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# The Physiology of Lying

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## ABSTRACT

Lying is a complex phenomenon shared by practically all humans, seen among all cultures, and in almost all age groups. As with all behaviors, lying originates in the brain and is mainly controlled by the prefrontal cortex. Outside of the prefrontal cortex, physiological manifestations have been monitored. For example, they include the common signs of lying for example increased heart rate and sweating, to more covert changes such as blood flow, neurotransmitter release, neural activity, and alterations in brain structure. Even though research on these various manifestations of lying has provided some evidence, there is no concrete linkage between each of these responses. Since lying provides many common symptoms, there is also a desire to detect it, as seen by polygraph testing extensively used between the late 1930s to 1988. However, if technology were to advance to the stage of measuring brain activity or neurotransmitter release and determining with high accuracy if a person was lying or not, it would lead to substantial ethical issues, mainly for patients or personal privacy. Overall, this literature review compiles and analyzes extensive research on the aforementioned physiological responses to lying, facilitating future research not only in the physiological but also psychological aspects. Furthermore, it also explores the implications of lie-detecting technology for society by looking at the safety and security risks it can bring. Thus, this literature review advances the science behind lying and underscores the necessity to understand the ethical undertones of research in this field.

## Introduction

A lie or the action of lying is, simply defined, an intentionally false statement told usually to get oneself out of a situation or to be deceptive (Smith, n.d.). Lying and deception are described to be the most fundamental human activities, prevalent across all age groups (Sanford, 2003). Studies indicate that children begin lying around the age of 4 to 5 years old, with young adults lying “the best,” and as they age, the art of lying starts to decline around the age of 45 (Schaarschmidt, 2018).

The reasons why someone may lie are complicated. Yet, the majority of these reasons can be categorized as the self-protection of one's own interests in which a lie is told to avoid being embarrassed, to hide an awkward situation, or to have others think better of them (WebMD, 2020). However, some special cases in which a person lies could be the result of a personality disorder including antisocial, narcissistic, and histrionic personality disorders. People who lie frequently have been shown to have a desire to be in control, and fully believe that the depiction made was indeed the truth (Grubin, 2005).

With regards to how a person lies, he or she must suppress an initial response, the truth, realize what the intended audience may think and adjust the lie accordingly to create a “realistic” scenario, and recognize the consequences if the lie is caught (Schaarschmidt, 2018). Due to the demanding aspects of lying, extensive cognitive resources are required.

In general, there are multiple reasons for which somebody may lie, and there are many techniques to do so. The exact mechanism through which humans lie is complicated and involves the combination of both physiological and psychological actions within the body. Though the physiological and psychological elements of lying have been explored, this review compiles, analyzes, and focuses on the physiological aspects of lying as less research has been conducted in this field. These topics include changes within the structures of the brain, blood flow, neurotransmitters,

and neural activity, as well as the visible characteristics when a person lies. Therefore, this literature review builds upon research on the physiological realm of lying and compiles it for future reference.

## Lying and Physiological Manifestations

### Physiological Signs of Lying

On the surface level, a person who lies exhibits many changes in the mouth, the eyes, the body, the voice, and other physical manifestations. The majority of these responses are due to the nervousness a person feels resulting in the abnormal response. Starting off, a liar will have substantial changes in the facial expression including the eyes and mouth (Cherry, 2020). Once a person lies, their eyes may look up to the left, flicker, become unfocused, or stay tensed up. The main reason for this is the need for the person to process the truth and give out a lie, requiring more cognitive resources and ultimately shifting eye behavior. Looking at the mouth, many people may try to smile out of a lie, in which a fake smile is characterized by forced lips and muscles. Additionally, they may lick their lips or perform a hard swallow. In general, facial expressions change minutely yet noticeably when a person lies, representing the visible physiological characteristics a person may demonstrate when deceiving.

Regarding more of the body's responses, the liar may seem to sweat suddenly, fidget, or shield themselves (Cherry, 2020). Usually, when a person does lie, the increased demand on the brain puts the body under pressure, quickening metabolism, and resulting in sweating, usually seen on the palms or face. Fidgeting may show up as well in a liar as they may fiddle with objects, touch the top of their heads, or tap their feet, in order to reduce the stress they're facing. Furthermore, some people may take defensive stances, which can be seen through crossed arms, tucked hands, slouched shoulders, and fewer hand gestures (Darrin, 2019). Similar to the face, the body alters slightly while lying, which is another sign of physiological change.

Finally, an alteration in the voice of the person can be detected where he or she may display less confidence in projecting a response or making vocabulary more formal by reducing contractions (Darrin, 2019). Overall, the majority of the responses listed above are a way in which a normal liar will try to cope with the lying and the exhausting "symptoms" that come with it, thus, reducing the stress he or she has to face. Overall, these various signs exhibit what a person will "look like" when deceiving and illustrate how complex lying is physiologically, and how nuanced the internal mechanism to control these external behaviors are.

### Lie Detection Instruments Based on Physical Manifestations

Nevertheless, these physical manifestations can be used to differentiate liars, as seen by the usage and functionality of a conventional lie detector, also known as a polygraph test. Polygraph tests are instruments that record the physiological symptoms in a person most linked to arousals such as heart rate and blood pressure, respiration, and skin conductivity or sweating (Moore, 2003). As mentioned, these same responses show up as signs of a person that is lying. The test begins when the proctor delivers basic and easy questions to the patient or suspect in order to measure their symptoms when they tell the truth. These are usually prompts like "What is your name?" or "When were you born," and act as a control or comparison. After the initial round of interviews, more case-specific questions are asked possibly relating to a crime. A pattern of heightened physiological responses (i.e., increased heart rate, a greater rate of sweating, etc.) to these "experiment" questions can indicate deception, while a negligible difference between control and experiment questions suggests truthfulness.

Due to the measurement of the symptoms and the general anxiousness of the person, the accuracy and validity of polygraph tests have been questioned (Moore, 2003). By simply maintaining a calm and collected response, liars can appear innocent. This is especially easy in repetitive or pathological liars as studies indicate that the more a person lies, the less guilt they feel which leads to lower stress and nervousness, resulting in little to no display of the previously

mentioned physical manifestations lying normally brings. In addition, those who are easily nervous may exhibit the traits of a liar under these tests, consequently having the potential to cause a false accusation to be made if the polygraph test is used in a criminal setting. With all of these risks, polygraphs have accordingly been used less and less. Alternative tests such as guilty knowledge tests, which involve a multiple-choice style test utilizing stimulus that only a guilty subject would know and react substantially to, have shown some promise (Moore, 2003).

However, the aforementioned lie detection approaches are limited as a "symptom" may be caused by general nervousness or lack of knowledge. Overall, lie detectors have some relation to lying as they are based on the visible characteristics many people do show when lying, yet it is this measurement that results in the restraints of lie detectors since these are ultimately only correlated with lying. All in all, the physical manifestations of lying are shown by many and include variations in visible and measurable features of the person. Therefore, from an outside perspective, these symptoms describe the broad physiological changes a person experiences when lying.

## Lying and Brain Structures

Requiring an extensive cognitive component, lying utilizes numerous structures within the brain in order to facilitate the process. The major area involved with lying is the prefrontal cortex as this region is crucial in cognitive control functions, such as choosing an answer (Schaarschmidt, 2018). As a person lies, fMRI scans detect neocortical changes in blood flow in response to changes in neural activity. However, this physiological response was true for both those who lied and those who were *thinking* of lying (Schaarschmidt, 2018), making it challenging for it to be used as a detection metric for liars. Relating to fMRI scans of the brain in liars, there was no specific region in the prefrontal cortex that was highlighted to "control" lying. In fact, research showed the collaboration of various areas in this cortex when a person did indeed lie (Schaarschmidt, 2018).

With regards to material changes in the prefrontal cortex specifically, an experiment published in 2018 by the *British Journal of Psychiatry* showed that pathological liars had a 22% to 26% increase in prefrontal white matter alongside a 36% to 42% reduction of prefrontal gray/white ratios (Yang et al., 2018). Gray matter processes and interprets sensory information while white matter projects information to various parts of the body. The results from this study show the importance of the prefrontal cortex with respect to lying and decision-making. Nevertheless, the experiment was limited to only identifying this area as being prominent in the process of lying and did not pinpoint a specific region, furthering the aforementioned conclusion above.

Finally, a separate experiment utilized electrodes attached to the scalp to measure the activity of the anterior prefrontal cortex, which has been associated with moral and ethical choice-making. When researchers inhibited this region of the prefrontal cortex by decreasing the excitability with the electrodes, people became more pronounced at deceiving others (Schaarschmidt, 2018). More specifically, as illustrated by the graphs in the study, when the electrical signal was passed through (cathodal), a decrease in feelings of guilt were seen by a probability of $p=0.023$, correlating alongside the fact that the less guilt the subjects felt, the easier it became for them to deceive during an interrogation (Karim et al., 2009). Furthermore, her results also indicate that patients who were exposed to the electrodes had a faster reaction time in lying by over 200 milliseconds. To further back up the data, Karim proved that the increased efficacy of lying was not caused by an increase in cognitive efficiency: participants generally just became better at lying. This was shown by a separate attention test done by Karim, where the test subjects and the control group performed the same. Thus, the electric current passed through the electrodes into the anterior prefrontal cortex and left the participants with fewer cognitive resources to assess the ethical implications of their lie. Overall, the various regions collaborating in the prefrontal cortex allow a person to lie through specific tasks or actions or by regulating the emotions of said person.

Outside of the prefrontal cortex, the amygdala is also heavily affected/changed when a person continuously lies. The amygdala's main function is its "fight or flight" response, as it responds accordingly to fearful or threatening stimuli, thus regulating this type of emotion. Furthermore, it has also been shown to be involved in the reward process and decision-making (Baxter & Croxson, 2012). Therefore, as a person continues to lie more and more, the amygdala

becomes less and less responsive because feelings of guilt decrease (Schroeder, n.d.). Though research on this topic isn't extensive, some studies show that humans hate to see themselves as liars. Due to this, the activation of the amygdala decreases, so humans can avoid the guilt that comes from lying. The prefrontal cortex alongside the amygdala holds the key to understanding a liar. Generally, the amygdala identifies environmental stress, and then the prefrontal cortex will act on that stress (Liu et al., 2020). Correspondingly, it can be assumed that lying follows a similar process in brain response and activity in which the stressor in life is detected by the amygdala, and the prefrontal cortex acts upon it. Yet, current research has not established a definitive physiological link between the two. Nevertheless, the interconnectedness of them exists as aforementioned.

## Lying and Neurotransmitters

In order for the brain to communicate, various neurotransmitters are involved in the process, with some more related to lying than others. The major hormones released when a person is lying are known as catecholamines. More specifically, it includes epinephrine and norepinephrine, which are both "fight or flight" hormones. Both of these hormones are produced and released when the body begins to feel stressed, or when it needs to protect itself from a harmful situation. Correspondingly, as lying is a stress response mechanism, both of these hormones are released in the body too (Paravati et al., 2021). Therefore, it leads to the "telltale" symptoms of lying such as sweating and an elevated heart rate. Both these neurotransmitters and other types of catecholamines are involved as a response to or symptom of lying. Nevertheless, they cannot solely act as a detection method for lying as other stimuli can cause the production of hormones and the release of various neurotransmitters as well.

## Lying and Brain Activity

Since lying involves so many regions of the brain, numerous electrical signals are emitted in order to facilitate communication in the brain. In order to measure this, electroencephalography, otherwise known as EEG, is used for this purpose. EEG is a device that records the electrical activity of your brain due to the impulses created when neurons communicate with one another. Through the usage of electrodes, which are small metal discs with thin wires placed on the scalp, EEG readings display wave patterns based on the state of the brain (Scalp EEG). Readings display a series of wave patterns that change based on the state of the brain. There are various waves that EEG can detect including alpha, beta, delta waves. The wave of importance for lying is the P300 or the P3 wave. The P3-P300 waves that are recorded in the parietal lobe (top part of the head) appear to be involved in decision-making as well as recognizing patterns, a crucial necessity for lying. The event-related potentials of the P300 wave portray brain activity in response to stimulus or activity and are shown as a positive deflection on the EEG around 300-800ms. As this wave is involved in decision-making, it will spike when it sees something familiar (Rosenfeld, 2019). Therefore, in relation to lying, the wave would be active and spike in this case as the person must choose to tell the truth or a lie. For instance, in criminology, if a witness noticed something familiar, such as a weapon, the P3 wave would spike up on the EEG. While the exact relationship is unknown, a correlation does indeed exist between the two. Additionally, this technology could be used in criminology as referenced by the above example. However, numerous ethical implications exist with this technology in this field, which will be discussed below.

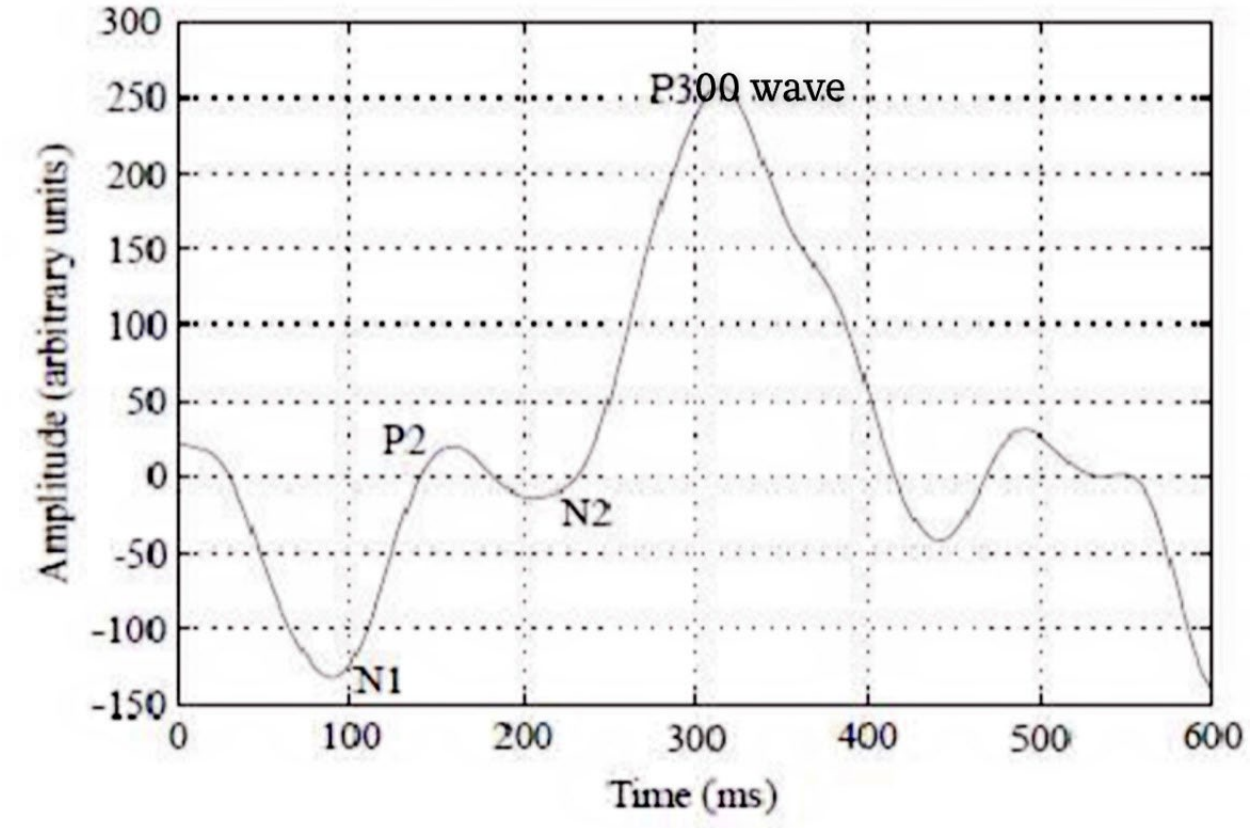


**Figure 1.** A graph of a P300 wave, illustrating the excitation being seen on an EEG output. Adapted from "Signal Processing and Classification Approaches for Brain-Computer Interface," by Tarik Al-Ani and Dalila Trad, 2010, ResearchGate, Uploaded Figures

## Discussion

Lying is a complex behavior shared by all humans. To reiterate, it involves numerous regions of the brain, neurotransmitters, as well as brainwaves to occur. While more and more research continues to take place linking different physiological reactions in the brain and body to lying, a variety of concerns, ethical in nature, arise. As aforementioned, polygraphs have been the go-to device since the late 1930s when the topic of "detecting a liar" comes across a person's mind (Synnott et al., 2015). Nevertheless, as discussed, these devices are only correlated with lying, and the metrics the device measures are not always accurate as other stimuli can trigger the metrics as well. However, with breakthroughs in the field of neuroscience and deception, the ability to accurately detect if a person is lying becomes possible. For instance, the combination of examining which regions of the brain, recorded with functional MRI, when a person intends to lie combined with the usage of EEG and the P300 wave could lead to a more accurate method of detection. Similarly, examining structures like the amygdala or correlating the release of catecholamines and other "indicators" of lying through machine learning models could further the sensitivity and specificity of determining who is lying and who is not.

**Table 1.** A brief description to summarize a few methods of lie detection covered in this literature review.

| Lie Detector | Description |
|---|---|
| Polygraph | Records the physiological symptoms, such as heart rate and blood pressure, respiration, and skin conductivity/sweating, which are related to lying |
| fMRI | Views the flow of blood in the brain structures to regions in the prefrontal cortex to see if a person is lying, about to lie, or will not lie. |
| EEG | Measures the P300 wave to see if a spike occurs when a witness sees something familiar but gives an opposite statement to what was recorded. |

As lie detection tests continue to develop and become more advanced, such as the usage of fMRI, the usage of these methods in criminology or a court of law legally has been debated. A case that explored this topic early on was the US Supreme Court case in 1998: *United States v. Scheffer*. In this case, Scheffer was under investigation for drug possession at an Air Force base and was given both a polygraph and urine test. He passed the polygraph test but failed the urine one. In his case, however, the Military Rules of Evidence prevented him from using polygraph evidence, unlike in normal Federal Rules of Evidence (Greely, 2005). Scheffer's case represents Federal Rule of Evidence 403 which states, "The admission of any evidence is subject to the court's determination that its probative value outweighs its costs in prejudice, confusion, or time." In summary, this usage of his evidence informs one of the many debates on the usage of such lie detecting tests in courts of law in the United States. In contrast, Canada excludes polygraph evidence due to its unreliable nature and its violation of the old common law evidentiary rule against "oath helping" (Greely, 2005).

With such controversy already existing about polygraphs, newer technology would have an even greater impact with regard to lying. The main issue would be the privacy of a person or suspect. Even though the usage of such equipment would bring about faster verdicts and more concrete evidence, the idea of ethics comes into major play. For example, how much do we trust the new lie detectors? Though the accuracy would be much better, all evidence gained from it, especially in a court of law, should not be the only evidence used. Lie detectors always have faults and over-dependence on technology could lead to mistakes, some mistakes leading to wrongful conviction. Furthermore, how does this relate to personal privacy? With devices hooked in and up to your head, not much-considered thought can be put into it and most liars will be caught. Nonetheless, this severely invades a person's privacy, and even if this test has the option of being turned down, there may be other tools used for the assessment of the client.

All in all, lying involves numerous parts of the brain, as well as the body. It gives numerous responses, many of which have and can be measured. As this science continues to evolve, the applications of linking lying to an actual physiological response can be used in places such as a court of law, interrogations, etc. Thus, as a researcher, it is crucial to understand the safety and security risks behind the development of this ever-expanding field of neuroscience.

## Conclusion

This literature review explored the interconnectedness between physiological manifestations in the brain and the body that show the common behavior of lying. It has compiled into a single paper the changes in the brain structure, blood flow, neurotransmitter, and EEG brain wave activity when a person deceives and analyzed these topics. Through this, further research can pursue all fields related to lying. Additionally, this paper sets the grounds for future research in which the psychological aspect of lying can also be researched alongside the physiological responses. Finally, the ethical aspects of medical devices that detect lying were discussed, as new technology like this can have major

consequences on many fields and careers today. Overall, lying is a complex process, and though new methods have been tested to detect a liar, ethical issues must also be considered when this technique is used.

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