Cross-cultural variation and fMRI lie-detection

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Abstract

As decidedly underscored by a recent editorial in Nature Neuroscience (2010), many experiments in cognitive neuroscience have been carried out with a sample that is not representative of the general human population, as the subjects are usually university students in psychology. The underlying assumption of this practice is that the workings of the brain do not vary much even when subjects come from different cultural groups. Recent research by Henrich et al. (2010) shows that this assumption is unwarranted. On several basic features of perception and cognition, Western university students turn out to be outliers relative to the general human population, so that data based on them should be interpreted with caution. In particular, this situation seems to provide an argument for questioning the conformity of functional Magnetic Resonance Imaging (fMRI) lie-detection to Federal Rule of Evidence 702 and Daubert. Deception is a social phenomenon and it is related to mental functions, such as theory of mind, for which cross-cultural variability at the neural level has been detected. Furthermore, culture is a multi-dimensional variable whose effects are diverse. Thus, the use of fMRI lie-detection in legal contexts may hinder the ascertainment of truth if the experimental results are not shown to be conserved in different cultures. Cross-cultural variability in neural activation patterns is just a facet of the broader issue of external and ecological validity for neuroscientific experiments on the detection of deception; nonetheless, fMRI lie- detection is unlikely to meet the Daubert standards if cross-cultural variation is not controlled by appropriate experiments.

Keywords: fMRI, lie-detection, culture, cross-culturality, Daubert standard

Introduction

In this paper I discuss functional Magnetic Resonance Imaging (fMRI) lie-detection and claim that this technique should be used in courts only if its experimental basis includes checks for cross-cultural variation. The concept of ‘culture' refers to features of human groups that typically vary according to geographic areas and which depend on social learning; it includes shared attitudes, practices, and beliefs, together with languages and religions.

Cross-cultural variation in human psychology is pervasive (Norenzayan & Heine, 2005; Nisbett & Masuda, 2003) but it is rarely addressed in the behavioral sciences (Sears, 1986; Henrich, Heine, & Norenzayan, 2010). Cross-cultural variability in psychology corresponds, in some cases at least, to cross- cultural neural variability (for a review about cross-cultural neural variation, see Han & Northoff, 2008).

Lying is a social activity. As society and culture are closely related, deception is unlikely to be free of cultural variation on both the psychological and the neural level. Moreover, culture possesses several dimensions (Hofstede, 2001), which are notoriously difficult to measure, so that it is much more complex to take this source of variation into account than others, such as for instance a mono-dimensional factor like age. For these reasons, the neuroscientists who are developing fMRI lie-detection should be aware of the problem and include cross-cultural experiments into their experimental strategies, in order to check if the Blood Oxygen Level Dependent (BOLD) activations that correlate with lying are conserved in different cultures. If this is not done, the experiments about fMRI lie-detection run the risk of having both a reduced ecological validity, i.e. the experimental settings are too heterogeneous relative to the parts of the real world they want to model, and a low external validity, i.e. the experiments are based on an idiosyncratic sample which is not representative of the general population. In this case the results would tell little about what happens outside the lab. If the experiments do not possess a sufficient degree of external and ecological validity, they are unlikely to provide error rates that are applicable to the real world and to gain general acceptance in the scientific community. But if the real-life error rates and general acceptance are absent, fMRI lie-detection will probably not be accepted as a valid expert testimony either in the jurisdictions that follow the Daubert ruling (Daubert v. Merrell Dow Pharmaceuticals, Inc., 1993) or in those that adopt the older Frye (Frye v. United States, 1923) test. This is because both tests take general acceptance into account and because one of the Daubert standards is the "known or potential error rate" in real life applications.

The concept of 'culture'

First of all, some words are due on the way I avail myself of the concept of ?culture' which is central to my overall argument. According to my working definition, ?culture' refers to some properties of human groups that depend on social learning. Languages, religions, shared attitudes and beliefs, family structures and hierarchies are all parts of culture. Culture varies not only moving from one social group to another, but also from an individual to another in the same group[1]. Both the geographical variability and the individual variability have behavioral consequences. For instance, Chua, Boland and Nisbett (2005) have demonstrated that Americans and Chinese feature different saccades[2] patterns when they are shown a picture composed by a salient object and a background: Chinese tend to focus more on the background than Americans. As to individual variation, priming for individualism or collectivism[3] performed on bicultural individuals, such as Japanese-Americans, modulates both their ways of self-description (general, context- free descriptions vs. contextual descriptions) and the corresponding BOLD signals in areas related to self- representation (Chiao et al., 2009). One of the major problems in dealing with culture as a factor of behavioral and neural variation is that culture is not easy to measure. One framework that I find helpful is Hofstede's (2001) five dimensional model, which collocates every culture along these dimensions:

1 See for instance Haidt & Graham (2007) about the different moral principles used by liberals and conservatives.

2 Saccades are quick and simultaneous movements of both eyes in the same direction. Human beings are usually not aware of performing saccades.

3 Individualists think that people are independent from each other and that they are characterized by a context- independent set of personality traits. Collectivists see persons as interconnected and describe them as embedded in specific social situations, which constitute a part of their personality.
making decisions;

1. individualism – collectivism;
2. small – large power distance: It measures the difference in power between the most and the least powerful members of the group. If power distance is large, the leaders of the group are much more powerful than the subordinates. If power distance is small, the leaders of the group are almost on the same level as subordinates;
3. short – long term orientation: to what degree a group considers the remote future when
4. weak – strong uncertainty avoidance: how much a group is willing to take up risks;
5. masculinity – femininity: here Hofstede uses the Western stereotypes as metaphors, without any commitment about the actual psychology of men and women. Masculinity symbolizes an assertive and competitive stance, whereas femininity indicates a caring and modest attitude.

According to this model, every society is characterized by a set of five values that describe its position along the dimensions, but any individual in the society might depart from the group's values. For instance, the United States (US) are considered as one of the most individualistic societies in the world (Henrich et al., 2010), but a single US citizen can endorse collectivist values for a variety of reasons, such as religious tenets or family education.

Lastly, it must be understood that ethnicity is not a synonym of culture, since immigrants retain their ethnicity for some generations (as long as they have children with other immigrants coming from the same ethnic group), whereas they rapidly lose their original cultural traits (Heine & Lehman, 2004). Individual and intra-national variation also prevents us from identifying culture with nationality, even though nationality has a great influence on culture.

The sampling bias in the behavioral sciences

This being said, I can continue with the sampling bias. Most experiments in the ?behavioral sciences' (cognitive science, economics and psychology) are carried out on culturally homogeneous samples. Arnett (2008) has surveyed the articles of the main peer-reviewed journals in psychology in the 2003-2007 period and has found that 68% of the subjects come from the US. Furthermore, 67% of this US population is composed of university students who take psychology courses. Therefore, the bulk of experimental subjects in the behavioral sciences is composed by a very specific human group: undergrads in psychology.

On the one hand, this is an advantage, because very homogeneous samples allow the attribution of differences in the subjects' behavioral responses to the differences in the experimental conditions (e.g. distinct stimuli), which are manipulated by the researchers. Moreover, university students are easily available, cheap and permit a fast replication of the experiments.

On the other hand, this poses serious questions of generalizability of the experimental findings. How can a researcher be sure that the experimental results are valid under different cultural conditions? This risk is particularly serious if we take into account that university students are a very specific sample relative not only to the global human population, but also to the US population. As Rozin (in Henrich et al., 2010) has pointed out, the university student experiences a unique life transition from family life to a peer-centered life. Moreover, they usually earn little or no income, live in a very liberal, educated, and open-minded

environment (the campus), and have not built their own family yet. Therefore, their behavior on several accounts, such as economic decisions, is likely to be different even from that of the average US 30-year old person. This is evidenced by cross-cultural studies (Henrich et al., 2005) which show that the behavior of university students coming from Western, industrialized countries on some economic games like the ultimatum game and the dictator game is very different from the behavior found in many small-scale societies around the globe. A further consideration is that cultural variability does not only involve social behaviors like theory of mind[4] and its neural correlates (Kobayashi Frank & Temple, 2009) or economic behavior, but has a much broader scope. For instance, on the behavioral level culture influences general strategies of reasoning (Nisbett, Peng, Choi, & Norenzayan, 2001), the performance on the visual ?rod-and-frame' task
(Kitayama, Duffy, Kawamura, & Larsen, 2003), and the effectiveness of visual illusions (Segall, Campbell, & Herskovits, 1963).

Since one may understand the aim of the behavioral sciences as describing universal features of human behavior and accounting for those features by means of appropriate theories, experiments that are carried out on a very specific sample are of little utility to the pursuit of such a purpose, at least as long as they are not repeated in different human groups that diverge culturally. It should be noted that universality must not be intended as a digital variable: there are discrete degrees of universality that can empirically be tested. For instance, a cognitive phenomenon can be present in almost all human groups, but perform different functions in different contexts, or it can be consistently present and robustly perform the same function in all contexts. Universality can be tested by means of three kinds of experiments: the two-cultures experiment, the triangulation study, and the cross-cultural survey (Norenzayan & Heine, 2005).

In a two-cultures experiment a determined response to an experimental setting is taken into account. Two cultures that differ on many cultural dimensions are examined and the experimenters check whether the effect is conserved. If it is, the experiment provides some evidence for some degree of universality; if it is not, the difference in the behavioral effects of the setting must be traced back to a cultural dimension. But since the two cultures that have been examined differ on many dimensions, identifying the dimension that is responsible for the variation is not straightforward. In order to do so, a triangular study is needed. Such a study must start from a theory that allegedly explains the previously tested effect and that allows researchers to make hypotheses as to which cultural dimension is responsible for the variation. Then the experimenters take into account three cultures that differ from each other along two theoretically relevant cultural dimensions. For instance, if the theory leads to the prediction that dimensions D1 and D2 may be relevant, the cultures will be selected in such a way that cultures C1 and C2 differ on D1, and C1 and C3 differ on D2. If the difference is spotted between C1 and C2, D1 will be the relevant dimension; if the difference is found between C1 and C3, D2 will be chosen as explanatory instead. Of course, it must be assured that in the different cultures the experimental conditions are interpreted by the subjects in the same way and that the experimental protocol does not change.

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4 Theory of Mind (ToM) or Mentalizing is the ability to attribute mental states (both cognitive and affective) to other human beings.

A cross-cultural survey entails examining many human groups around the world, both in small-scale societies and in urban societies. If no differences are detected, it provides a strong evidence for some degree of universality. Nonetheless, it is costly and difficult to carry out, as experimental rigor cannot be maintained without considerable efforts when different research teams have to work in diverse environments. These cross-cultural investigations can be carried out by means of meta-analyses too, if sufficient data have already been gathered.

Furthermore, there are some types of behavioral research in which universality is not an issue, so that idiosyncratic samples can be used without any problems in these cases. As Gächter (in Henrich et al., 2010) correctly points out, US freshmen and sophomores can be very useful to falsify theories in behavioral economics. Falsification is about the research of counterexamples, not about generalizability, so that using undergrads as participants in an experimental study is appropriate when a study aims at falsification. Furthermore, students are cognitively sophisticated as economic theories often require agents to be.

This being said about the sampling bias and how to address it, let us look at the part of the behavioral sciences that concerns me most in this paper: cognitive neuroscience. Here, the situation is probably even worse than in experimental psychology. According to Chiao (2009), 90% of the peer-reviewed neuroimaging studies come from Western industrialized countries. But the sampling bias would be a problem only if significant evidence for cultural variability at the neural level has been gathered. Cultural neuroscience provides substantial evidence to this effect. I briefly review part of this evidence (for a more comprehensive review, see Han & Northoff, 2008). Gutchess, Welsh, Boduroglu and Park (2006) have used fMRI to identify the neural correlates of a cross-cultural difference between Caucasian Americans and East Asians in image processing: Americans fixate a salient object more than East Asians. This proves that culture modifies neural function when non-verbal stimuli are processed.

Zhu and colleagues (2007) have found a differential activation of the Medial PreFrontal Cortex (MPFC), which explains the distinct construal of the self in American and Chinese subjects. In Americans, whose concept of self does not include intimate relatives, the MPFC is activated only in response to judgments concerning the subject himself, whereas among East Asians the same area of the brain also responds to stimuli concerning close relatives, such as the subject's mother.

Hedden and colleagues (2008) uncovered the neural correlates of another cross-cultural bias: East Asians are better than Americans at performing tasks that have contextual demands. Conversely, Americans are better than East Asians at ignoring the context if this is required.

By means of an fMRI study on Japanese bilinguals, Kobayashi, Glover and Temple (2006) have found differences in BOLD activation in Japanese and American cultures when subjects perform false belief tasks. The false belief task is one of the main tests for theory of mind.

Wong and colleagues (2004) have shown in a Positron Emission Tomography (PET) study that the processing of auditory pitch patterns engages the left or right insular cortex when the pitch has a linguistic function, as in Chinese, or not, as in English, respectively. This demonstrates that linguistic variation across cultures correlates with distinct neural correlates.

One can conclude that cross-cultural variation at the neural level concerns both basic brain functions, such as visual processing, and 'higher' functions such as self-construal. How can this problem be tackled? MRI scanners are expensive and it is difficult to find them in developing countries or to bring them to the homelands of small-scale societies. Conducting cross-cultural experiments in cognitive neuroimaging is therefore difficult. Nevertheless, East Asia provides a rich and industrialized area in which cultural variability relative to the West is still sufficiently high to make two-cultures neuroimaging experiments meaningful. One possible agenda for cultural neuroscience is to look for the neural correlates of the behavioral variation that has been found between East Asia and the US in cultural psychology. The precise mechanisms by which culture can sculpt the human brain have not been elucidated yet, but the existence of brain plasticity is now an established fact. It has been studied both in the context of functional recovery after lesions (Wall, Xu, & Wang, 2002; Frost, Barbary, Friel, Plautz, & Nudo, 2003; Winship & Murphy, 2009) and in the context of learning (for instance Maguire et al., 2000). Brain plasticity yields a good theoretical framework to create detailed neural explanations of cross-cultural variability in behavior, but cultural neuroscience still has a lot of work to do in order to reach the neurophysiological level on which small neural populations are taken into account. In addition, there are well-known and warranted ethical limitations to neurophysiological experimentation in humans.

In the next section I will examine fMRI lie-detection.

fMRI lie detection

Deception has been defined as “a social behavior in which an individual attempts to persuade another to accept as true what the deceiver believes to be untrue” (Ganis & Keenan, 2009, p. 465). Deception is a natural phenomenon that spontaneously develops in human beings (Spence et al., 2004). Deception as a mental task requires the suppression of a prepotent response, namely telling the truth; moreover, a new cognitive item, i.e. the lie, must be built up starting from the beliefs of the person to be deceived. Then the reactions of the deceived must be constantly monitored, so that consistency between the lie and their beliefs can be maintained. The lie can be very simple, as in cases in which one answers ?no' instead of ?yes' to a question, or quite complex when a whole piece of narrative must be devised to disguise the truth (Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003). All this requires response inhibition, working memory, theory of mind, and other mental functions. Briefly, many high-order capacities of the human brain are engaged when one lies. Moreover, voluntary deception is essentially social: It is a way in which an individual manipulates her relationships with other human beings. Furthermore, there are many kinds of deception. In addition to the aforementioned distinction between structurally simple and complex lies, there are also the following differences:

1. self-related lies vs. other-related lies;
2. lies in which the subject says she did perform an action she has not carried out vs. lies in which the subject says she did not perform an action she has actually carried out (suggested by Kozel et al., 2009);
3. verbally expressed lies vs. non-verbally expressed lies;

4. well-rehearsed lies vs. improvised lies[5];

5. lies in which a lot is at stake, in terms of rewards and risks, vs lies in which little is at stake. Since the phenomenon is inherently social and there are many kinds of lies, the existence of a simple biological marker for all kinds of deception is unlikely (Sip, Roepstorff, McGregor, & Frith, 2008).

fMRI lie-detection has been tested in the lab using a variety of paradigms: a version of the polygraph Guilty Knowledge Test featuring playing cards (Langleben et al., 2002), a mock crime scenario (Kozel et al., 2005, 2009), autobiographical memories, and others. Nonetheless, all of these methods have common shortcomings.

Firstly, even if in some cases additional monetary rewards are promised to the subject if her lies are not detected by the experimenters (e.g. Kozel et al., 2005), the motivation to lie in the lab is very low relative to some real life circumstances, in which the risks and gains of deceiving can be tremendous.

Secondly, in the lab, subjects are instructed to perform deception, so that the intention of lying is not spontaneous. Sip et al. (2008) claim that the lack of a voluntary intention to deceive prevents these experiments from studying deception. Instead, these experiments study “some of the complex executive functions that are associated with the phenomenon [i.e. deception]” (Sip et al., 2008, p. 48). This major shortcoming might be avoided by adopting an experimental setting in which subjects are put into a situation that indirectly induces them to be mendacious, on the lines of the experimental paradigm used by Greene and Paxton (2009). Nonetheless, to my knowledge no such study on deception has yet been conducted.

Thirdly, in all of these experiments the presence of lies is guaranteed by the experimental design, whereas in a real life setting the relevant issue is whether someone is lying or not. The findings of an experiment in which the presence of lies is secured cannot be extended to situations in which lies may or may not be there (Langleben & Dattilio, 2008).

Fourthly, the time between the fact about which the subjects are questioned and the scanning is usually short in lab settings (minutes or hours), whereas in real life it can be very long (months or years) (Spence et al., 2004).

Fifthly, the current paradigms compare two mutually exclusive conditions: Telling the truth vs. lying. In real life lies can be more nuanced: an account in which deception and what has actually happened are merged can be given. All of these factors contribute to creating a problem of external and ecological validity of fMRI lie-detection studies.

These experiments have identified a series of brain regions that correlate with lying in the experimental setting, i.e. that show an increased BOLD signal on a Lie minus Truth (henceforth written as Lie>Truth) contrast[6]. Many distinct brain regions have been indicated and researchers do not agree on which the most relevant regions are (Spence, 2008; Kozel et al., 2009), but some consistencies have been found (Monteleone et al., 2009). Firstly, there is no activation for Truth>Lie, showing that telling the truth is a baseline response. The regions that are regularly activated in Lie>Truth are associated with the cognitive

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5 For this last dichotomy Ganis & Keenan (2009) found different BOLD activations relative to a baseline constituted by telling the truth.

6 fMRI investigation is normally based on the subtraction of the BOLD signal in the task condition from the BOLD signal in the control condition. In this case lying is the task and telling the truth is the control.

functions that have been predicted to be involved in lying: response inhibition, working memory, theory of mind, and others. The main areas that have been implicated are the MPFC (especially the ventromedial part known to be related to emotion processing, see Damasio, 1994), the orbitofrontal cortex, the anterior cingulate cortex, and the temporal parietal junction (TPJ). The dorsolateral prefrontal cortex seems to show an increased activation when lies are structurally complex, so that it may be related to the creation of a new cognitive item (Spence et al., 2004). If only one area is examined, the best detection in terms of sensitivity at $p < 0.01$ is achieved by using the MPFC as in this way an accuracy of 71% is reached (Ganis & Keenan, 2009). Increasing sensitivity above this level entails a rise in the number of false positives. If the number of liars in a population is very low, the number of false positives can be higher than the amount of the true positives, making the test useless. Therefore, false positives must be minimized if the technique is to be used in real life. The relatively low specificity of the test is due to the scarce specificity of the correlation between brain regions and deception. Those regions carry out many other functions and therefore their activation does not necessarily indicate deception. At the state of the art, fMRI lie-detection is only slightly more accurate than the traditional polygraphy (Simpson, 2008). Nonetheless, fMRI presents two advantages in comparison to polygraphy. Firstly, it measures a Central Nervous System (CNS) signal and not a Peripheral Nervous System (PNS) signal, therefore a closer correlate of behavior and secondly, it is independent from arousal. In the next section, I will discuss some issues that arise from the potential application of this technique in criminal and civil proceedings.

fMRI lie-detection in judicial settings

I exclusively deal here with the US legal system, because to my knowledge fMRI lie-detection has not been proposed in Europe yet. Firstly, I examine the legal standards that regulate the acceptance of scientific evidence and some recent decisions. Secondly, I argue that both external and ecological validity are central when the admission of fMRI lie-detection in court is discussed.

The admission of scientific evidence in US federal courts is regulated by Rule of Evidence 702, which concerns the testimony of scientific or technical experts. For the admission of the witness three conditions must be satisfied:

1. the testimony is based upon sufficient facts or data;
2. the testimony is the product of reliable principles and methods;
3. the witness has applied the principles and methods reliably to the facts of the case (Rule of Evidence 702).

These conditions are applied together with other standards that were fixed by two decisions of the Supreme Court of the US, the aforementioned Frye v. United States (1923) and Daubert v. Merrell Dow Pharmaceuticals Inc. (1993). The Daubert standard is valid in federal courts and in most state jurisdictions in the US. The Frye standard applies to the remaining state jurisdictions (among which are California and New York).

The Frye standard simply states that expert witnesses can be admitted in courts if “the thing from which the deduction is made” has “gained general acceptance in the particular field in which it belongs”. Therefore, general acceptance on the part of the relevant scientific community is required. This general acceptance has not been reached in the case of fMRI lie-detection, as a 2008 editorial on Nature Neuroscience demonstrates. Moreover, a recent New York State decision in a civil case rejected the admission of fMRI lie-detection under Frye[7].

The Daubert standard attributes to the judge the role of gatekeeper with regard to expert witnesses. The Daubert standard must ensure that the testimony is relevant to the case and has been obtained by means of reliable methods. To ascertain this, a test with five non-exclusive and flexible prongs is proposed. The points are the following:

1. empirical testing: the grounding theory must be falsifiable through experimentation;
2. peer-reviewed publication of the scientific bases of the testimony;
3. potential or known error rate of the procedure in real cases;
4. existence of technical standards for the procedure;
5. general acceptance in the scientific community.

The admission of fMRI lie-detection under Daubert has been recently denied in the federal criminal case USA v. Semrau. The decision of Magistrate Judge Tu M. Pham[8] excludes fMRI lie-detection on two grounds:

1. under Rule of Evidence 702 and Daubert, because "there are no known error rates for fMRI-based lie detection outside the laboratory setting", because "standards controlling the real-life application have not yet been established", because Dr. S. J. Laken, who performed the scans, violated his own protocols when he rescanned Dr. Semrau on a positive result for deception, and because "fMRI-based lie-detection has not yet been accepted by the scientific community";
2. under Federal Rule of Evidence 403, because the evidence was more prejudicial than probative, since the scans were taken by Dr. Laken without notifying the government. In this way, Dr. Semrau risked nothing in undergoing the tests, because positive results for deception would not have been released.

As Magistrate Judge Pham himself notices, the rejection of expert testimony is the exception, rather than the rule. This makes his decision particularly relevant.

The second point is not against fMRI lie-detection per se, but it concerns the contingent circumstances of the USA v. Semrau scans, so that it is not relevant for our discourse. The first point in contrast is paramount: fMRI lie-detection is not admitted inter alia because there are no reliable error rates. This is due to the fact that most of the current experimental work tells us little about real life application of this technique. Concerns about external and ecological validity are particularly relevant in legal contexts. In fact, judicial applications of fMRI lie-detection might be conducted on people who are medicated, who may have a psychiatric history, who are unwilling to cooperate, and who may try to use countermeasures to the test. However, the technique has been tested so far on subjects without any psychiatric condition, present or antecedent, who are unmedicated, and who are willing to follow the instructions of the experimenters.

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7 Wilson v. Corestaff Services, decided May 14th 2010, Justice Robert J. Miller, 32996/07. Available at http://blogs.law.stanford.edu/lawandbiosciences/files/2010/06/CorestaffOpin1.pdf (accessed December 25th 2010). I thank Prof. Henry T. Greely for having pointed this case out to me.

8 USA v. Semrau, May 31st 2010, Magistrate Judge Tu M. Pham, No. 07-10074 Ml/P. Available at http://blogs.law.stanford.edu/lawandbiosciences/files/2010/06/fMRI-Report-and-Recommendation1.pdf (accessed December 26th 2010).

Another factor, which is specific to legal settings, must be taken into account. As Simpson (2008) correctly points out, the current paradigm of fMRI lie-detection focuses on functions such as response inhibition and correlated regions in the brain. But response inhibition is likely to be very often engaged by a defendant in a criminal trial, since defendants must be circumspect about what they say in courts and repress feelings of outrage at accusations, if they are not guilty. Therefore, if lie-detection is carried out in the context of a criminal trial, response inhibition seems to be an unreliable marker for deception. This shows again that the experimental paradigms used so far might have little bearing on how deception outside the lab, and specifically in a court, is detected.

This allows us to conclude that fMRI lie-detection is unlikely to be accepted under the Federal Rule of Evidence 702 and Daubert unless problems relative to external and ecological validity are solved.

In addition to this, I argue that cross-cultural validity is an important issue in this set of problems and that it needs to be addressed if fMRI lie-detection is to enter courts under the laws currently in force. For this claim I present four arguments. First, as briefly mentioned above, Kobayashi and her co-workers (2006, 2007) have shown that different areas of the brain are activated in East Asians and Caucasian Americans when they perform the false belief task. In particular, the TPJ activation would be culture-dependent and specific to English-speaking cultures (Kobayashi Frank & Temple, 2009). Nonetheless, Adams et al. (2009) have found a consistent activation of the posterior part of the superior temporal sulcus (pSTS), which partially overlaps with the TPJ, in both American and Japanese subjects. But Adams and co-workers (2009) used a different task than the one that Kobayashi Frank and Temple (2009) availed themselves of. The task used by Adams et al. (2009) is non-verbal and based on eye stimuli, whereas the false belief task is normally verbal. The different results of the two groups might be due to the distinct stimuli that were used. Despite this, researchers agree that the brain areas activated during ToM tasks depend on cultural background. Furthermore, culture impacts on ToM in other ways. For instance, people are better at detecting mental states in targets belonging to their in-group relative to out-group members and different areas of the MPFC are activated when subjects are asked to use ToM on targets that are respectively similar or dissimilar to themselves (Mitchell, Macrae, & Banaji, 2006). From this I can conclude that the neural underpinnings of ToM show a high degree of cross-cultural variation. If ToM is a necessary cognitive component of deliberate deception (and it is difficult to think it is not, as deception requires a manipulation of another's beliefs), this cultural variation is likely to be shared by deliberate deception too, even though experiments are needed to confirm this theoretical prediction. And if BOLD patterns varied significantly across cultures in deception, fMRI lie-detection would risk being unreliable when a single experimental paradigm is used on subjects belonging to different cultures.

Secondly, the sheer number of immigrants in the US constitutes a good argument for cross-cultural checks. There were 38 million first-generation immigrants in the US in 2007 (Segal, Elliott, & Mayadas, 2010), amounting to about 12% of the US population. If fMRI lie-detection was used in court, more than one out of ten suspects could potentially show cultural variability in the neural correlates of lying, assuming arguendo that immigrants end up under trial or in civil litigation with the same frequency as the general US population. Therefore, if cross-cultural validity of fMRI lie-detection is not checked by means of appropriate experiments, errors could be widespread, leading to sub-optimal outcomes of judiciary procedures. Of course, the real amount of cultural variation in the neural correlates of deliberate deception cannot be estimated without actual cross-cultural experiments.

Thirdly, culture is different from other forms of variation in that it has many dimensions and components, together with a degree of individual variation. Unlike age, which is mono-dimensional, culture is manifold and therefore difficult to handle. Each cultural dimension could have a different effect on the neural correlates of voluntary deception, so that adapting the experimental setting of the technique to the culture of the individual to be tested might prove a daunting task. A careful measurement of the different cultural dimensions of the individual might be required. If the BOLD signals found during deception varied with culture, it could be extremely complex to devise an fMRI lie-detection technique suitable to use in courts under Daubert, since the error rate would be high. On the contrary, assuming arguendo that the neural correlates of deception vary with age, it might be easier to modify the experimental paradigm to factor this source of variability in, since the age of every person can be easily assessed.

Fourthly, the social nature of deception makes it theoretically likely that culture plays a big role in shaping this phenomenon, as culture, unlike for instance age, is a source of variation that results from human sociality. Deception requires a continuous surveillance on the beliefs of the deceived, an estimation of the long-term consequences of deception, and a maintenance of trust by means of pseudo-cooperation (Sip et al., 2008). Variations in belief systems and in what is considered to be advantageous or disadvantageous could thus make substantial changes in the psychological nature of deception. Since psychological differences are often coupled with underlying neural differences, this variability would affect BOLD signalling as well.

I am not claiming that the neural correlates of deception vary with culture, but that from the theoretical point of view this is likely to be the case. This hypothesis must be addressed by means of cross-cultural experiments.

There are of course many other legal and ethical issues that are raised by fMRI lie-detection in a legal setting. Firstly, there is the concern that lie-detection might illegitimately reduce the prerogatives of the finder of fact, who has inter alia the role of assessing the credibility of witnesses. Then, we find the so-called ‘CSI effect', as Simpson (2008) states it:

> The aura of big science and high technology surrounding complex and expensive tests may lead to an overestimation of the reliability and utility of fMRI lie detection among lay people, including law enforcement personnel and other investigators, judges, and jurors (Simpson, 2008, p. 496).

A third issue is related to the Fourth and Fifth Amendment of the US Constitution. Concerning the Fourth Amendment, fMRI lie-detection could be seen as an unreasonable search and seizure and as a violation of the individual's cognitive freedom (Wolpe, Foster, & Langleben, 2005) if it is performed without an appropriate warrant. Concerning the Fifth Amendment, forcing the defendant to undergo lie-detection might be interpreted as an instance of self-incrimination. These problems are very important and must be carefully considered when discussing the ethical and legal acceptability of fMRI lie-detection in court. Nonetheless, dealing with them in depth would lead me astray as they are not connected with cross-culturality and because they play a minor role in the USA v. Semrau landmark decision. In the next section I will address some possible objections that can be made against my arguments.

Discussion of objections

Kozel and colleagues (2005, 2009) have done much to tackle the external and ecological validity problem, of which the cross-culturality issue constitutes a part. In particular, Kozel et al. (2005, 2009) used quite diverse samples, which cover a broad age interval, different ethnicities, professions and levels of education. None of these factors is significantly correlated with the results of the experiments. This strengthens the external validity of the study. Moreover, the more recent study makes use of a mock sabotage scenario which is much closer to a real life situation than the previous scenarios (subjects are asked to go to a separate building, find a CD containing evidence of a crime, devise a way to destroy it, and go back to the experimenter; a phone rings in the room where the CD is kept in order to enhance emotional stress). This increases ecological validity. Finally, Kozel et al. (2009) addressed the aforementioned problem of the time interval between the relevant action (in this case the sabotage) and the scanning. They have brought the time-lapse to 105 hours, but it is not clear whether this time interval is sufficient to solve the issue, as in real legal applications the time would probably be much longer. Nevertheless, this is another step towards a greater ecological validity.

Does the work of Kozel and colleagues (2005, 2009) undermine the legitimacy of requesting cross- cultural checks? I argue it does not, because experiments were carried out in a US university, using a sample of general US residents, and because ethnicity cannot be identified with culture. For instance, African Americans and Western Africans may be very similar from the ethnic point of view, but they undoubtedly differ a lot along many cultural dimensions. Even though the populations used by Kozel et al. (2005, 2009) are diverse, they are likely to be relatively homogeneous from the cultural point of view, as they are mostly composed of people born and raised in the US. If a significant proportion of first-generation immigrants had been included, more precise conclusions about the need of cross-cultural checks could have been drawn. This does not detract from the value of the studies conducted by Kozel and colleagues (2005, 2009), which according to my view is the only research on fMRI lie-detection that takes the important problem of external and ecological validity into account.

A second important objection refers to the current practices of lie-detection and the role cross- culturality plays in them. Juries currently evaluate the truthfulness of witnesses not only by the plausibility of their statements and by the consistency of their account, but also through a gamut of behavioral cues (fidgeting, speed of speech, keeping eye contact with the jury, and so on) whose reliability is not above chance (Rand, 2000; Ganis & Keenan, 2009; Schauer, 2009). Nevertheless, jurors may consider these cues to be quite reliable. It is likely that these clues undergo cultural variation[9]: What is considered to be a sign of reliability can obviously change across cultures. Specific evidence to this effect is available: e.g. Bond and colleagues (1990) have shown that American and Jordanian observers rely on partially different sets of cues

9 I thank one anonymous referee for pointing this out to me.

to detect deception. Therefore, it may be the case that for instance immigrant defendants are already disadvantaged in trials because they do not know what kind of demeanour they are supposed to keep in front of the jury in order to look truthful. They might abide the unwritten rules of their home culture and use a body language that does not match the expectations of the jurors. As Rand (2000) points out, truthful African-
American witnesses could be seen as liars by Caucasian American jurors because of this 'Demeanor Gap'. Therefore, so the objection goes[10], we already have a cross-culturality problem in lie-detection. This renders a cross-culturality problem in fMRI less important, as we would simply not solve a problem we already have in the current situation. Continuing on the same lines, as fMRI is much more accurate than behavioral cues as a tool of lie-detection, it would be a good idea to adopt it, since it simply keeps the cross-culturality issue unsolved, but provides a much higher detection rate. According to Bold (1990), both American and Jordanian observers have detected lies with an accuracy rate of slightly more than chance (about 54%). FMRI lie-detection reaches more or less 70% (Ganis & Keenan, 2009) without false positives.

To this argument I respond that the ‘CSI effect' generates a big difference between lie-detection by bodily cues and fMRI lie-detection. The jurors would consider the latter as 100% accurate. Jurors would probably have some doubts about truthfulness assessment via body language and voice pitch, whereas fMRI lie-detection seems to eliminate all uncertainty. Therefore, cultural biases in current trials produce milder harms than those that would result from alleged cultural biases in fMRI lie-detection. Given the CSI effect, false negatives in fMRI lie-detection might cause severe trouble. Then, if we move from this level to the legal standards for admission, we notice that this argument is irrelevant for the conformity of fMRI lie-detection to the Daubert requirements. Already having a problem in our current practices does not make the case for fMRI lie-detection relative to Daubert easier.

A third objection claims that we should not wait to use fMRI lie-detection, since:

1. the current practices of lie-detection are really bad (see the behavioral cues above);
2. there is a huge societal demand of lie-detection (Langleben, 2008), such that the US government continues to use polygraphy even though its accuracy is far from being perfect;
3. current methods of extracting information, such as waterboarding, are cruel and violate human rights (Spence et al., 2004);
4. cross-cultural checks would take a long time, a time that we cannot allegedly afford to lose.

My response to this is threefold. Firstly, lie-detection is not mind-reading, which is at present a totally futuristic technology, so that fMRI lie-detection cannot be considered an information extraction technique. Therefore it is improbable that fMRI will replace forms of torture in the near future. Secondly, using fMRI lie- detection without checking for generalizability might entail sub-optimal outcomes of the judicial processes, such as punishment of the non-guilty, acquittal of the guilty, and payment of undue compensations. It is not clear if an early use of fMRI lie-detection would make criminal or civil trials better in the present situation. Given the possibility of a ?CSI effect' with regard to fMRI lie-detection, the risk that

10 It should be noted that this objection is not proposed by Rand (2000), but is rather a theoretical reconstruction of a possible line of argument.

it would not improve trials is significant. Thirdly, the societal demand for lie-detection can be questioned from two perspectives. On the one hand, it might be argued that the demand for lie-detection is an American peculiarity, maybe even an obsession, as historian Ken Alder (2007) has claimed. On the other hand, this demand can be cast into doubt from the ethical point of view. Is this demand warranted? What kind of balancing between security and individual liberties do we want to adopt? How are we to interpret the citizens' cognitive freedom? This is an
issue I cannot discuss here, but of course the legitimacy of this societal demand cannot be taken for granted. As a matter of fact, neuroethics experts like Levy (2007) have argued that early adoption is the main risk when neuroscientific lie-detection is discussed.
The fourth objection comes from Schauer (2009): he denies the relevance of any kind of scientific considerations concerning external and ecological validity. Schauer argues:

> If the ease of telling an instructed lie in the laboratory correlates with the ease of telling a real lie outside the laboratory, research on instructed lies is no longer irrelevant to detecting real lies. With any positive correlation between instructed and real lies, experiments on the former will tell us something about the latter, and whether that 'something' is enough depends on the uses for which the research is employed. That which is inadequate for scientific publication or criminal prosecution might be sufficient for a defendant seeking to suggest reasonable doubt (Schauer, 2009, p. 102).

The overall point Schauer (2009) is making is that legal and not scientific standards matter in assessing evidence in courts. Both external and ecological validity are scientific standards and therefore are allegedly not relevant in a legal context. It is sufficient to have 'something' that binds the lab setting and real life to permit some use of the experimental results. Therefore, even though fMRI lie-detection has some problem of external validity on the scientific level, it could be used in legal settings, such as civil litigation, where the standards of evidence are not “beyond a reasonable doubt”, but “a preponderance of evidence” or “a reasonable suspicion”.
What surprises in this account is that Schauer's (2009) arguments ignore the Federal Rule of Evidence 702 and Daubert altogether. These norms state that the legal standards for expert witness are at least in part scientific standards. If these scientific standards are not met, the evidence cannot be legally admitted. This also applies to all arguments for differential application of fMRI lie-detection (admissible in civil cases but not in criminal cases; admissible for the defense but not for the prosecution inside criminal cases) at the federal level. The Federal Rule of Evidence governs proceedings in the federal courts of the US whatever the case at issue (civil or criminal), so that there seems to be no room for differential application. Judges, as gatekeepers, must decide on admissibility on a case per case base: every use must be separately evaluated in its specific context. Nevertheless, the federal judge must abide the Federal Rules of Evidence and Daubert in doing so. Therefore, external validity cannot be dismissed as being merely scientific and not legally relevant.
The fifth and last objection underlines that no cross-cultural variation was found by using behavioral tests for

deception such as the polygraph[11] and that no cross-cultural neural variation has been reported so far for deception paradigms. The two points seem to show that the worry I am expressing is implausible. If there is no behavioral cross-cultural variation for earlier lie-detection techniques and neural cross-cultural variation has never been detected in deception, maybe there is no good reason to presume that the latter can be a problem for fMRI lie-detection. To this I reply that it is difficult to find cross-cultural variation in a test if this is not explicitly searched for, especially if there is no way to double-check for the correctness of the result. If a polygraph is used in a real-life setting and signals a suspect or witness as a liar, it is not so easy to check whether the machine is right or not, because the reliability of the subject was doubtful in the first place. Furthermore, behavioral researchers often start from the implicit assumption that cross-cultural variation is negligible, so that they do not notice this phenomenon unless it is macroscopic. To the best of my knowledge, neural cross-cultural variation in deception is yet to be tested. I would welcome any experimental attempt either to show its presence or to demonstrate its nonexistence.

Conclusion

The long and the short of this paper is that cross-cultural experiments on fMRI lie-detection should be performed before this technique enters courts, because the lab experiments with US citizens risk having an unacceptably low external validity. As a matter of fact, I suggest the technique cannot live up to the Daubert standards without such checks, because no error rate calculated in the lab can be projected onto real life without them. I do not take any position about the ethical acceptability of fMRI lie-detection, but argue that more neuroscientific research is needed (not only in the cross-cultural field) in order to assess its full potential both legally and morally. I therefore encourage and endorse more funding for fMRI lie-detection research. Only sound and carefully conducted empirical research can lead to new forensic technologies that can be useful to ascertain the truth and to justly determine legal proceedings.

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11 To the best of my knowledge no cross-cultural variation is explicitly reported in the polygraph literature.

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