The Cognitive Neuroscience of Deception:

Advances in Neuroscience, Criminal Law Applications and Ethics

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ABSTRACT: Neuroscientific advances promise to change the way the law and the legal system are viewed. In this paper, neuroimaging technology is discussed in terms of its development and how it has improved understanding of deception pathways. As knowledge builds, mistaken convictions that lead to wrongful punishment of innocent parties could be avoided. Likewise, the release of dangerous criminals back into society could also be prevented. In addition, ethical issues (i.e. premature adoption, misapplication through misunderstanding of technology and privacy concerns) that currently prevent the implementation of mind reading or deception detection technology in the courtroom are discussed. Limitations of such technology are also discussed along with advances and future directions in research. Finally, a pathway is proposed that could explain the origins of the mechanism of deception and how it could be tested.

Introduction

Criminal law is a field of growing interest in the world of neuroscience because of its recent technical advancements. Research suggests the possibility of more precise sentencing through, among other things, mind reading and deception detection. Methods such as functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), the P300 memory reading method and the Concealed Information Test (CIT) have been suggested to be appropriate tools in the attempt to undercover previously inaccessible evidence within the brain of the individual being prosecuted. However, there are a number of issues to be addressed in considering this as a possible way of obtaining evidence: relevance of evidence, accuracy of techniques, the idea of 'cognitive privacy', etc. Given the wide scope of literature in the topic, this paper will focus on the relevance of evidence and how the new evidence may affect a jury in making a conviction with the use of neuroscientific babble and 'expert witnesses'. Additionally, ethical concerns must be addressed to provide context to the problems that integrating this new technology in a court of law might bring. For the sake of simplicity, the focus of this paper will be on the potential use of neuroscientific evidence by the prosecution in criminal trial to provide background to the neuroscientific evidence of interest.

At this time, the probative value of neuroscientific evidence in the courtroom is still under scrutiny. In particular, the use of neuroimages has been suggested as admissible evidence for criminal cases by the prosecution to determine pathologies that might be signatures of antisocial or criminal behavior with little success (Sinnott-Armstrong et al., 2008). Given the magnitude of literature surrounding this field of study, we simply mention the research but it will not be discussed further. Similarly, it has been suggested that neuroscientific evidence could be used to pinpoint neurological pathways associated with deception—the research on which this paper will focus (Abe et al., 2007; Abe 2009; Abe 2011; Langleben et al., 2005). This field of research is not new, as it follows from previous attempts to detect deception through the use of polygraphs or other scientific tools for measuring arousal (Wolpe et al., 2005; Abe, 2011). The use of polygraphs has been deemed to be unreliable by the scientific community, but application of new technology has not yet been tested with subjects on trial because of several ethical issues that must be defined. Regardless, there is a growing body of research suggesting that implementation of neuroscience evidence in this regard would be beneficial to the law system, adding a degree of efficiency in criminal sentencing. Pertinent evidence suggesting advances in technological research has been reported, shining new light on answering the question of relevance of neuroscientific evidence applied to deception detection.

1. Deception and the Brain – In search of a pathway

Deception is a psychological process by which one individual deliberately attempts to convince another person to accept what the liar knows to be false—typically in favor of the liar or sometimes others—to maximize gain of a given benefit or to avoid loss (Abe, 2011; Abe, 2009; Lefebvre at al., 2009; Abe et al., 2007). Among the many activities and situations in which deception is covered—white lies, jokes, disguise, forgery, magic, financial fraud and scams, and more—there exists a need to recognize different genres of deception and how these are shaped by the brain and mapped in the brain (Abe, 2011). While some lies may lead to serious consequences—either positive or negative—because of their selfish and antisocial premise, others may lead to smoother communication and overall self-fulfillment because of their altruistic and pro-social foundation (Abe, 2011; Abe, 2009).

Over the years the study of deception has captured increased attention among psychologists and neuroscientists. Not surprisingly, lie detection has become the most popular area of research because of the useful implications of such methodologies in the courtroom, classroom and clinical setting, among others. In terms of human behavior, some non-verbal cues have been found to be directly associated with lying such as changes in physical expression, pitch of voice and body posture (Abe, 2011; Frank & Ekman, 1997). Lie-detection systems, such as the polygraph, have been suggested in the past as appropriate methods of deception detection as they measure a subject's physiologic responses by monitoring chest expansion, pulse, blood pressure, and electrical conductance of the skin—all aspects which are often physiologically amplified when someone is lying (Abe, 2011; Wolpe et al., 2005). However, there are a number of limitations to this method. The main problem is that the polygraph assesses activity of the autonomic nervous system, so signal changes may reflect not only arousal during deception but general anxiety regardless of the cause (Wolpe et al., 2005).

Another method that has been suggested is the use of event-related potential (ERP) (Lefebvre et al., 2009; Cutmore et al., 2009; Mertens & Allen, 2008). This method focuses on the use of brain responses in lie detection, but like the polygraph it has not been assessed to be entirely reliable. Regardless, these systems provide preliminary insight into the psychological processes associated with various aspects of deception (Abe, 2011).

Pioneering work by Spence et al. (2001) led to an increase in the number of neuroimaging studies that have resulted in a better understanding of the brain regions associated with deception. Through these neuroimaging studies, it was found that the prefrontal cortex plays a role in deception, though the precise role of this region and other subregions of this area are still unclear (Abe et al., 2007; Phan et al., 2005). It has further been posited that the anterior cingulate cortex is involved in the inhibition of true responses and the production of deceptive responses (Abe et al., 2006; Nunez et al., 2005). Also, activity in the amygdala has been reported as crucial for emotional processing and is thus reportedly seen in relation to deceptive intention (Abe et al., 2007). Nonetheless, the neural mechanisms that lead to activity in the prefrontal cortex subregions are still under investigation. Given that the mental activity associated with deception is complex, developing a better idea of what these mechanisms are will continue to be a difficult task. One of the obstacles is being able to differentiate between the process involved in developing a deceptive idea and isolating that mechanism from the neural activity associated with the intention of deceiving—deception with social intentions (Abe, 2011; Abe et al., 2007). It should be noted that, in relation to deception, the dorsolateral prefrontal cortex is associated with executive function and the ventromedial prefrontal cortex with emotional regulation of social interaction (Abe et al., 2007). In the following sections, empirical evidence will be discussed that has led researchers to suggest the possibility that such neuroimaging should be tested in a real courtroom setting because of its promising efficiency and relative accuracy.

The application of neuroimaging to understand deception has been developed in what is now known as cognitive neuroscience of deception (Abe et al., 2007; Davatzikos et al., 2005). There are multiple laboratory groups around the world that devote their research to understanding the complex neural system that makes deception possible in primates. Humans' evolutionary development of deception still puzzles social evolutionary scientists. The rest of the report will focus on human studies for the sake of brevity and topic relevance.

Abe et al. (2007) reported a positron emission tomography (PET) study trying to dissociate the development of a deceptive idea and the associated neural signaling from the intention of deceiving and the relevant neural connection to the subregions of the prefrontal cortex. Abe et al. hypothesized that the development of a deceptive idea would be associated with the lateral prefrontal cortex while the intention associated with the deception would show higher activity at the medial prefrontal cortex. Results emphasize a critical aspect of human deceptive behavior: it "provides clear evidence that at least two factors essential for human deception are supported by distinct subregions within the prefrontal cortex" (Abe et al., 2007). Since then, similar results have been obtained in the Abe laboratory using other neuroimaging methods such as fMRI (Abe, 2011; Abe, 2009).

Langleben et al. (2005) reported the first quantitative estimate of the accuracy of fMRI in conjunction with a formal forced-choice paradigm in detecting deception in individual subjects. The paradigm aimed to balance the salience of target cues to elicit deceptive and truthful responses. Accuracy was determined for this model in the classification of a single lie and truth event. As reported later by Abe, Langleben found that the net activation associated with lie production was observed in the superior medial and inferolateral prefrontal cortices. Reportedly "lie was discriminated from truth on a single-event level with an accuracy of 78% . . . [results suggest that] fMRI, in conjunction with a carefully controlled query procedure, could be used to detect deception in individual subjects" (Langleben et al., 2005).

Regardless of all the advances that technology has brought to the field of cognitive neuroscience of deception, there is still more to learn and define before real world applications of suggested methodology can be implemented. It appears that the proposed region association suggested by Abe et al. (2007) has promise, but his future publications show no significant advances in getting closer to answering the mechanism question. In a paper published in 2011, Abe states that functional neuroimaging conducted in healthy subjects does not provide direct evidence that a certain brain region is necessary for a specific cognitive process. There is a baseline error that must always be accounted for and, based on the circumstances, there might also be further activation error due to the unusual or unexpected conditions a test subject might be in. Furthermore, it should be noted that there is a line that must be drawn when comparing experimental subject scenarios to real life scenarios, due to experimental limitations that would not be factored in during real life trials (i.e., motivation of the subject to lie, motivation of the subject to be present at the study, etc.). However, the relevance of empirical evidence should be questioned in par with data obtained for analyses in other fields—there is no reason to believe that deception data will be less helpful than other empirical data thus acquired. One must be careful when comparing group to single individual data. In order to fully understand the question of how cognitive and neural correlates of deception are related with other processes researchers have to look at group and individual experimental data and show significant differences between experimental conditions and group data. Furthermore, care must be taken when studying individual neuroimaging data of complex cognitive processes—such as deception—in individuals between single trials. These comparisons are particularly challenging because of the low signal-to-noise ratio in such trials (Ganis, 2009).

Even though research in the field of cognitive neuroscience of deception has been growing tremendously in the past few years there is still much work to do. However, at this point in time, findings suggest that neuroimaging studies are not at a point to provide significant evidence to be relevant in a court of law. But, how can relevance be defined?

3. Relevance of Neuroimaging as Evidence in a Court of Law

According to the Federal Rules of Evidence (Sinnott-Armstrong et al., 2008), courts follow the following definitions of relevance:

FRE 401: "relevant evidence" means evidence having any tendency to make the existence of any fact that is of consequence to the determination of the action more probable or less probable than it would be without the evidence.

FRE 402: All relevant evidence is admissible, except as otherwise provided by the constitution of the United States, by Act of Congress, by these rules, or by other rules prescribed by the Supreme Court pursuant to statutory authority. Evidence which is not relevant is not admissible.

FRE 403: Although relevant, evidence may be excluded if its probative value is substantially outweighed by the danger of unfair prejudice, confusion of the issues, or misleading the jury, or by consideration of undue delay, waste of time, or needless presentation of cumulative evidence.

Reviewing FRE 401, it is explicitly stated that in order for evidence to be deemed relevant it must add to the evidence already in place in a concrete manner. Thus, the existing evidence must gain value and insight from the addition of the suggested new evidence to be considered relevant. Because of this, neuroimaging data should provide an accurate report that will make the final decision by the jury easier and more definitive. To be able to discard the variable of deceit would be an incredible feat for neuroscience and a great advancement to criminal prosecution and fact reliability. From this point onward any suggestion of evidence relevance will be presented from the perspective of the prosecution.

FRE 402 and 403 go hand in hand, as both of these rules define evidence admissibility. FRE 403 is particularly important because it brings up important issues that should be considered when thinking about neuroimaging as evidence for pinpointing deceit intentions and actions. Some of these questions have been described before but will be presented again (Sinnott-Armstrong et al., 2008): (1) Should neuroimaging evidence be admitted in trial?; (2) What is the probative value neuroimaging evidence would provide in relation to deception detection?; (3) Is there a danger of the prosecution biasing the jury with the use of neuroimaging data? Could the prosecution use such evidence in a way that is misleading or confusing to the jury?; and (4) If so, does the danger outweigh the probative value of such evidence?

Answers to these questions have not been pursued, in terms of neuroimaging application to combat deceit in the courtroom—partly because the opportunity has not presented itself to suggest such evidence as admissible in court to date. Even though mock scenarios have been studied and other researchers have tried to determine the accuracy of such applications (Langleben et al., 2005; Lui & Rosenfeld, 2008; Winograd & Rosenfeld, 2011) in depth analyses of these questions in this context are yet to be produced. This study proposes some potential answers from analysis of the literature.

The first question is directly related to the topic of relevance and can simply be answered with FRE 402 and FRE 403. If the criteria are met then the evidence should be presented. From the perspective of the prosecution this would help in determining whether the defense has hidden information that the defense is reluctant to reveal or—if permitted after an ethical review—whether the defense has a hidden agenda or outside sources that might be illegally aiding their client. The second question tries to define the probative value of neuroimaging evidence in deception detection. It makes intuitive sense to assume that removing the variable of deception would add significant value to the evidence and stated facts in a court of law. Thus, from a purely intuitive perspective the probative value of including neuroimaging evidence in deception detection is very high. Is the evidence dangerous? To answer this question, the study conducted by Langleben et al., (2005) where 78% accuracy in detecting lies was found must be considered. The result is well above chance, but one must consider that even if ~80% of individuals were convicted without reasonable doubt, there would be ~20% who may be telling the truth but are detected as lying or vice versa. This means ~20 individuals out of 100 put on trial would be unjustly sentenced or not sentenced when they should have been. The number is ludicrous when not considered as a mere percentage and thought of in terms of individuals. From the perspective of the prosecution, in a perfect world where the prosecution was not challenged, the percentage would assure them the majority of case advantages simply by presenting an expert witness detailing the 'facts' of neuroscience. However, the use of neuroscientific babble by the expert witness might suggestively tarnish the jury's bias and they might make up their mind before the end of the trial. Thus, there are dangers that must be considered. However, the dangers seem to fall short in relation to removing the deceit variable from trial in a court of law. Even though empirical congruency must yet be found, the benefits may outweigh the dangers of neuroimaging implementation to combat deceptive behavior in the courtroom.

4. Ethical Concerns: An Introduction

Ethical concerns in relation to lie-detection methods have been presented and have been studied in depth over the past few years. Due to the current state and development of neuroimaging and other methods of lie-detection the key concerns that have surfaced should be discussed (Wolpe et al., 2005): (1) premature adoption; (2) misapplication through misunderstanding of technology; and (3) privacy concerns.

Premature adoption has become an imminent threat because of the pressure put on research organizations by the federal government, which provides most of the research funding. In particular, the defense-related security agencies are seeking to get the new technology out as soon as possible. Even though such security promise might be desirable, the consequences could be dire if not enough testing is done to make sure the technology is at the level it should be. Furthermore, competition is thus heightened among research groups and thorough analysis is sometime sacrificed in order to gain funding. Quality of results should not be regarded as inessential, for a good foundation is the basis of a successful tomorrow.

Misunderstanding technology can also lead to problems both in results analysis and application in the courtroom. Wolpe et al. (2005) states: "none of the new imaging technologies actually detect "lies." By this statement, Wolpe means that there are a number of physiological processes that lead to 'signal activation' that is seen in neurological data presented by P300 electrophysiology, fMRI images or PET scans. The main challenge, Wolpe claims, is the "separation of a deception-related signal from the host of potentially confounding signals . . ." (Wolpe et al., 2005). As presented earlier in this paper, it appears that such a separation was empirically supported in the prefrontal cortex (Langleben et al., 2005; Abe et al., 2007; Abe, 2009; Abe, 2011). Regardless, mechanisms are yet to be suggested as research continues to understand differentiations between baseline signals and those associated with deception. Until these mechanisms are better defined a lack of understanding of the technology and its applications will continue to hinder progress.

Finally, privacy is an issue that much literature has noted as a major source of concern before such methodology can be used to assess individuals on trial (Wolpe et al., 2005; Abe et al., 2007; Abe, 2011; Winograd, 2011). At present, privacy in the courtroom has been defined by constitutional law as a the inherent right to privacy that protects the liberty of people to make certain crucial decisions regarding their well being without government coercion, intimidation, or interference. Moreover, the government is not constitutionally permitted to regulate deeply personal matters. By this definition one would have to assume that intimate thoughts are a deeply personal matter and thus, the government has no right to regulate or make these thoughts public. In order for neuroimaging evidence to be considered appropriate, the definition of privacy in the courtroom would have to be redefined. Does an individual have the right to keep his or her subjective thoughts private? This would be the first question that would have to be addressed in defining cognitive privacy. The ethical issue at hand is what may keep deception detection methods from entering the courtroom as an aid in assessing individuals on trial in the near future.

5. Conclusions

From a scientific perspective, there appear to be specific subregions of the prefrontal cortex that are activated during deception. The development of a deceptive idea appears to be associated with the lateral prefrontal cortex while the intention associated with the deception seems to be associated with the medial prefrontal cortex. The fact that these regions have been determined is a step in the right direction for pinpointing the exact mechanism by which deception originates. However, there is still much ground to cover as researchers seek to define the fine line between brain activity—related to preparing a lie and deceiving—from brain signaling associated with other physiological functions. Given the mechanistic complexity of deception it will be some time before a pathway can be defined with more certainty. Even though other brain areas such as the ACC and amygdala have been suggested to be involved in the pathway, a precise association has not been made. One potential mechanism could be a loop association between the dorsolateral PFC and the ventromedial PFC with somatosensory associations that will eventually define the baseline of the deception pathway. Since it has been established that (1) the dorsolateral PFC is associated with executive function and (2) the ventromedial PFC is associated with emotional regulation of social interaction, it could be posited that an emotional trigger first determines the intention of deceiving which is followed immediately by conscious executive control—inhibition of the truth—that eventually leads to the act of stating a lie. Experiments to test this hypothesis would have to consider confounding variables that may also affect brain signaling during experimental trials. Identifying these variables would be the major challenge. The scenario would more accurately be portrayed in a real life simulation so that motivation is not lacking. Given the technological advances in virtual simulation, this test would be feasible and something for researchers to explore.

Advances in neuroscience are also affecting the way law is portrayed. For the first time, neuroscience research has made it possible to examine the human brain—the 'seat' of consciousness, decision making, thought, memory and personality (Aronson, 2010). Some scientists suggest that neuroscience will eventually change the law and our legal system. Here, for example, the idea that use of deception detection techniques in the courtroom would necessitate redefining privacy has been considered. Since the increasing neuroscientific literature covers a much larger scope than deception detection, the ways in which new evidence will affect our understanding of responsibility (Sinnott-Armstrong, et al., 2008) and free will (Greene and Cohen, 2004) should also be explored. There are some, however, who argue against the admittance of brain related evidence, stating that such evidence does not change the fact that people--not brains--commit the crimes. In light of such arguments, it is nonetheless clear that additional advancements in neuroscience will be necessary if indeed the field is to influence the legal system, as some researchers expect it will. It is not far fetched to imagine that neuroscience will enter the courtroom in many ways and forms in the future.

What about the ethical limitations in implementing deception detection or mind-reading techniques in the courtroom? These issues are at the core of the problem of introducing neuroscientific data in the courtroom. Proposed probabilities regarding lie detection have been presented from the study by Langleben et al. (2005). However, when dealing with a human life, one cannot be nonchalant about error probabilities. Is it ethical to convict an individual without hard, definitive evidence? As technology progresses and understanding of deception mechanisms advances, hopefully, the goal of reaching definitive convictions will be accomplished.

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