Emotion and Motivation

Part 2: The Cingulate, the Insula, and the Orbitofrontal Cortex

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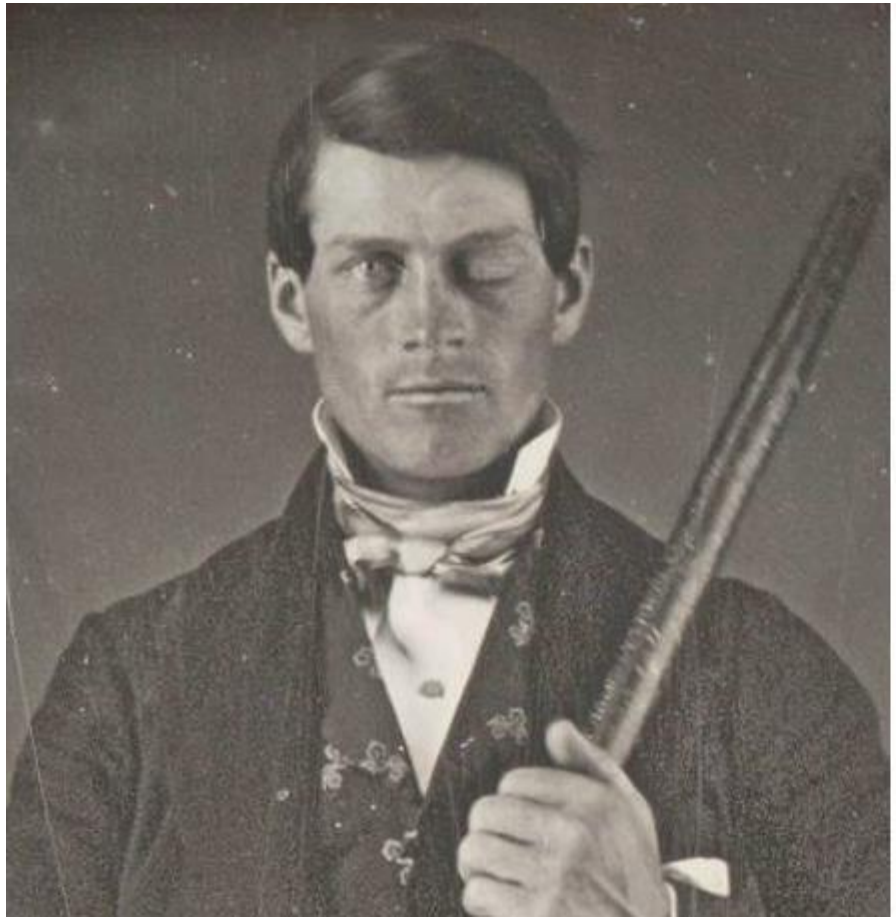
Introduction: Phineas Gage



- ***19C thinking***: "primitive" subcortex and "advanced" cortex
- But! ***Prefrontal cortex*** injury was followed by ***emotional*** change:
- Hardworking and responsible

  ↓
- Fitful, irreverent, capricious, vacillating

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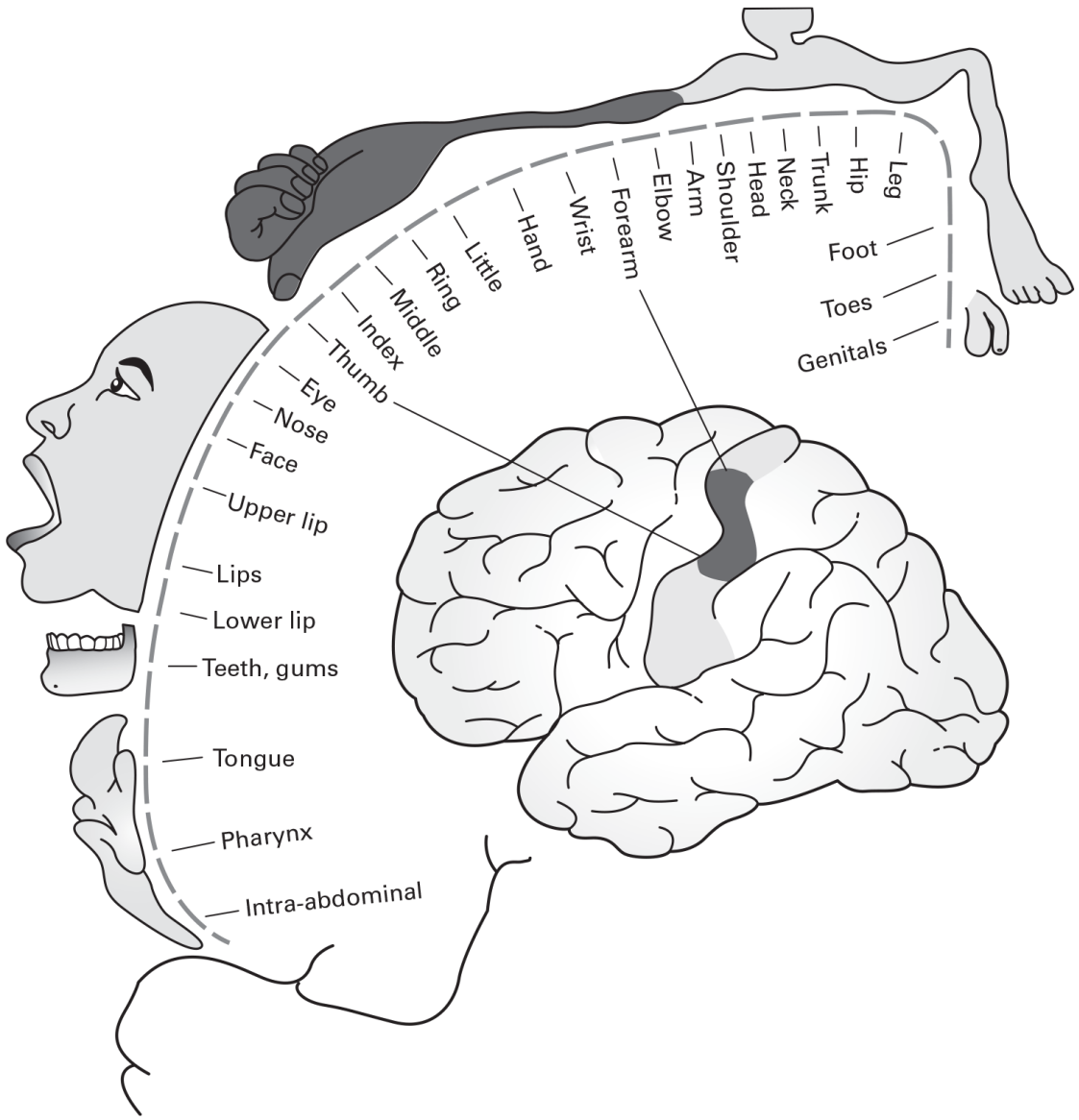
Introduction: Consciousness

- Emotion ***feels*** like something
  - Many researchers consider this property one of its defining properties
  - Emotion is frequently conceptualized as tied with conscious awareness (one of the "highest" components of the mind involving the cerebral cortex)
- What is ***emotion***?
  - William James: "emotion is tied to the ***changes that occur in the body*** during a triggering event"
  - Carl Lange: "emotional events are ***brought to consciousness*** in that they are brought to the centers of taste and vision in the cortex"
- Even in early attempts to understand emotion, the cortex was involved.

Using Electrical Stimulation

- Electric stimulation usually happens ***during surgery***, to avoid removing cortical tissue producing language or controlling movement
- ***Homunculus*** (little person) discovered by the neurosurgeon Wilder Penfield using electrical stimulation



The Cingulate Cortex

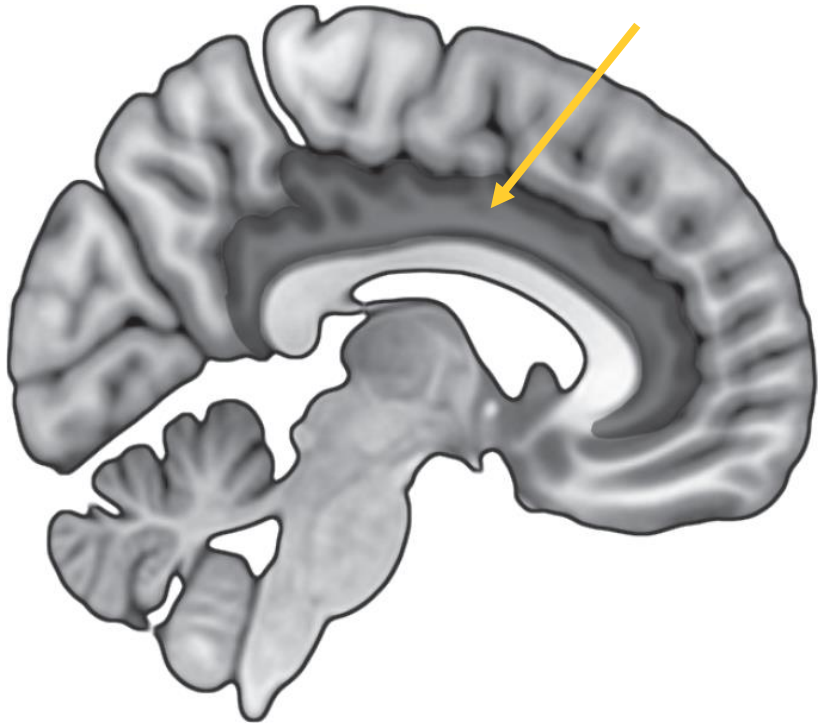
- Tumors in the cingulate gyrus were associated with "change in ***personality*** or ***character***" and "loss of ***spontaneity*** in emotion" in some clinical cases

  →Perhaps this area is a cortical centerpiece of the "emotional brain"

- Electrical stimulation in areas of the cingulate cortex arouse ***overwhelming feelings of fear***

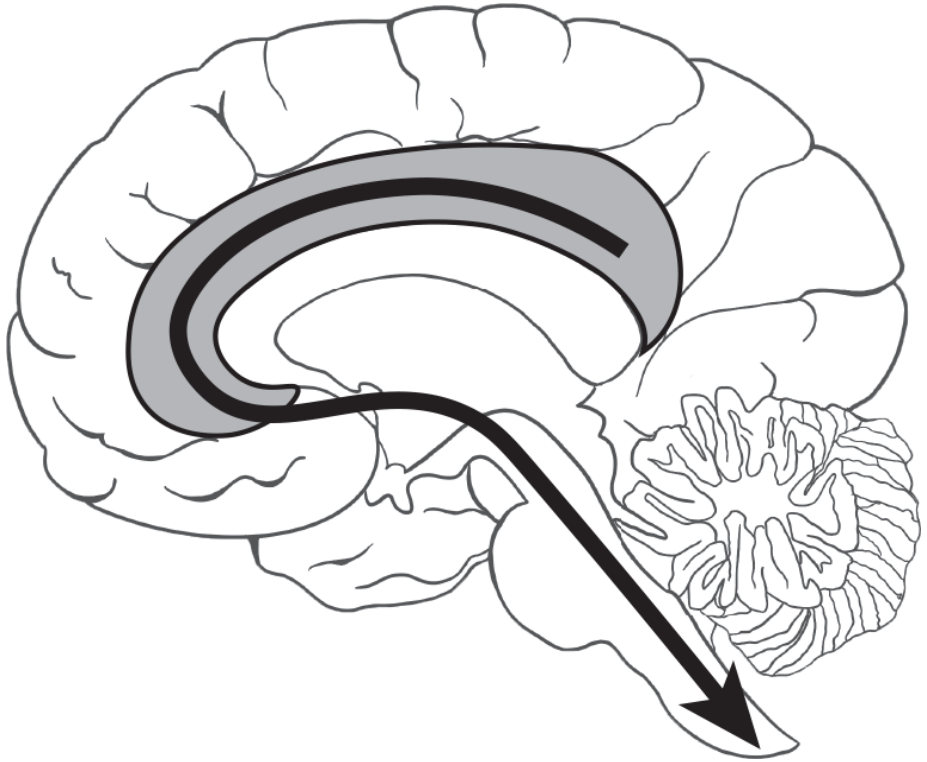
  - Further studies discovered changes in respiration, blood pressure, heart rate, and pupil dilation when stimulating the cingulate gyrus

  → The cingulate cortex engages in ***autonomic changes***



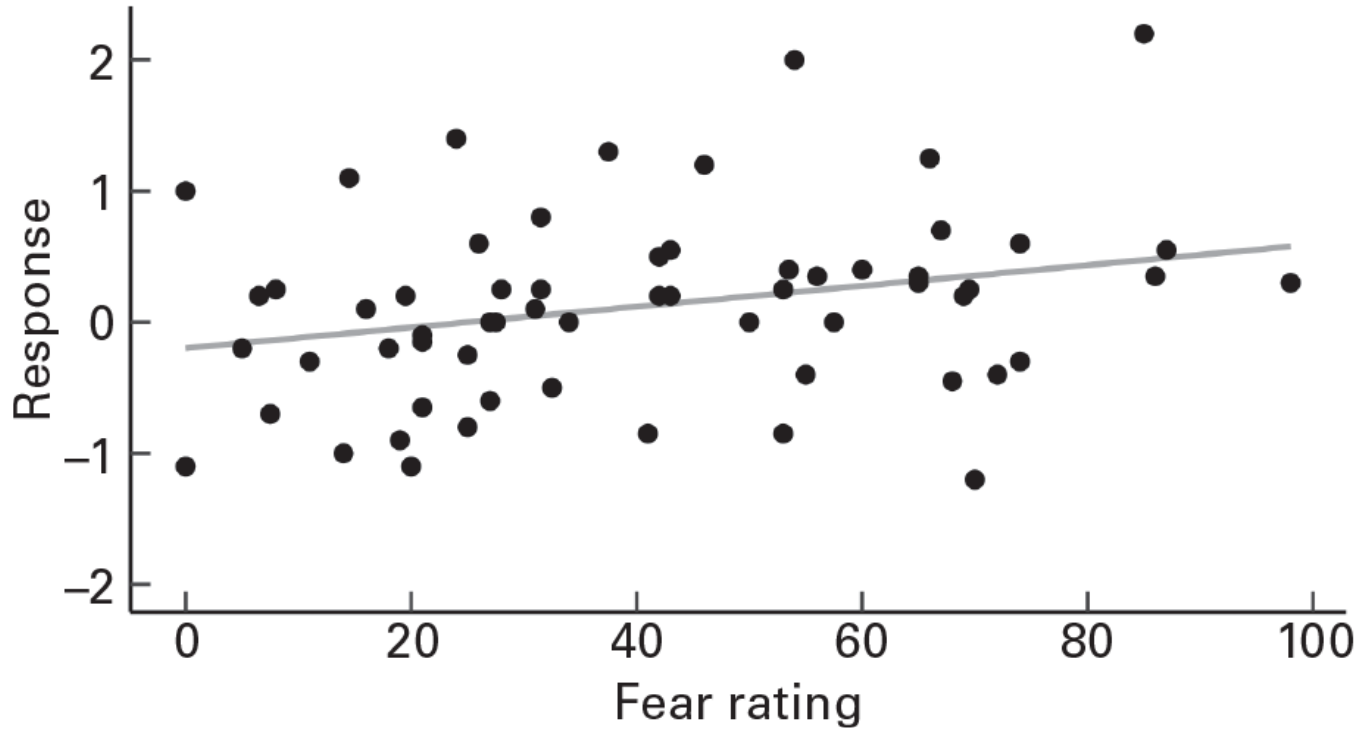
The Cingulate Cortex: Anatomical Connectivity

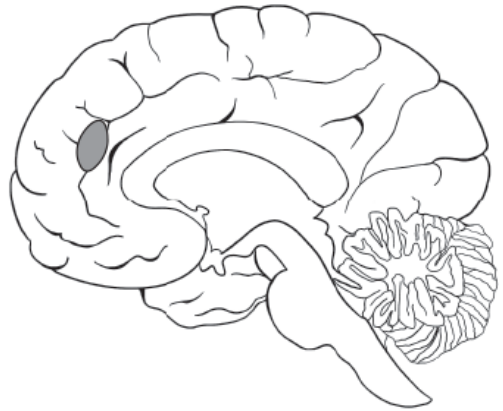
- Autonomic changes are consistent with ***connectivity***
  - The Cingulate cortex targets the hypothalamus, PAG and other brainstem areas, and structures in medulla
- Although the cingulate cortex is often viewed as an outflow (image to the right), it receives inflow signals from the brainstem.
  - Respiratory, cardiovascular, gastrointestinal signals → Nucleus of the solitary tract ⊂ Medulla → Cingulate cortex
  - Pain-sensitive circuits → thalamus → Cingulate cortex



The Cingulate Cortex: Appraisal

- ***Appraisal*** is the evaluation of the emotional "value" of stimulus
- fMRI studies indicate that responses from the CC reflect appraisal:



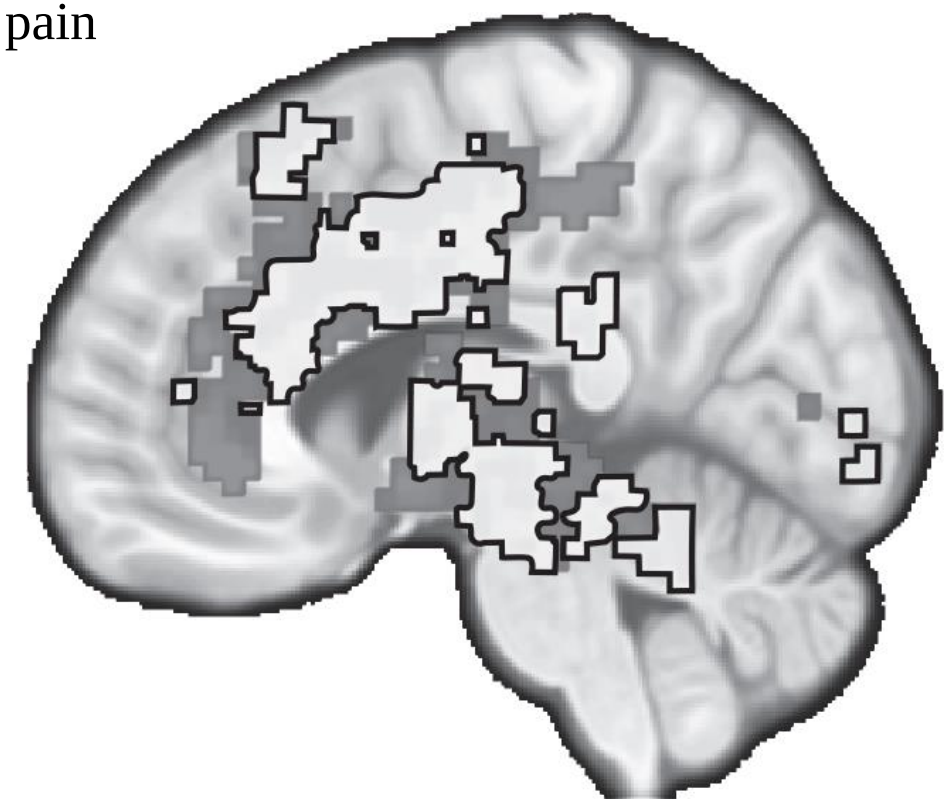


The Cingulate Cortex: Appraisal

- The cingulate cortex participates in an important role in ***extinction learning***.
  - "unlearning fear"
- The anterior cingulate cortex is linked to ***pain***
  - Wager et al., 2013: the higher the subjective level of pain, the stronger the response in the ACC
- How can we objectively ***measure*** pain?
  - Supervised machine learning algorithms trained on fMRI data can do the job
  - A type of "brain reading" that can predict pain ratings of participants!
  - A quantitative angle in a largely qualitative field is rare

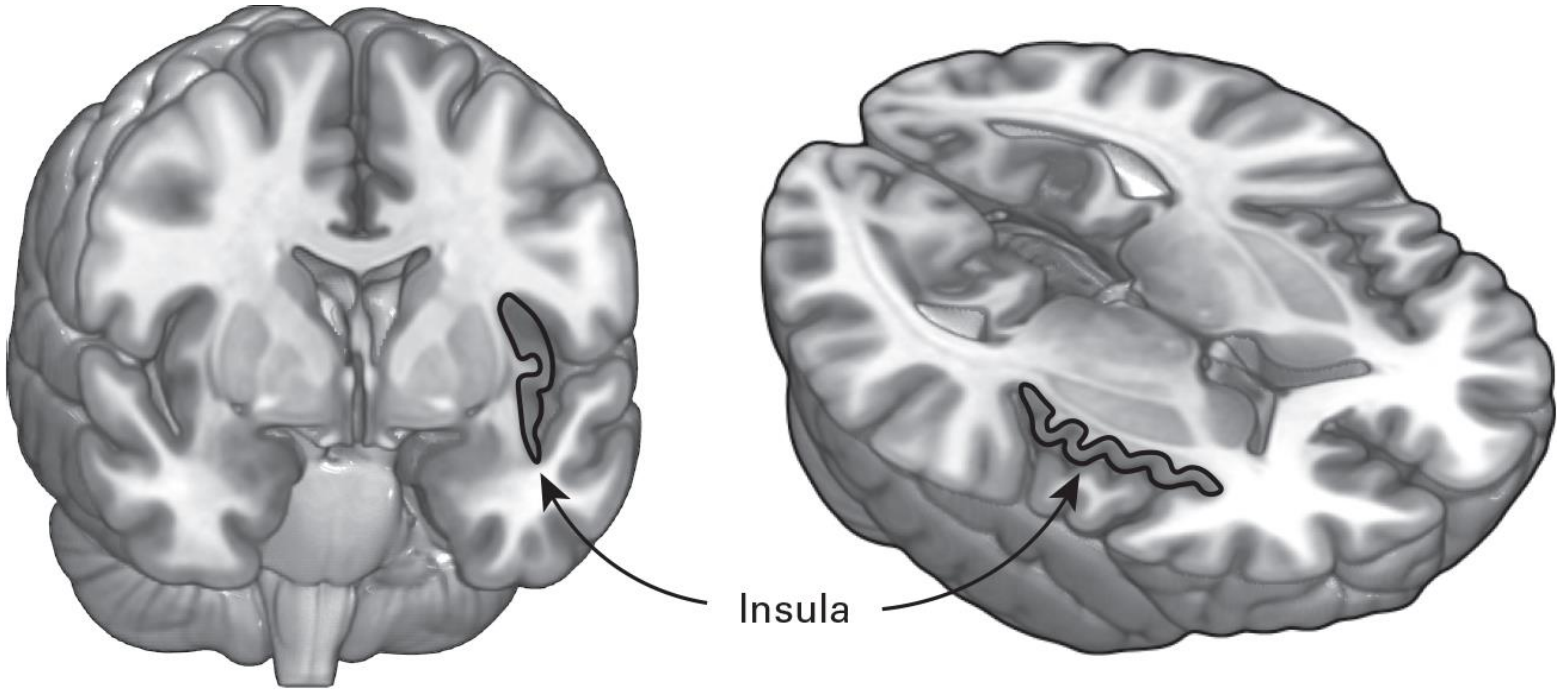
The Cingulate Cortex: Appraisal

- The figure shows contributions of brain areas to ***predicting pain***.
  - Light gray → predicts more pain
  - Dark gray → predicts less pain



The Insula: The Island of the Cortex

- The cortex of the ***insula*** is a sensory cortex which registers the ***state of the body***
  - Viscerosensory signals reflect temperature, pain, itching, tickling, sensual touch, thirst, hunger
  - Demonstrated by Penfield's electric stimulation studies



The Insula: The Viscerosensory Sector

- Sympathetic and parasympathetic signals are conveyed in the insula
- The insula is involved in various forms of touch sensation (lesion studies)
  - Inferring sensory pleasure
  - Emotion-related dimensions of the stimulation
- Soft brush stroking produces fMRI responses in the insular cortex as well as the somatosensory cortex
- But the insula is not merely an ***input*** station: ***bidirectional*** communications exist
  - There are descending projections (mostly from the posterior insula) that affect the body

The Insula: More than a Viscerosensory Sector

- Signals in the ***anterior insula*** correlated with ***task performance*** when asked to maintain a visual pattern in mind for a few seconds.
- fMRI studies in the 1990s: Responses in the insula were ***observed consistently*** in perceptual and cognitive tasks
- Large-scale analysis of thousands of neuroimaging studies show that the ***anterior insula*** is among the most *functionally diverse* regions of the brain
  - Responses are observed across studies of perception, cognition, emotion, motivation, and action
  - These results suggest that the insula is more than a viscerosensory sector
  - It seems as if our *sense of self* involves the insula

The Orbitofrontal Cortex

- Patient E.V.R. (age = 35) underwent neurosurgery that excised the ***orbitofrontal cortex*** to treat a tumor. Following recovery, E.V.R. exhibited ***radical personality changes***:
  - Successful and stable marriage → divorced, remarried, and then divorced again
  - Keen sense of business → series of brief, disastrous business ventures → bankruptcy
  - Accomplished professional, secure promotions, good performance → unable to maintain employment
  - Did the surgery affect his intelligence? Post-surgery IQ = 135 (intelligence was not the problem)
- Patients like E.V.R. become ***emotionally "shallow",*** sometimes to the point of exhibiting pseudo-psychopathy or "acquired sociopathy"
  - displaying persistent antisocial behavior, impaired empathy, and bold, disinhibited, egotistical traits

The Orbitofrontal Cortex: Value Computer

- Electrical stimulation studies revealed that the orbitofrontal cortex, along with the cingulate cortex and insula, are involved in ***autonomic processes***
- Recent research aims at understanding how it contributes to the ***computation of value***