Judges' perceptions of expert reports: the effect of neuroscience evidence

Valerie Moulin, Caroline Mouchet, Tessa Pillonel, G-M Gkotsi, Bernard Baertschi,

Jacques. Gasser, Benoit Testé

International Journal of Law and Psychiatry

Corresponding author: Valerie. Moulin, Maitre de Conferences, Unit for Research in legal Psychiatry and Psychology, Institute of Forensic Psychiatry, Department of psychiatry, Lausanne University Hospital (CHUV), Site de Cery, Bat. Les Cèdres, 1008 Prilly, Lausanne, Switzerland :

Mail: Valerie.Moulin@chuv.ch

Abstract

This article explores the impact of neuroscience evidence on how expert reports are perceived and their effects on the decisions made by trial judges. Experimental psychology has demonstrated a number of cognitive effects arising from exposure to neuroimaging data which may bias judgments and lead to (mis)interpretations that can affect decisions.

We conducted a study on a sample of 62 Swiss and French judges in order to determine whether their perceptions of the credibility, quality and scientific basis of a psychiatric evaluation of a criminal defendant vary according to whether or not the evaluation includes neuroscientific data. Quantitative analyses were conducted in order to evaluate significant differences between the two conditions (one-way analyses of variance) and moderation and conditional analyses to examine whether the participants' sex and length of professional experience moderated the effect of the conditions. Terminological and thematic analyses were carried out on open questions.

Quantitative and qualitative results suggest that the presence of neuroscience data in an expert report affects judges' perceptions of the quality, credibility, and scientificity (reliability, objectivity, scientific basis) of the report, and the persuasiveness of the evidence it provided. Moreover, this phenomenon was stronger in more experienced judges than in less experienced judges.

Keywords : neuroscience data, expert reports, judges, perceptions of neuroscience

1. Introduction

The inclusion of neuroscience evidence in psychiatric assessments of criminal defendants has aroused great interest(Aggarwal, 2009; Greely, 2012; Looney, 2009; Sandys, Pruss, & Walsh, 2009), but also a certain amount of reserve and considerable debate among scholars, lawyers and forensic practitioners(Kulynych, 1997; Larrieu, 2012; Oullier & Basso, 2012; Roberts, 2006). Neuroscience evidence was first introduced in the 1970s in the United States. Since then, its use has increased substantially in both the United States and Europe, especially during the last ten years (as the science has advanced). In 2011, France became the first country to introduce specific legislation covering the use of neuroimaging data in expert reports, via a bill modifying the country's laws on bioethics (Article 16-14 of the Civil Code, created by Act n°2011-814 of July 7, 2011).

For some authors, neuroscientific discoveries offer the possibility of providing the courts with more reliable and more objective evidence, thereby reducing the potential for error associated with traditional psychiatric/psychological evidence, which has been frequently criticized in recent years for being subjective, unreliable and lacking in scientific rigor (Byk, 2012; Lamparello, 2010; Ouiller, 2012). Neuroscience evidence, produced by techniques such as structural and functional neuroimaging, is most commonly used during trials, often by the defense, to demonstrate and "objectivize" psychopathological or neurobiological disorders that may be linked to the violent behavior of which the defendant is accused(Gkotsi, Gasser, & Moulin, 2018). Although advances in neuroscientific research are likely to greatly improve understanding of people and people's behavior, the use of such data in criminal trials raises numerous scientific, epistemological, technical, and ethical issues(Gkotsi & Gasser, 2016; Oullier & Basso, 2012; Pignatel & Oullier, 2014). One such issue is the impact of neuroscience evidence on how expert reports are perceived and their effects on the decisions made by trial judges.

Neuroimaging data has great persuasive power, which raises the question of how such data influence judges' perceptions of expert reports (Oullier & Sauneron, 2009; Pignatel & Oullier, 2014), most notably in terms of whether neuroscience evidence is perceived as more scientific than other types of evidence (Munro & Munro, 2015). Neuroscience evidence, like all forms of scientific data presented during trials, may be considered as a "*scientific truth*" whose validity is attested by the highly technical process involved in obtaining it, and therefore accorded greater value (Larrieu, 2012; Roskies, 2006). Even though the inquisitional system (the most common system in Europe) allows judges to assess freely the value of the evidence presented, the latter generally tend to give more weight to science-based information (Larrieu, 2012; V. Moulin & Palaric, 2013; Oullier & Sauneron, 2009). Experimental psychology has demonstrated a number of cognitive effects arising from exposure to neuroscientific explanations and/or neuroimaging data and which may bias judgments and lead to (mis)interpretations that can affect decisions.

Several studies have investigated perceptions of neuroscience data and their impact, especially concerning evaluations of the "quality" of a scientific explanation or argument (Weisberg, Keil, Goodstein, Rawson, & Gray, 2008), experimental study showed that readers (who were not neuroscience specialists) evaluate an argument as being of high quality when it contains this type of information, even when the explanation has flaws and/or when the data do not provide relevant information. Conversely, readers are more likely to recognize weaknesses when neuroscience data are not included. Hence, neuroscience data appears to make explanations more satisfactory, most notably by masking their shortcomings. A variety of explanations for this phenomenon have been suggested. One such explanation is the tendency for people to view the so-called "soft" sciences, such as the social sciences and psychiatry, - as less reliable, less valid, and less rigorous than "hard" sciences, such as physics and biology (Munro & Munro, 2015; Simonton, 2009). Hence, when arguments incorporate neuroscience data, rather than being based on psychological/psychiatric analyses alone, they are judged to be of higher quality and more valid, and participants express a greater degree of agreement with the expert on the pathology described (Munro & Munro, 2015). The reasons for this are related to the fact that explanations containing technical language are perceived as more scientific, even when they are not (Munro & Munro, 2015).

Another effect is the result of a natural tendency to prefer simple, even reductionist, explanations for complex phenomena (Crommelinck, 1995). Neuroscientific explanations are based on concrete images of the brain, rather than non-observable, abstract concepts, as is the case for psychological explanations, and this may contribute largely to their appeal (Gurley & Marcus, 2008; McCabe & Castel, 2008) (Henson, 2005). Because images of the brain provide a physical basis for "revealing" abstract cognitive processes, they could have great persuasive power and could therefore be likely to impact evaluations of an argument's credibility. However, research on this matter has evolved in the light of new data: recent meta-analyses do not confirm that brain images can affect jurors' judgments (Schweitzer et al., 2011), however neuroscience evidence was found to be more persuasive than psychological evidence. The disappearance of the effect of neuro-images in the jurors' perception could be attributed to the fact that people have gotten more used to neuroscience evidence (Schweitzer et al., 2011).

These effects are not specific to neurosciences; they are also valid for other sciences and thereby show the wider importance of examining the influence of scientific data on judges' decisions. The particularity of neuroscience data is that they are capable of generating them and are therefore likely to have particularly great persuasive power (Weisberg et al., 2008). This research suggests that including neuroscience evidence in an expert report may impact the way the report is assessed by non-specialists, such as judges, whose work requires them to take into account such reports.

Very few studies have compared professional judges' perceptions of evidence including neuroscientific data versus "traditional" expert reports [most studies include samples of participants with no training in or experience of the justice system (mock jurors) or jurors (Schweitzer et al., 2011)], and those to have done so have been conducted in countries with an adversarial system (relevant literature does not include any studies carried out in European countries with inquisitorial systems).

In this light, we decided to carry out a study on a sample of Swiss and French judges in order to determine whether their perceptions of the credibility, quality and scientific basis of a psychiatric evaluation of a criminal defendant can vary according to whether or not this evaluation includes neuroscientific data (a written description of a structural neuroimaging MRI scan).

2. Procedure and method

2.1 Study sample

We asked 100 judges (50 Swiss and 50 French), practicing within inquisitorial justice systems, to take part in the study. We received responses from 62 of these judges (21 Swiss judges and 41 French judges).

Recruitment of the judges

We recruited Swiss judges via letters sent to all the public prosecutors and court presidents in the country's French-speaking cantons, and then to every magistrate. French judges were recruited from judges attending continuing training courses in Paris. Participation in the study was entirely voluntary and we guaranteed that all data collected would be anonymous.

Criteria for inclusion in the sample

Our sample consisted of judges who use expert reports during trials (prosecutors, examining judges, and trial judges), without taking into account characteristics such as sex, experience, or geographical location.

2.2 Practical case: expert reports

The research was presented orally, and then judges who so wished could participate. A document was given to the judges in the form of a clinical case followed by questions (questionnaire). The document included handover instructions (reading the clinical case and answering questions). It then collected sociodemographic information and information on the functions performed and the number of years of experience. After reading the clinical case, the judges were invited to answer the open questions (text) and closed questions (Likert scale) directly on the document. They had the time they needed to read and answer the questions (no time limit). They then had to file the document with someone who collected the questionnaires.

In order to evaluate the effects of neuroscientific evidence on judges' assessments of expert reports and on the decisions they take, we asked the judges to read one of two expert reports describing a clinical case study. One of the reports included neuroscientific data while the other report did not. The reports we used were inspired by real cases so we could provide the judges with a realistic, concrete situation (Hughes, 1998). The report was written like a traditional expert report. A traditional report contains separate parts :1/ the offense mentioned in the criminal report based on the review of records; 2/ anamnestic data (based on observation, clinical interview psychological tests, complementary sources); 3/ the psychological status and psychiatric diagnosis based on observation, clinical interview, psychological tests and complementary sources) ; 4/ the offense as presented by the subject; 5/ a discussion section, which takes into account all of the previous points in order to argue and debate to the specific questions asked by the judges. 6/ a precise answer to each question asked by the judge.

The base report was identical for both conditions, the only difference between the two conditions being whether or not the report included neuroscience data. The first report "*condition without neuroscience data*" (CwithoutN) did not contain neuroscience data; the second report "*condition with neuroscience data*" (CwithN) contained the data mentioned below. As a result, we were able to compare the two groups (CwithN and CwithoutN) while controlling for the information contained in or absent from each report (Hughes & Huby, 2002). The report given to the judges in the CwithN group contained the following neurobiological information, drawn from a database of real court cases compiled as part of a larger study (Moulin, Gkotsi, Mouchet, Pillonel, & Gasser, 2017): "*the neurobiological evaluation conducted by Doctor F. using an MRI scanner detected "the presence of lesions in the frontal lobes of the brain which could have been produced by accidental traumas". "An evaluation of the brain's structure (using morphometric techniques), carried out to analyze the morphology of* *the cerebral cortex, showed statistically significant differences in the structure of Mr. M's brain compared with a group of subjects of the same sex and same age group. The morphological analyses revealed "differences in the density of the grey matter in the central zones of the brain, particularly in the area linked to the inhibition of automatic behavior and aggressive reactions"*. The discussion section included a further comment about the risk of reoffending: "*it (impulsiveness) could be explained by the lesions in the frontal lobes and the differences in the density of the grey matter revealed by the analysis of the brain's structure*".

2.3 Procedure

We divided the judges into two groups of 50 people. Judges in one group were given a report containing neuroscientific data; judges in the other group were given a report that did not contain this type of data.
We asked the judges to read the report and then answer a number of closed and open questions, most notably with respect to criteria relating to its scientificity (objectivity, reliability, scientific basis), and to evaluate the quality, relevance, credibility, and persuasiveness of the information it contained. These criteria were evaluated using 7-point Likert scales (e.g., 1 = not at all scientific, to 7 = very scientific). Three criteria (credibility, objectiveness, and persuasiveness of the information) were followed by open questions.

2.4 Analysis methodology of the data

We carried out quantitative analyses on the judges' Likert-scale responses in order to highlight trends (descriptive statistics) and detect any significant differences between the with and without neuroscientific data conditions. Differences between groups were analysed using one-way analyses of variance. We also conducted moderation and conditional analyses to examine whether the participants' sex and length of professional experience moderated the effect of the conditions on evaluations of the report. All these analyses were conducted using PROCESS for SPSS [Model 1, (Hayes, 2013)].
We subjected responses to the open questions to terminological and thematic analyses (Blanchet, 2007).

3. Results

3.1 Description of the study sample

Table n°1

The study sample consists of 62 judges: 15 prosecutors, 19 examining judges and 22 trial judges. The average age is 44 years; 27 men and 35 women; with an average of 13 years of experience.

3.2 Quantitative results

3.2.1. Differences between the With and Without neuroscientific data conditions

Table 2

We gave clinical cases with and without neuroscientific data to the same number of judges (50 judges in each condition), but we obtained more returns for CwithN (N = 40) than for CwithoutN (N = 22).

Results show significant differences between the two conditions (CwithN, CwithoutN) for all the items evaluated. The judges considered the expert report including neuroscientific data to be more relevant, more objective, better quality, more reliable, and more credible than the report without such data. Furthermore, they found the expert's arguments to be more persuasive and that these arguments had a greater scientific basis when the report included neuroscientific data than when such data was absent.

3.2.2. Effects of participants' sex and length of professional experience

We tested whether participants' sex and length of professional experience (M = 13.15 years, SD = 8.75, min = 2, max = 35) moderated the impact of neuroscientific data on evaluations of the report. Neither the main effect of participants' sex (ps > .055), nor the interaction between participants' sex and experimental condition were significant (ps > .11). Hence, we can conclude that the effect of the conditions did not vary as a function of the judges' sex.

On the other hand, we found a significant interaction effect between condition and participants' professional experience for three items: reliability, $F(1, 52) = 4.47$, $p = .039$, credibility, $F(1, 51) = 4.63$, $p = .036$, and persuasiveness, $F(1, 50) = 4.22$, $p = .045$. The interaction was also marginally significant for quality, $F(1, 54) = 3.17$, $p = .081$. The main effect of length of professional experience was never significant (*ps* > .25).

Table 3

When the expert report contained neuroscientific information, length of professional experience was positively and significantly related to evaluations of the report for all seven items except objectiveness (see table 3), but this relationship was never significant when the report did not contain neuroscientific information.

In addition, in this latter case the relationship between length of professional experience and evaluations of the report was negative for all seven items except objectiveness. These findings suggest that greater experience may lead professional judges to evaluate "traditional" psychiatric evidence more negatively and more critically but to evaluate "modern" psychiatric evidence containing neuroscientific data more positively.

3.3. Qualitative results: analysis of answers given to the open questions

Items evaluating the judges' perceptions of the reports' credibility, persuasiveness, and scientificity were followed by open questions asking respondents to indicate the reasons underlying their Likert-scale responses. The judges did not all reply to all the open questions, which is why there are differences in the numbers of responses reported for each.

Table 4

3.3.1. Credibility of the expert report

We asked the judges to state why they did or did not find the report credible. The degree to which a document is considered credible, in other words, worthy of belief, depends on the reader's opinion of the veracity and/or verifiability of its source and, by extension, his or her overall confidence in the information.

Results showed opposite trends in the two conditions. In line with the quantitative trend provided by the Likert-scale evaluations, in CwithoutN more arguments refer to the report's lack of credibility, whereas in CwithN more arguments refer to its credibility.

-In CwithoutN - 5 responses referred to the report's credibility, indicated by "its coherence, its measured tone, the fact it takes into account a variety of positive and negative factors", and "its clarity, it's precision". The judges used a number of terms to express this idea.

- 8 responses referred to the report's shortcomings and lack of precision, identifying oversights and weaknesses in the report. The terms used express the notions of "lack" and "absence", citing, for example, the "*absence of tests*" or the report's "*incomplete nature*".

-In CwithN - 7 responses did not answer the question or evoked difficulties in adopting a position: "*difficult to adopt a position on these questions without knowing more about the case and hearing what the accused has to say".*

- 3 responses criticized the neuroscientific data: *"data relating to the morphological analysis and to the brain cannot be considered reliable given the current state of medical research".*

- 16 judges were firmly of the view that the report was credible, as demonstrated by the *"different aspects on which it is based"*, the combination of *"medical history, personal observation, tests, examination of the case, neurological examinations",* and "*the absence of contradictions*". Other judges cited the report's "*coherence"* with respect to its different components: "*the arguments appear relevant and coherent, related to the facts and the defendant's life history. The unusual combination of 'clinical' and 'neurological' aspects is interesting",* or the *"analysis with concordant complementary data from different fields (psychiatric, psychological, neurological)"*. The most frequently used adjective to describe the evidence was "coherent". The judges' assessments of the report as being credible appear to have been influenced by the idea that it combines data from different sources (clinical, life history, and neurobiological data) and the fact that this data is not contradictory.

3.3.2. Persuasiveness of the report

The second open question asked the judges to comment on the persuasiveness of the report. Again, we found opposing trends between the two conditions. In CwithoutN, a majority of the judges said they had not found the report persuasive, whereas most of the judges in the CwithN condition said it was persuasive.

-In CwithoutN - 9 judges said they felt that the report was not persuasive and gave a variety of reasons for this, including: "*there is barely any reasoning"; "the lack of foundation for the diagnosis, the lack of demonstration, there is nothing about reoffending".* The most frequently used terms are those evoking negation ("*there isn't*", "*there's nothing*", "*the lack*"), which were used to highlight the report's weaknesses and defects.

- 3 judges said the report was persuasive: *"The medical history is complete, suggesting that the expert took the time to get to know M. Quite convincing link between M's personal history and his relation with V"*. The other responses (N=5/17) did not answer the question that was asked.

-In CwithN - 17 responses mentioned aspects of the report that made it persuasive: "*logical, coherent, clear, objective"; "absence of value judgments, very professional, concordance between different elements"*; "*the neuroscientific data objectivize the act. The medical aspects give it extra credit because they clarify the psychological analysis".* The most frequently used terms are "*logical"* and *"coherent*". Overall, the judges appeared to view neuroscience data as objective and therefore capable of providing objective support for psychological and psychiatric data.

- 6 responses questioned the value of the neuroscientific data, for example: "*skeptical about the neurological aspect, which is a little too hypothetical".*

- 9 "other" responses repeated sentences from the report without commenting on its persuasiveness.

3.3.3. Scientificity of the report

The third open question asked the judges to comment on the degree to which they felt the report was scientific. Here, too, there were opposing trends between the two conditions.

-In CwithoutN - 9 of the 17 responses mentioned "*the lack of references to the literature or to the methods used"; "no links between the literature and the activity of the subject, no scientific justifications for the statements made"*; *"absence of references to tests".* Terms such as "lack" and negative adverbs such as "not" were prevalent. From a thematic point of view, the report's shortcomings were expressed in terms of its failure to state the tools used and its lack of references to the scientific literature.

- 3 judges felt that it "*met criteria in the field".*

- 4 judges did not answer the question asked.

-In CwithN - 29 of the 35 responses said that the report was scientific, as it combined psychological and psychiatric data with neurobiological data: "*the expert cites a battery of tests: medical examinations (MRI) and the ICD-10. Hence, the diagnosis is based on scientific data"*; "*use of scientific measurement tools (neurological tests) and analysis tools used in the human sciences (psychology)*". Other answers mentioned the presence of "*objective bases, based on recognized norms"; "the interview is precise, the neurological data are objective*". Several answers referred to overall impressions: "*the analysis appears to be based on a scientific approach"; "it is based on a convincing clinical picture*".

- 3 answers questioned the lack of explicit links between the neuroscientific data and the violent behavior, without expressing an opinion on whether or not the report was scientific: "*physical tests but a lot of descriptions, few links drawn between the test results and the disorders described. What treatment should be given now?"; "I can't say because I have not seen any demonstration of the link between the brain lesion and impulse-control disorders"*.

- 3 “other” responses.

4. Discussion

To our knowledge, in European countries with inquisitorial systems, this is the first study attempting to explore the Swiss and French professional judges’ perceptions of a psychiatric evaluation of a criminal defendant, according to whether or not this evaluation includes neuroscientific data. Based on the quantitative and qualitative results of this research, we can make the hypothesis that the written neurobiological data included in the expertise affects the judges' responses. However, these results should be considered as preliminary results to be confirmed with a control case in which we will introduce other data.

The results of this study may be related to cognitive biases described in the literature (Munro & Munro, 2015; Simonton, 2009; Weisberg et al., 2008), in particular the perceived scientific nature of neuroscience data (its visual nature – brain scans – was not examined in this study). In the case we studied, including such data significantly modified judges’ perceptions of the quality, credibility, and scientificity (reliability, objectivity, scientific basis) of the report, and the persuasiveness of the evidence it provided. Moreover, this phenomenon was stronger in more experienced judges than in less experienced judges. In CwithN, more experienced judges were more likely than less experienced judges to view the report as relevant, reliable, credible, scientific, high quality, and persuasive. Hence, judges with more experience of assessing expert reports appear more disposed to give credit to this new form of expert report containing neuroscience data.

Qualitative analyses of the discourse have shown changes between the two conditions with neuroscience data and without neuroscience data. Some of these changes are similar to those found in other studies that analyze the effect of neuroscience (Weisberg et al., 2008; Munro & Munro, 2015) on the perception of reasoning.

<u>A greater ability to recognize shortcomings in expert reports when they do not contain neuroscience data</u>

In line with Weisberg (Weisberg et al., 2008) findings concerning perceptions of an argument's quality, judges are more likely to criticize and to find shortcomings and omissions in expert reports when they do not contain neuroscience data. Although many of the judges in the CwithoutN group found flaws in the report, few of the judges in the CwithN group noted weaknesses, with most perceiving the report to be satisfactory. Furthermore, perceptions that the report did not include contradictions and that the dimensions evaluated were coherent were stronger for the CwithN report than they were for the CwithoutN report.

However, the results have shown that a minority of judges cited criticisms of brain imaging data, mentioning their unreliability, their hypothetical nature or the lack of a direct link between the brain and violent behavior. These criticisms show that some judges question the contribution of neuroscience to understanding behaviors and the fact that they are aware of some of their limitations.

Expert reports including neuroscience data are perceived as more scientific

Globally, including neuroscience data increased perceptions that the report was scientific (Munro & Munro, 2015). When asked to state why they felt the report was scientific, many arguments provided by the CwithN group evoked the "*objective*" nature of neuroscience data. Here, the notion of objective has a double meaning.

First, "objective" is used in the sense of objectifying traditional data: neurobiological data, due to their supposed biological basis, may be seen as objectifying psychological and psychiatric data and thus as "physical" support for psychological and psychiatric conclusions. Hence, including neuroscience data may be perceived as making psychological evaluations more reliable, more coherent, and more scientific.

Second, it is also used in contrast to the notion of subjective, indicating a reality that is constructed in the mind, rather than to an "incontrovertible" external reality. Hence, the reality revealed by a psychological evaluation may be considered subjective because it is constructed from clinical signs (used to detect personality traits, disorders, or tendencies relating to the actions for which the subject is on trial, or the subject's responsibility for his or her actions) and “clues” perceived in the subject’s life history. In contrast, neuroscience data are perceived as providing an objective and faithful vision of reality because it is produced by a machine (MRI scanner, PET Scanner, etc.) and therefore thought to be exempt from interpretation.

However, it is important to remember that neuroscience data is also the result of interpretation, as the raw images provided by brain scanners are meaningless until they have been interpreted and this is especially true in case studies. For example, the results of functional magnetic resonance imaging (fMRI) scans are not direct observations (Roskies, 2006) even though the method uses high technology, the raw data from every scan has to be interpreted - data never speak for themselves. The scanner measures variations in blood flow, volume, and oxygen content, which are then converted into an image by applying a series of statistical analyses, each of which can introduce errors (Aguirre, 2014). The resulting image must then be interpreted by a human being. In addition, most of the hypotheses on which interpretations of neuroscience data are based (e.g., causal relations between the brain and the mind) are still controversial.

In an earlier study of real cases (coming mainly from an adversarial system) involving expert reports including neuroscience data(Gkotsi et al., 2018; Moulin et al., 2017), we noted that expert witnesses would often provide contradictory interpretations of a single set of empirical evidence. In addition, in many of the cases examined in this previous study, experts often found it difficult to meet the Frye or Daubert (de Munagorri, 1999) standards for admitting evidence (the degree of scientific consensus about the validity of an analysis method or diagnosis technique required for evidence to be admissible). All these factors argue against the idea that neuroscientific data are “more objective and more solid proof” capable of producing more reliable conclusions than analyses carried out in “softer” sciences such as psychology and psychiatry(Gkotsi et al., 2018). Rather, they highlight the uncertainty and interpretative nature of neuroimaging data. These results raise epistemological questions about how evidence is constructed and how the supposed scientific character of certain types of evidence affects the way it is perceived.

Our results suggest that neuroscience data are rarely questioned by judges (or marginally in relation to all responses). We can hypothesize that these results are related to the inquisitorial system. Inquisitorial systems are used primarily in countries with civil legal systems as opposed to common law systems. In the inquisitorial system, the judge is at the center of the investigation: they represent society and have an active role in preparing evidence, questioning witnesses and finding the truth. Unlike the adversarial model, in the inquisitorial system, serving justice goes beyond the interests of the parties of the trial and is very important for society, which is represented by a third entity that plays a role during the criminal trial: the public prosecutor's office (that is entitled, for example, to appeal a judgment). The victim also constitutes an integral part of the criminal trial; victims can lodge of a complaint submitted with or without a claim for criminal indemnification(Beliveau & Pradel, 2007). In the inquisitorial system, only the judge is entitled to appoint an expert. During the pre-trial phase (investigation phase), it is the prosecutor or investigating judge who appoints the expert (The expert can then be solicited later in the procedure during the execution of the sentence and also at the end of serving the sentence). The expert is committed to the judge who appointed them to fulfill their mission. The inquisitorial system is based on the free assessment of data and evidence by the judges, and the expert is appointed by the judge from a list of experts competent in the field in question. More, the judge is considered as not competent to evaluate the work of the expert but he is also not obliged to follow their expertise either. The expert does not have to justify the methods, tools or techniques used or their possible margin of error with regards to the data of the scientific community. In the adversarial system, the judge must verify the reliability of the expert testimony : experts are appointed and paid by the parties. Because of the diversity in opinions, it may fall to the judge to rule on scientific controversies. Depending on the country or state, specific rules are put in place. In the USA, from 1923, the Frye standard is a test to determine the admissibility of scientific evidence. It provides that expert opinion based on a scientific technique is admissible only where the technique is generally accepted as reliable in the relevant scientific community. In 1985, the DAUBERT decision specifies the requirements vis-à-vis the experts. Four axes specify the criteria required for the "testimony" of the expert to be admissible: the factors that may be considered in determining whether the methodology is valid are: (1) whether the theory or technique in question can be and has been tested; (2) whether it has been subjected to peer review and publication; (3) its known or potential error rate; (4) whether it has attracted widespread acceptance within a relevant scientific community. These differences in professional practices within the two systems could explain why the judges studied are less critical of the data introduced in the expert reports because they do not have to verify the data that can be used in the trial.

An opposite effect to simplification and reductionism: greater consistency and coupling of data

In contrast to the cognitive bias towards simplification described in the literature (Crommelinck, 1995), according to which associating a phenomenon with neurobiological causes should result in it being perceived in more simple terms, the judges in the CwithN group considered the expert report to be credible, persuasive, and scientific because it combined numerous coherent and non-contradictory elements (clinical, medical history, neurobiological). Hence, rather than differentiating between the dimensions and reducing the reasoning to a physical, neurobiological argument (more analytical conception(Pourtois & Desmet, 2007), which tends to simplify analyses by dividing them into ever smaller units), introducing neurobiological data triggers more “systemic” perceptions and conceptions (Morin & Le Moigne, 1999; Pourtois & Desmet, 2007), which reintroduces complexity by taking into account the different units and the links between them. By providing a biological “basis” for the report’s findings, the neuroscience data strengthens the reader’s confidence in the interpretation of the clinical signs and the clues provided by the subject’s life history, and in the coherence of the data provided.

Does including neuroscientific information reduce the ability to critically assess expert reports?

Several studies of European judges (Mouchet & Pillonel, 2016; Moulin et al., 2017; V. Moulin & Palaric, 2013; Palaric & Moulin, 2014) have shown that judges base their room for maneuver and their freedom to "criticize" an expert report on the clarity of its reasoning, the absence of contradictions, and its persuasiveness. Judges maintain that they do not have the expertise to question methods or conclusions based on scientific expertise [in inquisitorial criminal systems, experts with specific technical and scientific knowledge (attested by a registration procedure or specialist qualifications) are considered "legal auxiliaries" and are completely neutral. Furthermore, judges are considered unqualified to rule on scientific questions (Byk, 2012; Canivet, 2000; Garapon, 2005; Hureau, 2008)]. Because neuroscience data increases perceptions of the coherence of arguments, the absence of contradictions, and the presence of logical links between different elements, can unintentionally reduce judges' abilities to question and/or counter expert reports. Neuroscience data can also make evidence more difficult to understand, thereby affecting judges' abilities to analyze it critically.

Limitations

Several limitations must be mentioned. First, the results cannot be generalized because the sample size was too small. Increasing the sample size, especially in the CwithoutN, so the two groups were of comparative size, would provide more reliable and accurate results. So, the results should be considered preliminary results to be confirmed. Second, the observed changes could be related to the simple fact of adding data. Whatever the type of data entered. However, the qualitative responses at least partially refute this interpretation based solely on the amount of information, as the basis for the difference in judges' perceptions. Third, we did not include a control group presented with another type of data (e.g., biological), so we were unable to determine whether or not the effects we found were related specifically to neuroscience data. It would also be interesting to determine whether effects vary with different types of neuroscience data.

Conclusion

Neuroscience data, especially neuroimaging data, are already admissible as evidence in criminal proceedings in the United States and many other countries. Although the last ten years have seen spectacular technological and scientific advances in this field, scientists are still a long way from understanding fully how the brain functions and from establishing firm links between brain function and an individual's psychological or psychopathological state(Gkotsi et al., 2018). When neuroscience data is admitted as evidence in criminal trials, experts frequently disagree over how these data should be interpreted and over possible links between the data and the acts of which a defendant is accused (Chandler, 2016; Greene & Cahill, 2012; Witzel, Walter, Bogerts, & Northoff, 2008). The results of our study, carried out on judges working within inquisitorial criminal systems, which do not have Frye- or Daubert-type standards for the admissibility of expert testimony, show that scientific data can impact decision-making processes, especially in the case of professional judges with many years' experience. Hence, members of the legal profession must be trained in how to recognize the strengths and weaknesses of this new type of expert report without allowing its perceived objectivity to cloud their critical faculties. Only by correctly assessing neuroscience data, while remaining aware of its potential impact on their evaluative and decision-making processes, will they be able to exploit its potential contribution to evaluating and explaining behaviors. Although judges are mindful of their limits when it comes to assessing technical data, they appear relatively unaware that scientific data can induce cognitive biases and thereby affect their perceptions of expert reports.

Appendices to the text

Differences concerning the position and the status of expert and judges in Adversarial and an Inquisitorial Legal Systems

The position of the judge and the expert, as well as the status of the expert, are different between the inquisitorial and the adversarial system. Since inquisitorial and adversarial system attribute investigation duties to judges and the parties respectively, the status of the experts is different in each system: forensic expert and expert witness. In the inquisitorial system, experts must have previously acquired knowledge and skills that allow them to fulfill their mission and to be appointed by judges. In Switzerland and France, experts are considered specialists in their field and are required to regularly demonstrate their skills and training in order to be able to practice as experts (in Switzerland obtaining a specialization in legal psychiatry or psychology and in France by registering in special lists of experts) (Palaric et al 2014). In the adversarial system, for example in the United States, the parties may suggest the expert of their choice. It is still however up to the judge to check the skills of the expert (Blumrosen & Hertz-Béjot, 2007). As a result the contract does not bind the expert to the judge, but directly to the parties who appoint them, since it is their responsibility to fulfill the expert missions.

In Switzerland, ordering an expertise in the context of criminal adjudications is a regulated practice. For example, in the pre-sentence phase, the Penal Code mentions that the examining authority or the judge order an expert's assessment if there are serious doubts about the author's legal capacity (Article 20 Penal Code). In France, the expert's services must be solicited for certain categories of offense, The expert is expected to bring technical elements about specific points. When judges are dissatisfied by an expertise, they can ask for a complementary one or call on a new expert ("contre-expertise").

In the adversarial system, experts are appointed and paid by the parties. Because of the diversity in opinions, it may fall to the judge to rule on scientific controversies. Depending on the country or state, specific rules are put in place. In the USA, from 1923, the Frye standard is a test to determine the admissibility of scientific evidence. It provides that expert opinion based on a scientific technique is admissible only where the technique is generally accepted as reliable in the relevant scientific community. In 1985, the DAUBERT decision specifies the requirements vis-à-vis the experts. Four axes specify the criteria required for the "testimony" of the expert to be admissible: the factors that may be considered in determining whether the methodology is valid are: (1) whether the theory or technique in question can be and has been tested; (2) whether it has been subjected to peer review and publication; (3) its known or potential error rate; (4) whether it has attracted widespread acceptance within a relevant scientific community.

The judge must verify the reliability of the expert testimony. For this purpose, meetings between experts, judges and the parties (testimony) take place before the trial, during which the experts demonstrate their methodology. In the inquisitorial system, the judge is considered as not competent to evaluate the work of the expert but he is also not obliged to follow their expertise either. The expert does not have to justify the methods, tools or techniques used or their possible margin of error with regards to the data of the scientific community. He is free to use the techniques and tools that he prefers.

The development of the "Judicial Truth" (Byk, 2012, Canivet, 2000) is based on the principle of contradictory debates and the confrontation of points of view. In the inquisitorial system the judge freely appreciates evidence. Scientific data can help to construct the "legal truth", which, however, may not be reduced to these and judges are free to distance themselves itself from scientific data. They are led *to "interpret the scientific facts in the light of their reasoned intimate conviction"* (Byk, 2012).

Acknowledgements

We would like to thank the judges who participated in this research.

Funding

This work was supported by the “Académie Suisse des Sciences Médicales” (ASSM), fund *Kate Zingg-Schwichtenberg*.

Conflict of interest

No conflicts of interest to declare.

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Table 1: Characteristics of the study population

	Swiss judges	**French judges**	**Swiss and French judges**
Number	21	41	62
Age (mean)	44 years	44.5 years	44 years
Sex	14 men 7 women	13 men 28 women	27 men 35 women
Years' experience (mean)	13.7 years	12.9 years	13.0 years
Position Prosecutor Examining judge Trial judge	 15 prosecutors 7 trial judges	 19 examining judges 22 trial judges	 15 prosecutors 19 examining judges 22 trial judges

Table n°2: Differences between the With and Without neuroscientific data conditions

	Without N=22	**With** N=40	*F*	*p*
Relevance	4.30 (1.38)	5.89 (0.92)	27.53	< .001
Credibility	4.50 (1.38)	5.40 (1.34)	5.42	.024
Quality	4.05 (1.40)	5.71 (1.06)	26.75	< .001
Objectivity	5.14 (1.15)	6.04 (0.92)	10.65	.002
Reliability	4.50 (1.43)	5.80 (1.04)	15.81	< .001
Persuasiveness	4.32 (1.20)	5.61 (1.02)	17.78	< .001
Scientificity	3.55 (1.61)	5.32 (1.29)	20.31	< .001

Means, (standard deviation), *F* ratios and *p* values for the quantitative assessments of the reports With *vs.* Without neuroscientific data

Table n°3: Conditional effects of professional experience in the With and Without neuroscientific data conditions

	Without		With	
	Effect (SE)	*t*	*Effect (SE)*	*t*
Relevance	-0.01 (0.04)	-0.07	0.04 (0.02)	2.41*
Credibility	-0.05 (0.05)	-1.09	0.06 (0.02)	2.91**
Quality	-0.02 (0.04)	-0.61	0.05 (0.02)	2.68**
Objectivity	0.02 (0.03)	0.55	0.02 (0.02)	1.45
Reliability	-0.06 (0.04)	-1.36	0.04 (0.02)	2.15*
Persuasiveness	-0.03 (0.03)	- 0.80	0.05 (0.02)	2.84**
Scientificity	-0.02 (0.05)	- 0.40	0.05 (0.02	2.15*

* p <.05 ** p < .01

Table n°4 : Terminological and thematic analyses.

Conditions **Questions**	**Without neuroscientific data condition N=22**	**With neuroscientific data condition N=40**
Credibility	14 responses	36 responses
Terminological	5 : credible various terms	3 responses criticized neuroscientific data: "*data not credible and unreliable*"
Thematic	Taking into account a variety of dimensions	lack of scientificity
Terminological	8 : no credible : terms used express the notions of "lack" and "absence",	16 responses credible : most frequent adjective : "coherent"
Thematic	The lack	Combination of data from different sources
	Other : 1 response	Other : 7 responses
Persuasiveness	17 responses	35 responses
Terminological	9: no persuasive: words speak of negation: "There is nothing"	17. persuasive: "*logical*" and "*coherent*"
Thematic	Weaknesses and defects	Consistency and not contradiction between the data
Terminological	3: persuasive	6 responses questioned the value of the neuroscientific data: various terms
Thematic	complete and demonstrative	lack of scientific basis
	Other : 5responses, does not answer the question asked	Other : 9 responses, does not answer the question asked
Scientificity	17 responses	35 responses
Terminological	9 : non scientific, Terms such as "*lack*" and "*negative*" adverbs such as "*not*"	29 : persuasive. Terms: rigour, science, scientists
Thematic	The report's shortcomings were expressed in terms of its failure to state the tools used and its lack of references to the scientific literature.	Scientific approach, persuasive
Terminological	3 : Scientific : rigour and science.	3 responses : lack of explicit links between neuroscientific data and violent behavior
Thematic	Correspondence between the representation of science and the content of the report.	Lack of links