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## Brain imaging of deception

**Contents** [\[Hide\]](#)

- [Neuroimaging](#)
- [Cognitive processes](#)
- [Neuroimaging and cognition](#)
- [Implications and future research](#)
- [Bibliography](#)

Deception, whether intentional or unintentional, adds an important dimension to social interaction. Given the theoretical as well as practical benefits of detecting deceptive behavior, much effort has been devoted to developing methods of measurement that can accurately depict the act of deception. In the past, the only possible ways to detect deception relied on indirect measurement of physiological indicators that are linked to the acts of deception—for example, involuntary arousal of the autonomic nervous system during lying. Based on this connection, the polygraph was developed; it detects deception by measuring changes in skin conductivity and variations in the heart rate and respiration rate. Other methods of physiological measurement, such as biofeedback and electroencephalography, psychological instruments (pencil and paper tests), analysis of facial expressions and other body movements, and evaluation of handwriting and voice, have been developed with the hope that they could accurately detect the act of deception. Much effort has been made to examine the psychometric properties of these methods. The validity of these indices remains a matter of constant debate. The main limitation of these instruments is that they can provide only an indirect measure of the acts of deception—that is, measurement of the changes in bodily status that result from lying. Also, many liars are skillful in applying countermeasures to avoid detection once they have learned the design and aim of such instruments. However, recent advances in imaging technology have enabled direct observation of the activities of the human brain during various cognitive operations, including lying.

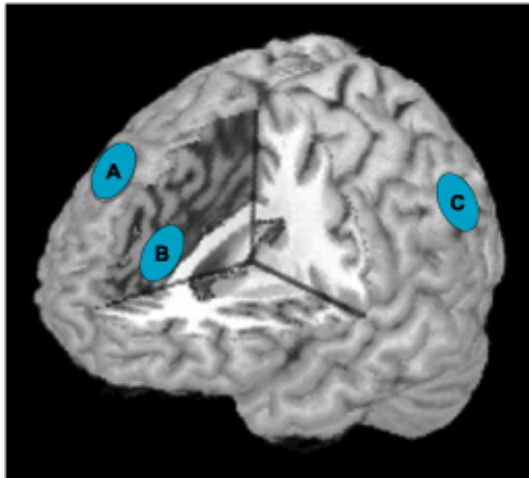
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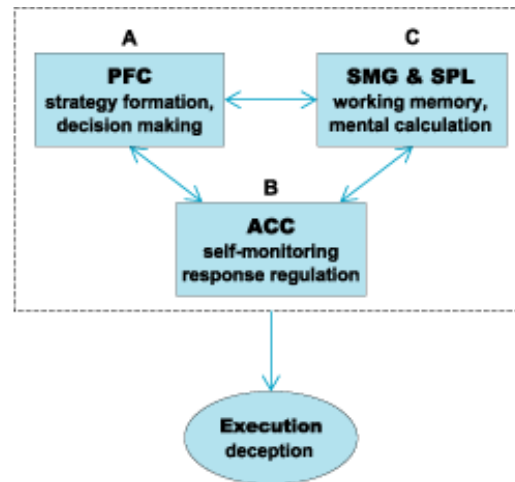
## Neuroimaging

Advances in functional imaging technology have made it possible to directly observe the brain activities associated with various cognitive operations. This method of measurement, thus, offers the unique opportunity to view the activity of the brain while the act of deception is being performed. The data generated are essential for unlocking the brain processes underlying deception, bringing researchers much closer to the goal of accurately detecting deception. The application of functional magnetic resonance imaging (fMRI) technology to study deception is a very new development, but it has been gaining momentum in recent years. Currently available fMRI data on the brain regions and mechanisms underlying deception have suggested that prefrontal cortex, anterior cingulate cortex, and parietal lobe (supramarginal gyrus and superior parietal lobule) activities are involved in deception (see [illustration](#)). The activation patterns appear to be quite robust across genders, forms of stimuli, and native language backgrounds. To understand what roles this functional network serves during deception, it is worth examining the cognitive processes involved in deception.

Schematic diagram of the neural areas likely involved in deception. PFC = prefrontal cortex; ACC = anterior cingulate cortex; SPL = superior parietal lobule; SMG = supramarginal gyrus.



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## Cognitive processes

Deception means that the truth is known but it is manipulated to achieve certain predetermined goals. Therefore, during the act of deception, the cognitive operations underlying the act should be more sophisticated and demanding than those involved in simply making truthful responses. In other words, deception requires the accurate recall of information followed by the conscious manipulation of the recalled information. Furthermore, to lie successfully, one has to possess the ability to inhibit the impulse to tell the truth. For example, in a test of deception using a forced-choice format, a subject could lie and potentially avoid detection by using a calculated response; that is, the subject could deliberately provide some incorrect responses to make it appear as though he or she is indeed trying to recall the information but is just unable to accurately remember all the information. Therefore, to regulate the complex behavioral pattern associated with deception, the activities of the specific neural structures involved in working memory, the cognitive control of response manipulation, the selection and adoption of retrieval strategies, and calculation of the proportion of correct responses should be essential to successful deception, especially when this behavior is tested by forced-choice memory tasks.

## Neuroimaging and cognition

The prefrontal cortex is involved in many neural functions and comprises many different anatomic regions. During deception, the activity of the prefrontal cortex is important for information manipulation and integration and the generation of strategies (see [illustration](#)). Indeed, the prefrontal cortex regulates motivated responses and allows the cognitive flexibility required to adjust one's behavior according to the demands of the context as well as to the anticipation of the consequences of actions. The prefrontal cortex is also the site where mapping between the goals and the corresponding cognitive strategies takes place. Furthermore, the anterior cingulate cortex, being strongly connected to the prefrontal cortex as well as to other cortical regions, plays an important role in self-monitoring as well as modulating cognitive control for the selection and execution of goal-directed responses (see [illustration](#)).

Activity of the parietal regions during deception could relate to the demands on working memory. Indeed, the supramarginal gyrus and the superior parietal lobule seem particularly relevant to deception. Previous studies have indicated that the supramarginal gyrus and the superior parietal lobule are activated by the demands on working memory (see [illustration](#)). Neuroimaging studies have also found evidence of activity in the prefrontal cortex and supramarginal gyrus regions in complex mental calculations (see [illustration](#)). Activation of the PFC-SMG network may be required for the real-time, or spontaneous, computation that is necessary to make calculated responses and to modify behavior during deception.

Brain activity may vary according to the nature of the tasks involved in deception. For example, some researchers have found that the left and right prefrontal cortex regions are engaged during general deception, but that the right anterior prefrontal cortex is more involved in well-rehearsed lies that fit into a coherent story about the subject's own life history. Other investigators have suggested that the medial prefrontal cortex is involved in the carrying out of endogenous plans (previously set plans to complete a primary goal), the lateral prefrontal cortex is involved in the carrying out of exogenous plans (plans contingent upon unpredictable events), and the frontal tip of the PFC is involved in mediating the interaction between the lateral and medial prefrontal cortex regions. Activity of the amygdala has been reported in some studies of deception, which is most likely related to the emotional arousal associated with the experimental tasks of deception used in the studies.

### **Implications and future research**

The use of functional imaging to detect deception has an advantage over behavioral methods, not only because it offers direct measurement of brain activities, but also because it may lead to more accurate detection of deception by providing knowledge of patterns of brain activities unique to specific types of deception. However, the work thus far is preliminary. While further improvement of paradigm design and image analysis methodology could increase the salience and the statistical power of the simulated deception paradigms, the question of whether the findings are generalizable to different populations in the real world awaits verification. In other words, would people suffering from damage to the parts of the brain involved in deception be unable to lie? What variation in brain activities during deception would be expected among different clinical conditions, such as antisocial personality disorder, impulse control disorders, and substance-abuse disorders? It seems that thorough experimentation and carefully designed clinical studies are needed to answer these important questions. Such knowledge will contribute to the eventual construction of a complete model describing deception.

Recently, there have been reports on the use of transcranial magnetic stimulation to study deception. Since a magnetic field emitted via transcranial magnetic stimulation could produce a transient cortical disruption, it has the potential to establish a cause-effect relationship between the roles of specific brain regions and the operation of the target cognitive task. Furthermore, the temporal brain dynamics between the different brain regions involved in deception is worth further investigation. Further studies that combine the benefits of fMRI, transcranial magnetic stimulation, and electroencephalographic technology would provide powerful paradigms that could help to unravel the mystery of the neural mechanisms underlying deception.

See also: [Brain](#); [Cognition](#); [Information processing \(psychology\)](#); [Medical imaging](#); [Memory](#)

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