Executive Functions, Personality and Morality
Executive functions is an umbrella term for the management (regulation, control) of basic cognitive processes including attention, working memory, and task flexibility. Higher-order functions require the use of multiple basic functions and include planning and intelligence (reasoning and problem-solving).

Personality has to do with individual differences among people in behavior patterns, cognition and emotion.

Morality is the differentiation of intentions, decisions, and behaviors between those that are good or right and those that are bad or wrong.

Evidence suggests that intact frontal lobes (with participation from other non-frontal areas) are necessary to carry out all executive functions, and express personality and morality.
Silent lobes to the organ of civilization. The importance of the frontal lobes for executive functions, personality and morality has only been recently appreciated. Unlike the busy sensory processes that occur in the other lobes, the frontal lobes were not easily linked to any single, easily defined function and were known as ‘the silent lobes’.

“He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires … A child in his intellectual capacity and manifestations … His mind was radically changed, so decidedly that his friends and acquaintances said he was ‘no longer Gage’.”

[Dr. Harlow, description of Phineas Gage’s recovery from the passage of an iron bar (in 1848) through his head (i.e., left frontal lobe)].
The concepts of executive control, personality and morality are now intimately linked to the function of the frontal lobes. However, the frontal lobes subserve other functions (e.g., motor control), and other areas participate in these functions (i.e., the frontal lobes are necessary but not sufficient).

➔ The prefrontal lobes carry out executive functions and express personality and morality.
Pre-Frontal Lobes 2

Three possible ways to define pre-frontal cortex:

• non-motor areas
• granular frontal cortex (layer 4 is present – thalamic input)
• projection zone of the dorsal-medial nucleus of the thalamus. The DM nucleus is critical for gating of information to and from prefrontal cortex. This feedback contributes to selective attention, enhanced responses for relevant stimuli and suppressed responses for distractive stimuli.
The prefrontal cortex has expanded over mammalian and primate evolution. A greatly enlarged prefrontal cortex is a distinctively human and primate feature.

According to Brodmann (1909), the prefrontal cortex accounts for 29% of total cortex in humans, 17% in the chimp, 11.5% in the macaque, and 3.5% in the cat.

While whales and dolphins have large brains, it is the parietal rather than frontal cortex that has expanded in these mammals.
Prefrontal cortex is usually divided into lateral (side) and medial (midline) regions, and dorsal (top) and ventral (bottom) regions. The part of the ventromedial prefrontal cortex that overlies the eyes is sometimes called the orbitofrontal cortex. The exact borders of each region are ill-defined.

**Divisions of the Pre-Frontal Lobes**

- **DLPFC** – dorsolateral prefrontal cortex
- **VLPFC** – ventrolateral prefrontal cortex
- **APFC** – anterior prefrontal cortex
- **DMPFC** – dorsomedial prefrontal cortex
- **VMPFC=OFC** – ventromedial prefrontal cortex
Prefrontal cortices (shown inside the yellow box to the right) are reciprocally interconnected and receive projections from most, if not all of the distinct functional units of the brain.

The DLPFC receives inputs from the where pathways out of the sensory cortices; the VLPFC receives inputs from the what pathways.
Executive functions are a set of cognitive processes that are necessary for the cognitive control of behavior including selecting and successfully monitoring behaviors that facilitate the attainment of chosen goals.

In particular, the executive system:
- forms goals and objectives and then devises plans of action to attain those goals;
- selects the cognitive skills needed to implement the plans, coordinates those skills, and applies them in the correct order; and
- evaluates our actions as success or failure relative to our intentions.
Evidence suggests that the dorsolateral prefrontal cortex forms plans of action. It receives inputs from the posterior parietal cortex (the attention controller) and outputs to the secondary motor cortex. Resultant activity is monitored by the dorsal anterior cingulate cortex (part of limbic system), which signals any need for adjustment.

Two broad types of cognitive operations are linked to prefrontal lobe executive functions:
• an ability to form goals/plans and to guide behavior by internal representations; and
• the capacity of ‘switching gears’ when something unexpected happens.
Much of the experimental evidence for the neural structures involved in executive functions comes from laboratory tasks such as the Wisconsin Card Sorting test and the Stroop test.

In the WCST, a number of stimulus cards are presented to the participant. The participant is told to match cards, but not how to match them (e.g., color, number, shape); however, he or she is told whether a particular match is right or wrong. The test is how the subject responds when the rule is changed unexpectedly (test of the DLPFC).

In the Stroop task, subjects are asked to name the ink color that color words are printed in when the ink color and word meaning are the same (for example the word “red” in red ink) or conflict (“red” in yellow ink) (test of the dACC).
Short-term Memory

Short-term – or working memory – is closely linked to the critical role the frontal lobes play in the temporal organization of behavior and controlling the proper sequence in which various mental operations are enacted.

Since the selection of information required to solve the problem at hand is made in the frontal lobes, they must store temporarily the information relevant to the current task.

Many areas of prefrontal cortex are involved in the processing of short-term memory (DLPFC; VLPFC).
Ingvar (1985) coined the phrase ‘memories of the future’ referring to one of the most important functions of advanced organisms: making long-term plans and then following the plans to guide behavior.

Unlike primitive organisms, humans are active, rather than reactive, beings. We are able to form goals, our visions of the future. Then we act according to our goals.

In order to guide our behavior in a sustained fashion, these mental images of the future must become the content of our memory: thus the ‘memories of the future’ are formed (via activity in DLPFC and VLPFC).
Intelligence has been defined in many different ways including as one's capacity for logic, understanding, self-awareness, learning, emotional knowledge, planning, creativity, and problem solving. It can be more generally described as the ability or inclination to perceive or deduce information, and to retain it as knowledge to be applied towards adaptive behaviors within an environment or context.

Evidence suggests that intelligence correlates with the size of, neural activity within, and communication efficiency among the dorsolateral prefrontal cortex, parietal lobe and anterior cingulate cortex (among other areas).
Personality refers to individual differences in characteristic patterns of thinking, feeling and behaving. The term personality trait refers to enduring personal characteristics that are revealed in a particular pattern of behavior in a variety of situations.

Personality can be determined through a variety of tests (e.g., Rorschach Inkblot test) or by self-report (answering questions that asks participants to indicate the extent to which sets of statements or adjectives accurately describe their own behavior or mental state).

Personality is usually broken into components called the Big Five.
Evidence suggests that four of the Big Five personality traits have distinct biological substrates (brain areas of larger volume; not exclusively in prefrontal cortex).

Whether cause or effect of experience cannot be determined.
Morality is the differentiation of intentions, decisions, and behaviors between those that are good or right and those that are bad or wrong.

In its descriptive sense, morality refers to personal or cultural values, social mores or codes of conduct. It does not connote objective claims of right or wrong, but only refers to that which is considered right or wrong.

Morals can differ from person to person, but some are widely held.

Principle of Double Effect
Side effect vs Intentional harm
The brain areas involved when humans reason about moral issues have been investigated in many studies. Intuitive reactions to situations containing implicit moral issues arise from the left temporoparietal junction (TPJ), whereas the explicit making of moral right and wrong judgments coincides with activation in the VMPFC.

TPJ and VMPFC mirror neurons, which fire when another person is observed doing a certain action, may play a role in not only in action understanding, but also in emotion sharing empathy (an ability to recognize and vicariously experience what another individual is undergoing).
The fragile frontal lobes
Frontal lobe dysfunction often reflects more than the direct damage to the frontal lobes themselves; that is, damage to the frontal lobes produces wide ripple effects through the whole brain.

Frontal lobe syndromes
Damage to different parts of the frontal lobes produces distinct, clinically different syndromes. The most common are dorsolateral and orbitofrontal syndromes.
Frontal lobe syndromes – Dorsolateral

Most common symptoms of dorsolateral syndrome are perseverative behavior, field-dependent behavior, and mental rigidity. These patients often typically have a flat affect: an emotionless voice and facial expression.

- **Perseverative behavior**: an inability to initiate behaviors, or once initiated be equally unable to stop.
- **Field-dependent behavior**: easily distracted, will engage in activities because objects are present in the environment (e.g. drink from an empty cup), even though actions make no sense.
- **Mental rigidity**: inability to change their mental state or approach to a problem (Wisconsin card sorting task).
Frontal lobe syndromes – Orbitofrontal

The orbitofrontal syndrome is in many ways the opposite of dorsolateral syndrome: the patients are behaviorally and emotionally disinhibited. Their affect is rarely neutral, constantly oscillating between euphoria and rage, with impulse control ranging from poor to non-existent.

Their ability to inhibit the urge for instant gratification is severely impaired: they do what they feel like doing, when they feel like doing it, without any concern for social taboos or legal prohibitions.