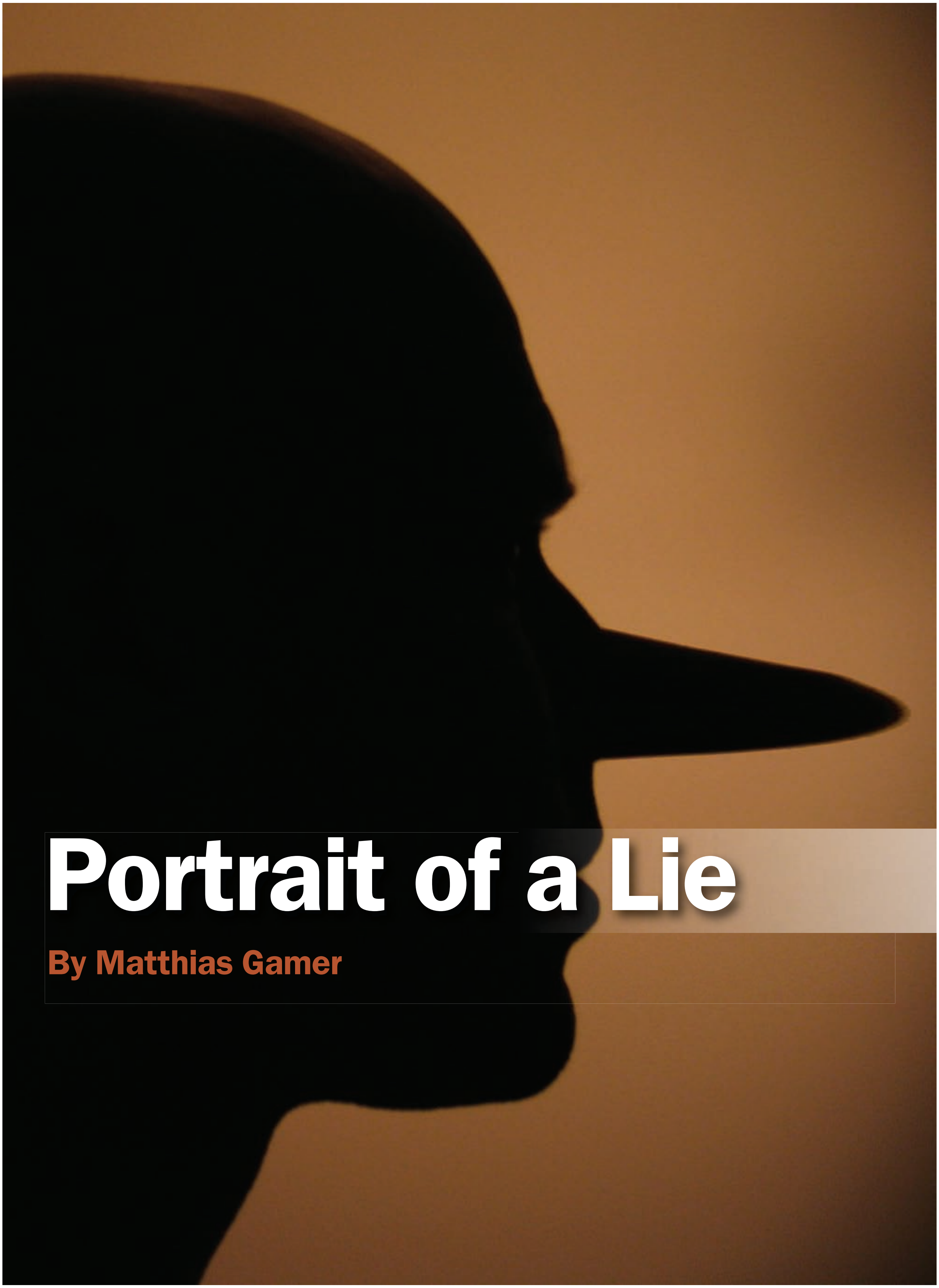


Portrait of a Lie

By Matthias Gamer

MICHEL DE NIJS iStockphoto

A young man steals across the hallway, slips through a door and scans the room. He opens a drawer, snatches a wristwatch inside and puts it in his pocket. Then he hurries out the door.

Sixty more people perform the same drill, half of them filching a watch and the others, a ring. Psychiatrist F. Andrew Kozel, now at the University of Texas Southwestern Medical Center at Dallas, and his colleagues promised to give a bonus payment to anyone who could conceal the deed from the scientists, who planned to look into their brains for signs of a cover-up.

Kozel and his co-workers scanned the volunteers' brains using functional magnetic resonance imaging, which provides a measure of neural activity in different brain areas. During the scans, the subjects answered questions about the theft such as "Did you steal a watch?" or "Did you steal a ring?" The researchers also asked neutral yes/no queries as well as questions about minor wrongful acts. Each participant could truthfully deny stealing one of the objects but had to lie about the other to conceal the deed. (The volunteers were supposed to answer the unrelated questions truthfully.)

Kozel and his team initially identified typical neural activity patterns for true and false statements. Then, in the first use of fMRI to detect deception in individuals, the researchers used the patterns they identified to correctly determine whether each of the subjects had taken a watch or a ring 90 percent of the time.

In search of a better lie detector, scientists are peering into the brain to probe the origins of deception

The use of fMRI represents the cutting edge of lie-detection technology. As far as we know, no region of the brain specializes in lies. But investigators have found that lying activates brain regions involved in suppressing information and in resolving conflicts—such as that between the impulse to describe reality and the wish to contradict it. The use of fMRI combined with a clever questioning strategy could lead to a better method for detecting lies or, more precisely, for getting at the truth despite a person's attempts to hide it.

Improved ability to detect falsehoods would be of significant use in solving crimes, for example, and perhaps also in ferreting out military spies. Unraveling the neurocircuitry of deception, moreover, might help doctors better understand, diagnose and treat patients with disorders in which compulsive lying is a prominent component, including antisocial personality disorder and substance dependence.

In contrast to Pinocchio's infamous nose, the "tells" that betray dishonest intent in humans are more nonspecific.

Questioning the Truth

Virtually everybody lies. Indeed, the ability to fabricate, at least to some extent, is important for normal social interactions and the maintenance of a healthy state of mind [see "Natural-Born Liars," by David Livingstone Smith; Scientific American Mind, Vol. 16, No. 2; June 2005]. Nevertheless, law-enforcement officials and employers, among others, often want to know whether someone is lying—either to cover up a crime or to simply make himself or herself look better.

Laypeople and psychologists alike have thus looked for behavioral clues such as slight hesitations or mistakes in speech, awkward gestures or lack of eye contact. These signs do not reliably indicate untruthfulness, however. We cannot distinguish a fabrication from the facts by observation alone. We are correct only 45 to 60 percent of the time, a rate barely better than chance.

Similarly, researchers have not found any specific verbal, behavioral or physiological cue that uniquely indicates lying. In contrast to Pinocchio, whose nose grows whenever he lies, the "tells" that betray dishonest intent in humans are more nonspecific. In the early 20th century psychologist William Moulton Marston invented the first polygraph, popularly known as a lie detector, to pick up some of these nonspecific signals. The polygraph measures physiological activity from a subject that may help an examiner glean the truth from his or her reactions to questions and statements. The instrument records such physical signs as heart rate dips, blood pressure boosts, slowed breathing and increased sweating on separate tracks in a graphical printout [*see box on opposite page*].

Lie detection, circa 1954

BETTMANN/CORBIS

The polygraph picks up emotional and peripheral nervous system arousal that is not specific to lying. Thus, blips on a polygraph can reflect fear or agitation resulting from just being hooked up to a machine and having to answer probing questions. To minimize that problem, researchers have designed questioning strategies that compare physical reactions to questions or answer choices that are connected to a crime with those of questions or choices that have nothing to do with the deed.

In the Control Question Test, for example, a practitioner compares the physiological responses to crime-linked inquiries such as the direct "Did you do it?" with the responses to incriminatory control questions about past acts such as minor traffic violations or lying to parents. In a pretest interview, an examiner leads subjects to believe that the control questions are important indicators of dishonesty so that they will trigger large physiological re-

FAST FACTS

Detecting Deception

1» **There is no telltale sign that reliably shows someone is a liar, although investigators have long used physical indications of arousal such as sweating and changes in heart rate.**

2» **More recently, researchers have probed the brain for a neural signature of a fib. They found that lying activates brain regions involved in suppressing information and in resolving conflicts—such as that between the impulse to describe reality and the wish to contradict it.**

3» **The use of brain imaging combined with physiological measures, along with a clever questioning strategy, could lead to an improved method for detecting lies.**

sponses when subjects lie about them in an attempt to appear respectable. In theory, a perpetrator should still react more strongly to crime-related queries than to the control questions. In contrast, innocent individuals should respond less vigorously to the crime questions, which they can deny with a clear conscience. Thus, the results of a polygraph test are supposed to point to guilt or innocence—and, indirectly, to deception by perpetrators trying to hide their ties to a misdeed.

Guilty Knowledge

Such tactics are imperfect, however. When combined with a Control Question Test, a polygraph may detect a reaction pattern in an innocent person that is very similar to that of the perpetrator if the blameless individual merely thinks he or she is being accused of a crime. Some researchers say that this combination wrongly implicates the innocent in up to 30 percent of cases. Conversely, if a person can remain calm, he or she could beat the test and successfully hide falsehoods.

Another questioning strategy, developed by the late psychologist David T. Lykken of the University of Minnesota, reduces such misplaced anxiety by not prodding a suspect directly about guilt. Instead of asking, "Did you steal the watch?" Lykken's Guilty Knowledge Test probes a person for inside information about the crime. It compares physiological responses to different multiple-choice answers, one of which contains information only the investigators and criminal would know. For the misdeed described above, one such inquiry might read, "Where did the thief find a watch? Did he find it (a) on the table, (b) in the jewelry box, (c) in the drawer or (d) in a shopping bag?"

If the person being interrogated responds systematically differently to the correct answer ("in the drawer"), he has an insider's knowledge of the crime, indicating guilt. In contrast, an innocent person should not react differently to the theft-related answers. The Guilty Knowledge Test relies on recognition, which is hard to suppress, rather than on fear or comprehension of culpability. It accurately detects concealed recognition of crime details 80 to 90 percent of the time. What is more, it incriminates the innocent in only 0 to 10 percent of cases, far fewer than the Control Question Test does.

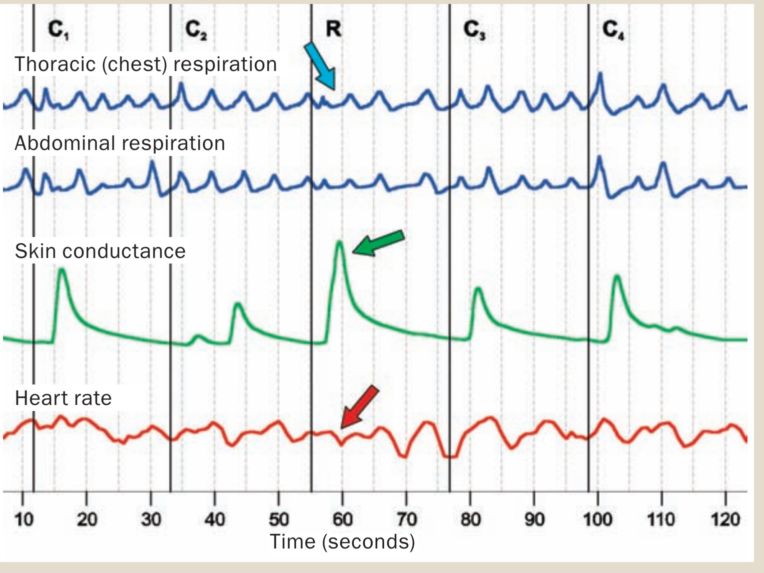
As a practical matter, the Guilty Knowledge Test requires that investigators have several pieces of insider information so that conclusions are based on more than just one or two deviant responses. Furthermore, interrogators must make certain that the general public is not privy to facts about the circumstances of the crime; otherwise innocent suspects might distinguish these facts from the neutral alternatives and react as a perpetrator would.

But in addition to trying to improve such interrogation procedures, many scientists are looking for a more precise physiological measure of deception. In particular, psychologists have been trying

Body Language

Can your body betray a lie? The so-called Guilty Knowledge Test is based on the idea that people react physiologically to information they recognize but are trying to conceal—such as that connected to a crime. When someone recognizes a crime-related detail, for example, he or she typically breaks out in a sweat and shows a brief heart rate drop, a reaction that might relate to enhanced attention. A polygraph (aka lie detector) tracks such responses. Tubes placed around the chest and stomach record respiratory rate (through chest and abdominal movement); two small metal plates on the fingers measure skin conductivity, which indicates the amount of sweat on the fingertips; and an electrocardiogram picks up the heart rate.

In the case shown here, the examiner compared a suspect's physiological responses when she heard a multiple-choice answer that was related to a crime (*R*) to her bodily reactions to four plausible control answers (C_1–C_4). Physiological aberrations that occur in connection with the crime facts may indicate involvement in an illegal activity. The reaction profile suggests that the person being interrogated has knowledge of the crime: when a crime detail is mentioned, her breathing slows (*blue arrow*); she sweats more, indicated by increased skin conductivity (*green arrow*); and her heart rate momentarily drops (*red arrow*). —*M.G.*



COURTESY OF MATTHIAS GAMER

(The Author)

MATTHIAS GAMER is a psychologist in the department of systems neuroscience at the University Medical Center Hamburg-Eppendorf in Germany.

to outline the signature of a lie in the brain. Deception is, after all, a cognitive event, so it ought to leave a trace in the neural machinery that underlies the ability to deceive.

Early efforts to perform brain "fingerprinting" involved attaching electrodes to a subject's head and recording his or her brain waves on an electroencephalogram. A characteristic brain wave called the P300 shows up when a person recognizes something familiar, which could indicate that he or she has an insider's knowledge of a crime, although such familiarity does not necessarily mean an individual is guilty [see "Exposing Lies," by Thomas Metzinger; Scientific American Mind, October/November 2006].

Telling the Truth

Finding the facts of a criminal case does not necessarily require fancy machinery. A method called Criteria-Based Content Analysis relies on evaluating the retelling of an incident for a set of defined narrative features that hint at whether it is a true account. The method is based on research indicating that a story of a real recollection differs from a fabrication in specific ways, according to a 2005 analysis by psychologist Aldert Vrij of the University of Portsmouth in England.

This idea suggests that descriptions of actual experiences have the following properties:

- **They are coherent and consistent but generally not in chronological order.**
- **They contain a lot of detail and include unusual and superfluous elements.**
- **They depict personal interactions and reiterate speech and conversation.**
- **They describe feelings and thoughts—the narrator's and in many cases those the storyteller ascribes to the perpetrator.**
- **They contain spontaneous corrections, the admission of memory gaps and doubts about the believability of the story.**

These criteria may be used in cases of suspected sexual abuse in children to assess the believability of the events as described by the underage victims. Some studies suggest, however, that testimony gained in this manner is somewhat less valid than that derived from polygraph tests. Indeed, the error rate of the method in experimental settings is as high as 30 percent. —*M.G.*

Patterns of Deceit

More recently, researchers have used sophisticated brain scanning to search for a neural portrait indicative of a lie. In one of the first attempts to employ fMRI for this purpose, reported in 2002, psychiatrist Daniel D. Langleben of the University of Pennsylvania and his colleagues gave 18 men and women a playing card to put in their pocket and told them to lie about having that card when asked if they had it during a brain scan. The subjects were supposed to tell the truth when they were queried about possessing other playing cards.

When a subject was fibbing, the scientists noted a burst of activity in a strip of brain tissue at the top of the head that is involved in motor control and sensory feedback and in the anterior cingulate, which performs cognitive tasks such as detecting discrepancies that could result in errors [see "Minding Mistakes," by Markus Ullsperger; Scientific American Mind, August/September 2008]. Langleben's team suggests that this neural pattern reflects the mental conflict that arises in the telling of a lie and the increased demand for motor control when suppressing the truth. Such inhibition of the truth, the authors state, may be a basic component of intentional deception. Because no brain regions were *less* active during deceit, the researchers contend that truth is the baseline cognitive state.

Other studies have similarly associated dishonesty with activation in the anterior cingulate. In their 2005 study, described earlier, Kozel and his colleagues showed that they could use an activation pattern in the brain that included this area to determine whether individuals had "stolen" a watch or a ring. The scientists theorize that the anterior cingulate monitors the incorrect and deceptive response to a question and then spurs other frontal brain regions to produce a falsehood. The ability to recognize a mark of deception in the brain further suggests that brain imaging might work as a lie detector in the courtroom and in other applications.

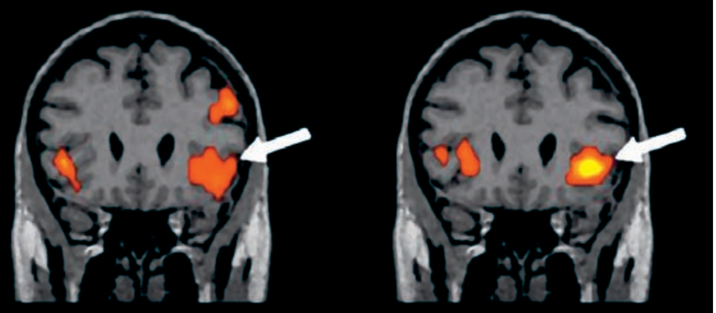
In a study published in 2007 my colleagues at the University of Mainz in Germany and I found additional support for the role of frontal brain regions in concealing knowledge. We asked 14 men to choose one of three envelopes containing money and a playing card and to keep them secret. While the men were in an MRI scanner, we gave them a

GETTY IMAGES

Researchers may eventually find a combination of brain images and body signals that accurately depicts deception.

Guilty Knowledge Test that included images of the contents of the envelope and of various other objects. In addition, we recorded skin conductivity to determine whether activity in the brain regions involved in concealing information is linked to the response of sweat glands to questions about crime details.

As expected, skin conductivity increased more when subjects saw the information they were trying to conceal than when they looked at the other options. The same held true for activity in certain regions of the frontal lobe, which plays a key role in memory and attention [*see illustration at right*]. Apparently, our volunteers recognized the secret information and mobilized additional brain resources to conceal their knowledge of it. In fact, we found that activity in inferior frontal regions and in the right anterior insula, which interprets bodily states as emotions, directly paralleled sweat gland productivity, lending credence to both brain and skin responses as indicators of fibbing.



In a study by the author and his colleagues, activity in certain lateral parts of the frontal lobe (*arrow in left image*) increased when a subject tried to conceal a detail that he recognized. The same region (*arrow in right image*) also became activated when skin conductivity increased as a result of any of various stimuli, hinting that activation of the area is linked to sweat gland output.

COURTESY OF MATTHIAS GAMER

Imaging on Trial

Still, many questions remain about the use of brain imaging to detect lies in real-world settings such as law enforcement. For one, experimental tests of the technology typically involve normal adults whose brains may be substantially different from those of individuals who have frequent problems with the law. Studies of people with antisocial personality disorders, for example, indicate that such patients may have damaged frontal lobes. Because of these discrepancies, a sociopath, psychopath or someone who is simply a good liar might well be able to suppress any suspicious neural responses to the "insider" choices and thus avoid detection. [For more on the use of brain scans in the courtroom, see "Brain Scans Go Legal," by Scott T. Grafton et al.; Scientific American Mind, December 2006/January 2007.]

And of course, the consequences of being caught in a lie in experimental settings are typically low: the subjects are usually asked to lie, after all. The brain activity recorded in such studies therefore is not necessarily the same as that which occurs in real-world scenarios in which people deceive to avoid severe social, emotional or monetary repercussions.

Functional MRIs of brain activity are far more expensive than polygraph exams, too, and we do not yet know whether they are really more sensitive and accurate than these traditional tests are. We can be fairly certain that neither polygraphs nor fMRI can identify responses that are exclusive to lying or identify the guilty with 100 percent confidence. Nevertheless, researchers may eventually identify a combination of brain images and signals from the body that comes much closer than do current methods to providing an accurate depiction of deception. M

(Further Reading)

- **Brain Activity during Simulated Deception: An Event-Related Functional Magnetic Resonance Study.** D. D. Langleben et al. in *NeuroImage,* Vol. 15, No. 3, pages 727–732; March 2002.
- **Criteria-Based Content Analysis: A Qualitative Review of the First 37 Studies.** Aldert Vrij in *Psychology, Public Policy and Law,* Vol. 11, No. 1, pages 3–41; March 2005.
- **Detecting Deception Using Functional Magnetic Resonance Imaging.** F. Andrew Kozel et al. in *Biological Psychiatry,* Vol. 58, No. 8, pages 605–613; October 15, 2005.
- **Covariations among fMRI, Skin Conductance, and Behavioral Data during Processing of Concealed Information.** Matthias Gamer, Thomas Bauermann, Peter Stoeter and Gerhard Vossel in *Human Brain Mapping,* Vol. 28, No. 12, pages 1287–1301; December 2007.
- **Detection of Deception with fMRI: Are We There Yet?** Daniel D. Langleben in *Legal and Criminological Psychology,* Vol. 13, No. 1, pages 1–9; February 2008.
- **Combining Physiological Measures in the Detection of Concealed Information.** Matthias Gamer, Bruno Verschuere, Geert Crombez and Gerhard Vossel in *Physiology and Behavior,* Vol. 95, No. 3, pages 333–340; October 20, 2008.