and temperance"[17] is essential to the understanding of Thomistic ethics and anthropology. Prudence is the perfected ability to make wise decisions. Prudence causes, measures, and informs the other virtues because it takes precedence in Thomas' metaphysical order: "Being precedes Truth, and that Truth precedes the Good."[17] In order to know the Truth, one must have the attitude of silent contemplation. This is the key prerequisite for the perfection of prudence as cognition, whose perfection in turn involves three elements: *memoria, docilitas,* and *solertia.* Memoria is true-to-being memory, the trait which allows a person to objectify the past and evaluate it accurately. In order to do this one must have docilitas, "the kind of open-mindedness which recognizes the true variety of things and situations to be experienced and does not cage itself in any presumption of deceptive knowledge."[17] In other words, docilitas brings objective honesty to memory. Finally, solertia is the function of confronting new situations "with open eyes and clear sighted vision, deciding for the good, avoiding the pitfalls of injustice, cowardice, and intemperance."[17] Solertia then, is the organizing and evaluative function. All three functions focus on the past and present. *Providentia* looks to the future and estimates whether a particular action will lead to the realization of good.

Prudence, it must be remembered, is a perfected virtue. Thomas does not mean that prudence is perfected in the sense of alleviating uncertainty or error but that practice moves a function toward perfection, accomplished principally by error reduction.

Prudence is itself directed by an intuitive desire or a "right wanting"[16] which predisposes one to establish goals and plan well. Finally, the prudent person is one who acts upon prudent choices.

Obviously, many cognitive functions must be accounted for in a discussion on moral cognition.

1. Environmental data must be perceived and placed in memory.
2. Memories must be reconstituted in appropriate situations.
3. Environmental cues and memory are incomplete and must be adjusted to account for a given situation.
4. Memory and cues must be used by a planning function capable of abstracting the future.
5. A feedback mechanism must be operative.
6. All functions must result in autonomous action.

A description of frontal lobe function will help correlate frontal lobe function with each of the requirements.

1. Environmental data must be perceived and placed in memory. The frontal lobes are generally not considered the primary location of memory but frontal lobe lesions produce cognitive impairments to the successful function of memory.[1]
2. Memories must be reconstituted in appropriate situations. Frontal lobe lesions do not cause a loss of ability to construct representations but lead to loss or diminishment of "the ability to create stable motives of recall and to maintain the active effort required for voluntary recall, and the ability to switch from one group of traces to another."[12] In addition, the frontal lobe interconnections with the limbic-diencephalic system are a significant part of the sensory interpretation and "routing" system of the brain. Significantly, the limbic system is

Cumulative evidence demonstrates the function of the frontal lobes as essential in the selection of environmental information, the organization of this information and the reconstitution of appropriate information.

the location of important emotional functions.[5]

3. Environmental cues and memory are incomplete and must be adjusted to account for the circumstances. The ability to draw from the situation appropriate data and use it to reconstitute appropriate memories is essential to moral cognition. That the frontal lobes are extensively involved in these functions is indisputable.[1,8,18] The general effects of frontal lobe lesions on the regulation of environmental cues and the organization and monitoring of data and behavior have been described by Milner and Petrides.[19] Specific deficits relative to an understanding of the relationship between time, source and event memory have been documented by several individuals.[20-22] The inability to identify relevant information and difficulty with multiple cues following frontal lobe lesions has been documented by Cicerone and Lazar.[10] The cumulative evidence demonstrates the function of the frontal lobes as essential in the selection of environmental information, the organization of this information and the reconstitution of appropriate information.

4. Memory and cues must be used by a planning function capable of abstracting the future. The ability to abstract the future is necessary to plan and execute autonomous behavior as documented by Pribram and Luria.[8] The studies of Lhermitte[23,24] and Lhermitte et al[25] provide a graphic description of behavior without these abilities; behavior is habituated, stereotypical, environmentally dependent, and lacking in the qualities to which we attribute human autonomy.

5. A feedback mechanism must be operative. As indicated in the initial anatomical description, the frontal lobe connections to other brain centers are both afferent and efferent, providing a complex feedforward and feedback function.

6. All of these functions must result in autonomous action. The studies of Lhermitte[23,24] and Lhermitte et al[25] confirm the importance of the frontal lobes to autonomous action.

This effort to correlate the neurologic activity of the frontal lobes while condensed, should serve to introduce the surgical technologist to the real life importance of the frontal lobes. The philosophical requirements for moral thinking or practical reasoning are directly related to frontal lobe functioning.

Summary

This article is intended to be one of a series of articles that will be published concerning the development of an argument for a unified biologic, psychologic, and philosophical approach to moral development, called "neuroethics."[14-15] The theoretical aspects demand interdisciplinary communication in the areas of neuropsychology, developmental psychology, and philosophy. While the theoretical considerations are generally outside the daily concerns of the surgical technologist, they illustrate the functions of the frontal lobes affected by both pathologic processes and surgical interventions with which the surgical technologist is familiar. It is hoped that this approach will heighten surgical technologists' awareness of the importance of the frontal lobes as they relate to those qualities that make us and our patients human.

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