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ORIGINAL PAPER

The Role of Neuroscience in the Evaluation of Mental Insanity: on the Controversies in Italy

Comment on "on the Stand. Another Episode of Neuroscience and Law Discussion from Italy"

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Abstract In the present manuscript, we comment upon a paper that strongly criticized an expert report written by the consultants of the defense (two of the authors of the present paper, PP and GS) in a case of pedophilia, in which clinical and neuro-scientific data were used to establish the causal link between brain alterations and onset of criminal behavior. These critiques appear to be based mainly on wrong pieces of information and on a misinterpretation of the logical reasoning adopted by defense consultants. Here we provide a point-by-point reply to the issues raised in the above paper and also discuss the potential role that neuroscience may contribute in the forensic context. Did the forensic neuroscience defense consultants claim the existence of a deterministic relationship between brain structure or function and behavior? How did the neuroscientific logic work in this specific case? How may the classic psychiatric/neurologic examination and neuroscientific evidence work side by side? Does the rarity of a disease impact on the causal relationship between the disease and the crime? Do neuroscientific data need to be interpreted? We address the above questions and conclude that neuroscience may strengthen the results of psychiatric evaluations, thus reducing uncertainty in the forensic settings.

Keywords Acquired pedophilia · Neuroscience · Law · Psychiatry · Criminal liability · Expert witness

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> "*Progress for the sake of progress must be discouraged.*"
> Dolores Umbridge
> Harry Potter and the Order of Phoenix

Introduction

In recent years, there has been a growing interest in the application of neuroscientific methods to the investigation of criminal behavior within the forensic setting, including in particular the evaluation of mental insanity in defendants [1]. As cognitive and molecular neurosciences are unveiling more and more the biological underpinnings of human behavior [2–7], a strong debate

has arisen around the true implications of these findings in the evaluation of responsibility in individual cases of criminal conduct [8–17]. In many instances, however, criticisms raised by opponents of the utilization of neuroscience methods appear to be based on distorted interpretations of reports when not even on simply untrue claims. As a matter of fact, this is the case with the paper by Farisco e Petrini [18] that strongly criticized an expert report written by the consultants of the defense in a case of pedophilia (two of the authors of the present paper, PP and GS) in which clinical and neuroscientific data were used to establish the causal link between brain alterations and onset of criminal behavior.

We believe it is important to comment on the Farisco and Petrini paper mainly for two reasons. First, some of the information provided in the paper and some of the logical argumentations attributed by the authors to the consultants for the defense are simply wrong. Second, in the paper we are commenting upon [18], the authors utilize the specific case of pedophilia to raise major concerns on the general role of neuroscience in court. These concerns seem to be mainly driven by a misinterpretation of the logical reasoning in the case under consideration.

In the current paper we would like to reply to the criticisms raised by Farisco and Petrini [18] in order to dampen the concerns regarding the actual role of neuroscience in psychiatric expert examinations in Italian courts.

A detailed description of the case of pedophilia under discussion has been published elsewhere [19]. Briefly, a 64-year old pediatrician was caught while enacting sexually inappropriate behaviors towards children. After a week in jail, he was sent to house arrest. Clinical history, psychiatric and neurological assessments consistently indicated an impaired frontal lobe functioning, raising the suspect of a frontal dementia. A brain magnetic resonance imaging (MRI) scan examination revealed a tumor originating from the cranial base (a *clivus chordoma*) that compressed portions of the brain, including the orbitofrontal cortex and the hypothalamus (please see [19]). The consultants for the defense provided multiple pieces of evidence in support of a causal relationship between the tumor and the impaired mental state of the defendant and therefore they concluded that the defendant should not be held criminally responsible due to mental insanity [19]. On the contrary, the judge's experts affirmed that the pediatrician become a pedophile in an attempt to revitalize his declined sexual life, as a sort of "behavioral viagra". Of course, each of these two so extremely different positions, hardly reconcilable, should be supported by evidence. In the following paragraphs, we will present the evidence in support of our conclusions and we will discuss the added value that the neuro-scientific methods may bring into the forensic setting.

As a general premise, we would like to recognize that within the neuroscientific (as well as the legal) community there are different opinions on the role of neuroscience in court. On one hand, some neuroscientists believe that neuroscientific methods will in the near future replace the classic psychiatric assessment [20, 21]. On the other hand, other neuroscientists, including us, strongly believe that neuroscientific methods are intended to provide more reliable markers to understand the crimino-genesis and crimino-dynamics [8, 11, 14, 22, 23], with no need to replace psychiatric examination as a consequence of this. In a wider context, we see no conflict between clinical psychiatry and neuroscience, nor any need or reason for neuroscience to 'take over' psychiatry. On the contrary, we believe that neuroscience will provide clinical psychiatry with more and more objective measures, thus reducing the gap that still exists between psychiatry and the other medical branches. Indeed, our consultations always include comprehensive psychiatric, neurologic, psychological and neuropsychological assessments, as we believe that the core of the mental insanity evaluation is, and always will be, the clinical psychiatric assessment [1, 7]. At the same time we believe that cooperation between the two disciplines, namely forensic psychiatry and forensic neuroscience, should be encouraged and fostered.

Currently, psychiatric assessment, by itself, is often not sufficient to achieve objective conclusions in the forensic setting. This because the classical psychiatric evaluation suffers from a major limitation: specifically, psychiatric diagnoses are made according to the symptoms reported by patients and also based on results from psychological tests and behavioral observations, which in turn rely heavily, if not completely, on information provided by the patient/defendant. While this aspect is less (or none) than a problem in the clinical setting, where patients are seeking help for their sufferance, the forensic context is a quite different situation [24]. Indeed, here the psychiatric assessment is made more complicated by the fact that psychiatric symptoms can be easily faked or exaggerated for defensive purposes and that most defendants assessed for mental insanity may have no or little psychiatric history.

The limitations of classic psychiatric evaluation have been provocatively investigated in a well-known experiment in 1973 [25], in which "pseudopatients" feigning hallucinations were all admitted to the psychiatric department of 12 different highly specialized hospitals: all but one (who was diagnosed having a bipolar disorder) received a diagnosis of schizophrenia. This study clearly demonstrates that relying upon symptoms reported by the patient is not as reliable as previously thought. Moreover, other studies investigated the accuracy [26] and the inter-rater reliability [27] of unstructured psychiatric interviews and reported dramatically alarming results: the accuracy of unstructured interviews was 53.8%, and the inter-rater reliability ranged from 45.5% to 54.5%. Altogether, the results of these studies highlighted the urgent need to have complementary and integrative results that, following the principle of the convergence of evidence, may strengthen the process to achieve a correct psychiatric diagnosis.

A strategy for dealing with malingering of psychiatric disorders, and thus overcoming the intrinsic limitations of the clinical psychiatric assessment, would be the validation of the reported symptoms with an objective anatomo-clinical correlation [28], as it is the case in the vast majority of cases in non-psychiatric medical disciplines (for instance, diagnosis of dementia is made on the basis of clinical symptoms and signs, but is also corroborated by objective findings, including radiological measures of cortical atrophy or vascular morbidity and so on [29]). In Italy, the pivotal aim of psychiatric assessment within the forensic setting is to determine whether or not the defendant suffers from a mental disorder, and whether or not the defendant's ability to make a distinction between right and wrong (ability to understand) or to do otherwise (ability to will) is completely or partially deficient due to the presence of a mental disorder (Italian penal code, art. 88, 89). Thus, the rational underlying the determination of criminal liability should always be based on the results from clinical, behavioral, neurological, neuropsychological assessments that cannot be replaced by the simple empirical evidence of the state of the brain. In this regards, however, neuroscientific methods may be crucial in providing supporting biological data that can be used to reduce uncertainty in forensic psychiatric evaluations, validate symptoms as non-faked, thereby minimizing the risk of malingering [8] and provide insights into the crimino-genesis and crimino-dynamics of the event [1, 8, 11, 19, 22, 23].

By constrast, neuroscientific evidence, in isolation from clinical information, are useless, if not even potentially dangerous, as they might increase confusion [23]. This is well exemplified in the case of Vincent Gigante (VG), a mafia leader who was charged with seven counts of murder [11]. This case is of high interest since VG received in a few years various diagnoses ranging from schizophrenia to Alzheimer's disease on the basis of the sole brain imaging results, without considering the clinical profile and the medication prescribed. Relying upon neuroscientific evidence alone led to misdiagnoses that would have been dangerous both from the clinical (i.e., wrong drug treatment) and forensic (i.e., incorrect conclusion on mental insanity) points of view.

We believe that neuroscientific evidence should not replace psychiatric evaluation *tout-court*, but rather should complement it, in order to strengthen the defense or prosecution by providing independent, supportive pieces of evidence that may converge towards the identification of a specific, forensically relevant, condition. As compared to the other branches of Medicine, psychiatry has always suffered from the lack of objective parameters whose measures could be used in aiding the diagnostic process [30]. We strongly believe that neuroscience is likely to fill more and more such a gap. This certainly does not imply that psychiatric examination will become obsolete, in the same way in internal medicine the patient's physical examination has not been abandoned because of the availability of laboratory tests.

In the following paragraphs, we will start from Farisco and Petrini assertions [18] to: i) correct the wrong and misleading information provided in their manuscript; ii) describe the logical reasoning of the defense's consultants adopted in the specific case reported in the above paper [18]. Both these objectives hopefully will clarify the role that, in our opinion, neuroscience should have within the forensic setting.

Forensic Controversies in Mental Insanity

As a general premise, we would like to emphasize that we do not intend to discuss the multiple authors' blunders that overall denote a superficial, if not an inadequate, knowledge of the whole case. Just for the sake of example: the performed MRI was not a functional one, as stated by the authors, but rather a structural MRI; the detected pathology was not an acute one, but a slowly

growing tumor; the thesis the authors present as the prosecutor's one was that of the experts appointed by the judge [18]. Rather, we will focus our discussion on the claims that try to discredit the role of neuroscience insanity assessment.

We would like here to demonstrate that the authors rely on the argumentative technique called "false attribution" or "strawman fallacy", which is a fallacy of relevance based on misinterpretation of an opponent's position. According to this technique, the authors [18] tried to discredit the argumentations supporting the defense's conclusions, that is, that the defendant was mentally insane. However, they attributed false argumentations to the defense's consultants, as the consultants never proposed those argumentations that the authors tried to discredit.

Are the Forensic Neuroscience Defense Consultants Claiming the Existence of a Deterministic Relationship between Brain Structure or Function and Behavior?

This is likely the main concern of forensic psychiatrists and it is clearly expressed by the Farisco and Petrini: "*These experts (the neuroscientists), after a functional MRI scan showing an acute brain pathology, claimed that the pedophilia of the defendant was acquired as a consequence of the pressure on the hypothalamus by the tumor. (…). As a result, the defense asked the defendant to be acquitted*" [18].

The neuroscience consultants are not claiming that the presence of any brain abnormalities (in this case the tumor) would be the basis of any mental insanity assessment in the absence of any clinical manifestations, as we have already explained in details elsewhere [1, 8]. Inferring the presence of altered mental states from the presence of brain pathology is called *reverse inference*. More generally, the reverse reference reasoning arises when the presence of a specific cognitive process is inferred from the presence of neural activation in a given brain region. Reverse inference is not deductively valid, since it reflects the logical fallacy of affirming the consequence [31, 32]. It might be valid if it assumed the form of a biconditional, i.e. the area X is involved if and only if the cognitive process Y is engaged. However, this never happens in neuroscientific research, where cognitive processes are supported by complex brain networks and each brain region is implicated in the correct execution of a variety of cognitive tasks e.g. [33].

If one forgets this, one risks to fall into the "teetotaler error" [34], a provocative example of a typical mistake that one might end up with when using reverse inference to interpret the results: the risk to interpret an individual difference in neuroanatomy as a sign of pathology. The key message is: neuroimaging results alone, not coupled with clinical symptoms, are meaningless.

As a matter of fact, in this specific case of pedophilia, the neuroscientists working for the defense (who noteworthy are a psychiatrist and a psychologist) in a preliminary clinical assessment found a number of symptoms and signs, which included impaired abstract thinking, easy frustration, onset of personality and behavioral changes (other than pedophilia) over the last several months, diplopia, tunnel vision, pathological crying and others [19]. Furthermore, the consultants conducted a comprehensive neuropsychological assessment, which revealed impairment in social intelligence tests (emotional attribution, moral reasoning, etc.), impulse disinhibition and other deficits (for a detailed report please see [19]). On the basis of these observations, the experts suspected the presence of a degenerative cognitive disorder (e.g., fronto-temporal dementia, as most of the behavioral symptoms for the behavioral variant of fronto-temporal dementia [35] were present in the defendant) and obtained permission from the judge to perform a structural brain MRI scan examination. The MRI scan revealed the presence of a rare bone tumor, a *chordoma*, which was growing from the *clivus* of the skull base. Thus, the process that led to the suspect of a pathological lesion within the brain was quite different indeed from the one described by Farisco and Petrini [18], who completely omitted to report the results revealed by the clinical examinations and that prompted the diagnostic considerations that led to further assessments. Specifically, the tumor was discovered because the presence of the clinically relevant behavioral symptoms described above, which were highly suggestive of a condition affecting frontal lobe functioning, were a mandatory clinical indication to obtain a brain MRI scan. This is exactly the other way around of what the authors claim [18], that is, that the behavioral symptoms were postulated following the results of the brain MRI.

We would like to remark that the results from the clinical, neurological and neuropsychological tests themselves would have been sufficient to sustain the pediatrician's lack of culpability due to mental insanity. In this respect, the neuroscientific data proved to be fundamental to understand the reason why the behavior

of this man changed at the age of 64 years, to explain this sort of 'behavioral fracture', from being a highly respected pediatrician with over 130,000 out-patient examinations performed in more than 30 years of career to becoming an individual with an overt pedophilic behavior, carried out in a case even in front of the young patient's mother. From a crimino-genetic and crimino-dynamic perspective, the role of the tumor appears to be a much more convincing and objectively based explanation as compared to the one proposed by the experts of the judge, that is, that the pediatrician became a pedophile in an attempt to revitalize his sexual life due to some sexual decline, as a sort of "behavioral viagra" (as documented in the court files). Their conclusion simply is completely speculative and, as such, unacceptable.

How Does the Neuroscientific Logic Work?

According to the reasoning by the neuroscience consultants, different pieces of evidence ought to be put together in order to explain crime-related behaviors. In other words, the explanation of crime-related behavior should always be supported by proofs, according to the principle of convergence of pieces of evidence. In the paper we are commenting upon, the authors provided two perfect examples of food for thoughts.

In the first place, the authors wrote: "*According to the prosecutors, the tumor do not press the orbitofrontal area, which is in front of the tumor's area: the chordoma presses the pons, the medioinferior part of the brainstem with the pituitary gland*" [18]. The tumor was growing downward according to the judge's experts, while it was growing upward according to the consultants for the defense. How can the judge decide who is right? The neuroscientific evidence runs in support of the defense claim. Indeed, the neuroradiological report (signed by an external, independent neuroradiologist) indicated that the tumor displaced the pituitary gland. Because the pituitary gland is above the tumor, claiming that the tumor pressed the brainstem (which was below the tumor) would mean denying this piece of evidence. Moreover, the claim of the judge's experts did not take into account the constellation of symptoms presented by the defendant, in particular diplopia and tunnel vision, which the judge's experts stated to be of hysterical origin. No explanation was provided in support of their conclusion, which, again, appeared to be completely unfounded. On the contrary, a rigorous and objective neuroscientific explanation for these symptoms is the compression of the optic chiasm. The optic chiasm is located above the tumor and just beneath the orbitofrontal cortex. Compression of the optic chiasm from below and in a medial to lateral direction was indeed consistent with both the observed neurological deficits and provided additional evidence that the tumor was growing upward.

However, the judge's experts rebutted that diplopia and tunnel vision were symptoms with no legal relevance: "*The prosecution's experts agreed with the defense's experts that the tumor had psychiatric consequences, like spastic crying, but they added that such consequences are not legally relevant for the case in question*" [18]. The consultants for the defense were perfectly aware that spastic crying, as well as diplopia and tunnel vision, per se were not legally relevant elements. However, these not legally relevant symptoms could not be ignored, as they were objective indications of a functional lesion in specific brain regions. According to the consultant logic, the presence of symptoms or signs, though not legally relevant, is of outstanding importance in order to understand the nature of symptoms and signs that are legally relevant. In this specific case, diplopia and tunnel vision were pivotal to corroborate the idea that the tumor was compressing the optic chiasm, whose position is just above the tumor and adjacent to the so called "retro-chiasmatic nucleus" of the hypothalamus, known to be responsible for sexual orientation [36]. Thus, the tumor was compressing the brain by expanding upwards. For the same reason, pathological crying, childish behavior, obsessive-compulsive behavior, symptoms that per se are not legally relevant, indeed all provided a strong indication of a pathological involvement of frontal cortical areas. The close correspondence between not legally relevant (i.e., childish behavior, spastic crying) and legally relevant (i.e., deficit in moral attribution) symptoms supported the frontal lobe dysfunction through the "convergence of evidence" principle, and thus corroborated the neurological origin of all the observed deficits (For illustrative purpose, please refer to Fig. 1). Thus, the legally irrelevant symptoms were important to understand the causal link between the brain tumor and the constellation of symptoms, among which was pedophilic behavior. Ignoring these symptoms because they are not legally relevant is a true mistake from a logical as well as a clinical perspective.

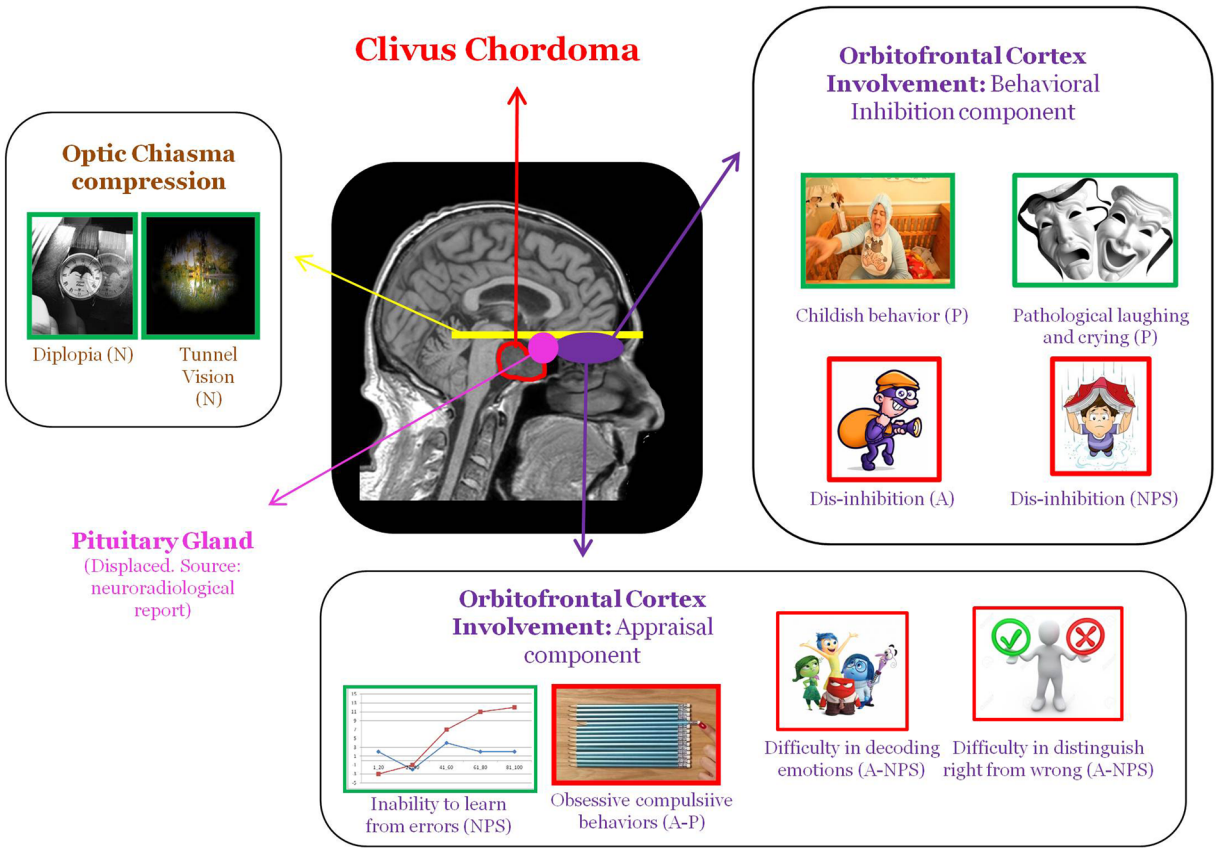

Fig. 1 The Figure summarizes the neurological and neuropsychological findings and illustrates their anatomical substrates. Legally irrelevant symptoms are framed in green, legally relevant symptoms in red. In brackets is indicated how symptoms were detected: N = Neurological examination; P = Psychiatric examination; A = Anamnesis; NPS = Neuropsychological examination. The image illustrating dis-inhibition (NPS) refers to the Hayling test, in which the patient has to complete incomplete sentences with words not related to that sentence. For instance, in the phrase "I'm covering from the rain with the ….", the patient was required to inhibit the predominant answer "umbrella" and produce a non related answer, for instance "book". The image related to the inability to learn from errors (NPS) depicts the defendant performance (blue line) at the Iowa Gambling Test in comparison to the performance in the control group (red line). The performance of the defendant on this task is strikingly similar to the performance of patients with ventromedial prefrontal cortex lesions [37]. All the remaining symptoms depicting images are self-explanatory

How may Classic Psychiatric/Neurologic Examination and the Neuroscientific Approach Work Side by Side?

Another issue we believe forensic psychiatrists are worried about is the presumed impossibility of psychiatry and neuroscience to work side by side, as if they were mutually exclusive. Indeed, some scientists are proposing that psychiatry will eventually be replaced by neuroscientific evidence [20, 21]. Here, we would like to expose our point of view. According with our idea, the ultimate aim of scientists (psychiatrists, neuroscientists, molecular biologists, psychologists, etc.) should be to integrate data derived from different disciplines (in this specific case: to integrate the data derived from neuroscience with knowledge from classical psychiatric/neurologic evaluations) in order to decrease the risk of committing errors in such a delicate area, as indeed it is the assessment of insanity in forensic settings. Neuroscience may provide cognitive models that are pivotal to interpret a disorder. For example, relevant for the case we are discussing here, the neurophenomenological model of sexual arousal [38] states that sexual arousal is created by three cognitive components (motor imagery, appraisal and attention), which are in turn influenced by the ability to inhibit an impulse, by motivation, by an emotional component and an autonomic and endocrine component. Critically, the model also states

that orbitofrontal cortex integrity is necessary for the ability to inhibit an impulse, while the hypothalamus is involved in regulating sexual orientation.

We strongly believe that suffering from a psychiatric/neurologic disorder per se is not sufficient to determine diminished culpability, since incompetency or diminished responsibility should be considered only if a strong evidence indicates a causal link between a pathological mental state and a given criminal behavior. We believe that psychiatric, neurological and neuropsychological evaluations are fundamental to establish the presence or absence of a pathological mental state, while neuroscience may be a potent tool to understand the causal link between a pathological mental state and a criminal behavior. In this specific case, we described a burden of clinical symptoms that explains the pedophilic behavior. This constellation of symptoms can be interpreted according to the INUS (Insufficient but Non-redundant parts of Unnecessary but Sufficient conditions) concept [39], as none of these symptoms, by itself alone, could account for the defendant pedophilic behavior, but all together they are able to explain the emerging paraphilic behavior. For instance, abnormal sexual interest in children, alone, could not be considered sufficient to cause pedophilic behavior, because in this case the patient would have been able to inhibit his urges. Similarly, the disinhibition, alone, could not be considered sufficient to cause the pedophilic behavior, because in this case not necessarily the patient would have been attracted by children. However, if an altered sexual orientation is coupled with an impairment in control of impulsive behavior and in understanding other's emotions, it may suffice in giving rise to this specific criminal behavior. This concept is illustrated in Fig. 2. Furthermore, we found a link between the altered state of mind and the brain tumor (i.e., the hypothalamus alteration was responsible for the altered sexual orientation and the orbitofrontal cortex alteration was responsible for the deficits in the moral reasoning and in impulse inhibition), an explanation that is completely in line with the neurophenomenological model of sexual arousal [19, 38].

Farisco and Petrini question both the altered state of mind of the defendant and the influence of the tumor on the altered state of mind [18].

First, they deny the presence of an altered state of mind in the defendant: "*they (the prosecution experts) concluded that it is not possible to affirm that the defendant had a totally or partially compromised ability to understand the nature of the acts for which he is accused*" [18]. Sustaining this thesis is in contrast with the results of the neuropsychological evaluation, which, among others, showed deficits also in moral reasoning and emotional attribution (see [19]), as well as with anamnestic data and the events themselves. For example, the defendant had an altered perception of risk, as indicated by the fact that he enacted overt pedophilic behavior in his office with a fully open door; in at least one episode, he showed a clearly ambiguous behavior with a patient in front of her mother [19]. This latter episode indicates also that he was completely unaware of the moral disvalue of his behavior as well as of its potential consequences. Finally, he also was unable to inhibit impulses, as emerged from his wife's depositions (for instance, he would steal postcards from exhibitors in museum shops) [19].

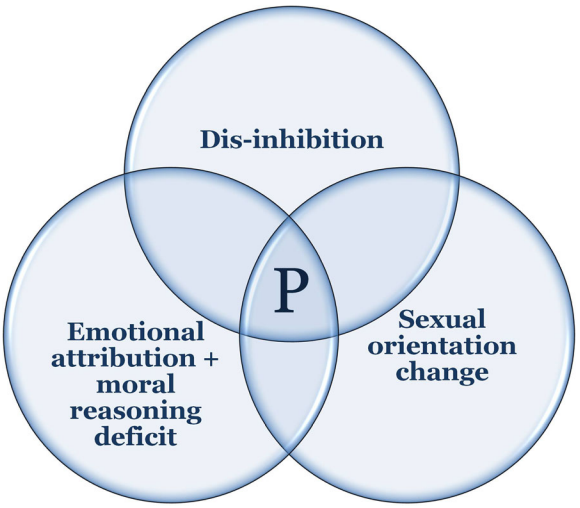

Fig. 2 The Figure illustrates the concept of INUS cause [35]: the pedophilic behavior (indicated as P in the image) emerged, in this individual, as a consequence of a combination of impaired functions, including dis-inhibition, deficits in emotional attribution and moral reasoning and changes in sexual orientation

Second, the authors deny any role of the tumor in causing deficits in moral reasoning: "*The experts appointed by the prosecution added that the chordoma can cause an altered perception of risk, but neither the absence nor the diminishment of the capability to perceive the negative value of the actions can emerge from such tumor*" [18]. This thesis again is in sharp contrast with the results of the neuropsychological evaluation as well as with the *resitutio ad integrum* that followed the surgical resection of the tumor. In the original paper describing this case [19], we reported the results of the

neuropsychological evaluation before and after tumor resection. After neurosurgery, all the symptomatology receded: diplopia, tunnel vision and deficits in moral reasoning, in emotional attribution, in impulse inhibition. Importantly, both pedophilic impulses and behavior receded as well and became highly criticized by the defendant.

Does the Rarity of a Disease Impact on the Causal Relationship between the Disease and the Crime?

In the paper we are commenting upon [18], the authors further question the causal relationship between pathology (i.e., the tumor) and behavior (i.e., pedophilia), because of the rarity of reports of acquired pedophilia in the literature: "*To date, the correlation between some organic pathologies and pedophilia has been shown in a very limited number of cases, so that such correlation can be assumed as an experimental hypothesis which is not unanimously accepted by the scientific community* "[18].

To consider the rarity of a disease as a relevant piece of information to determine the causal link between the disease and the crime is a logical bias, called "appeal to improbability" fallacy. The appeal to improbability is the logical fallacy of taking something as false merely because it is improbable.

Here it is crucial to clarify the distinction between a priori and a posteriori probability. In the present case, an a priori probability would have required an answer to the following question: How likely is that the defendant pedophilia may be due to a *clivus chordoma*? In the a priori probability it is still unknown that the defendant has a *clivus chordoma*. Of course, in this case the probability is extremely low, since *clivus chordoma* itself is a very rare tumor and a case of pedophilia as a symptom of chordoma had never been reported in the literature before the present one. Quite different is the a posteriori probability reasoning, which would have required an answer to the following question: given that the defendant has a *clivus chordoma* and that this tumor affects certain regions of the brain (including structures crucial for modulation of behavior and sexual drive), how likely is that the pedophilia insurgence may be due to the presence of the *clivus chordoma*? In this case, a causal relationship between the tumor and the pedophilia cannot be simply dismissed just because in general the occurrence of a *clivus chordoma* is a rare event. Of course, a causal relationship still remains to be proven. In the forensic setting, every case should be considered on its own, since in every case the causal link between a given disease and a crime may be different, and then it ought to be proven. In the current case, a variety of data supported a causal relationship between the *clivus chordoma* presence and the pedophilic insurgence: the close correspondence between legally relevant and legally irrelevant symptoms suggestive of frontal lobe dysfunction as well as the *restitutio ad integrum* that followed the surgical removal of the tumor. Indeed, all the neurological, psychiatric and neuropsychological deficits, including pedophilia, receded when the tumor was removed. Furthermore, it is also worth noting that the rarity of this specific disease, namely pedophilia induced by a *clivus chordoma*, implies that the causal relationship between the tumor and the behavior is not obvious, thus reducing the likelihood that the defendant could use the presence of the tumor (of which he was completely unaware until a few months after his arrest) as a defense strategy.

In the paper [18] the authors seem to deny the existence of acquired pedophilia, as the judge's experts did in their report as well. In contrast, the diagnosis of acquired pedophilia is well accepted by the scientific community. Indeed, a number of cases of acquired pedophilia have been described so far (for a review please see [40] and [41]). In the scientific literature these cases are defined as changes in sexual orientation occurring as a consequence of neurological disorders. The changes in sexual orientation might be different, and also include shifts from heterosexual to homosexual (i.e., the seventh case described in [42]) orientation or viceversa [43]. As far as the cases of insurgence of pedophilic urges is concerned, these cases have been recently summarized in a review of the literature [40]: four cases occurred following a brain tumor; four cases with dementias; three cases with Parkinson's disease and twenty-seven cases with other neurological disorders (epilepsy, Huntington's disease, hippocampal sclerosis and post encephalitic parkinsonism). Additional two cases were subsequently published: a case of pedophilia occurring with a brain tumor [44] and another case following traumatic brain injury [45]. Among all these cases, in their report the defense consultants focused their attention particularly on one case [46], due to the striking similarity between the published case and the current one. Indeed, in both cases, pedophilia emerged later in life (40 and 64 years, respectively), in both cases the defendants denied previous attraction to children, in both cases the tumor was discovered during the legal

process and, finally, in both cases the tumor resection was followed by a complete resolution of the symptoms. This case [46] has been also included in the Royal Society 2011 report (https://royalsociety.org/~/media/Royal_Society_Content/policy/projects/brain-waves/Brain-Waves-4.pdf), which was written and approved by experts from both the neuroscientific and legal communities, as an example of the possible role of neuroscience in court. Furthermore, the legal responsibility of individuals who manifest pedophilia as a consequence of a given brain disease has already been questioned [47].

Do Neuro-Scientific Data Need to Be Interpreted?

The last concern expressed by Farisco and Petrini is that neuroscientific data need to be interpreted by experts: "*The instrumental findings is neither self-evident nor self-explanatory data, but it needs to be interpreted by experts*" [18].

We agree with the authors that neuroscientific evidence must always be interpreted. Indeed, statistically significant differences in neuroanatomy, for example, may reflect either some brain pathology or an individual, clinically irrelevant, variation in neuroanatomy as well [48]. For instance, one could expect to find a greater neuronal density in the cortical motor regions of musicians as compared to the motor regions in a control group [49]. This neuroanatomical abnormality would reflect the higher abilities of musicians to control their own hand movements. However, a greater neuronal density in the same region is also observed in individuals with Attention Deficit Hyperactivity Disorder (ADHD, [50]) or with functional neurological symptom disorder (i.e., the presence of neurological symptoms not explained by a neurological disorder, [51]). In all these cases, a greater neuronal density in the cortical motor regions would not reflect an individual difference but rather a sign of some pathological process. Thus, neuroscientific results do not have a unique interpretation, as they assume a clear meaning only when coupled with behavioral/psychiatric findings and a comprehensive anamnesis. This is true for psychiatry as well as for general medicine. In psychiatry, for example, mood deflection can be a sign of asthenia or depression depending on the constellation of surrounding symptoms. Indeed, this is exactly one of the main reasons why psychiatric diagnoses show a low inter-rater reliability [26, 27]. Similarly, in general medicine, a low iron plasma level can be observed in vegetarian healthy individuals or during pregnancy, but it could also be a symptom, for instance, of colon rectal cancer or anemia [37]. The correct diagnosis can be achieved only by interpreting the datum within the clinical context.

Every discipline interprets criminal behavior using its own tools and expertise. In this specific case, the same behavior (i.e., sudden onset of pedophilia) was interpreted as an expression of sexual decline by the judge-appointed forensic psychiatrists or as a consequence of the tumor compression on the hypothalamus and orbitofrontal cortex by the defense consultants (a psychiatrist and a psychologist). Furthermore, the same neurological symptoms (i.e., diplopia and tunnel vision) were considered to be an expression of hysteria by the forensic psychiatrists and as a consequence of the tumor compression on the optic chiasm by the defense consultants.

What is the difference between the two conclusions? Simply, the first one is completely speculative, is not supported by any evidence and is in contrast with the lack of any history of mental condition in the defendant, while the second one is consistent with neuroanatomical findings and with the neurophenomenological model of sexual arousal [38] and it is further proven by the full *restitutio ad integrum* after the resection of the tumor [19], a piece of evidence that should not be neglected.

Discussion

In Italy, over the last decade the role of neuroscience in court has become more and more a matter of intense debate. Despite some neuroscientists, psychiatrists, psychologists, law experts are trying to promote cooperation and integration between classical forensic psychiatry and modern neuroscience [1, 7], the introduction of neuroscientific methods into the forensic setting in Italy is often criticized and thwarted, as clearly shown by the paper we are commenting upon [18].

Slightly different is the U.S. scenery, where the usefulness of neuroscientific methods in court is a highly debated topic, without drastically affecting their actual use. Indeed, according to the 2011 Royal Society report on neuroscience and law (https://royalsociety.org/~/media/Royal_Society_Content/policy/projects/brain-waves/Brain-Waves-4.pdf), neuroscientific evidence (mainly genetic and neurological) has been used in 449 cases of murder,

147 cases of assault, 91 cases of homicide, 88 cases of kidnapping, and so on (please refer to page 19 of the report). The number of cases in which neuroscience has been used has risen steadily over the past decade. Nearly 1600 judicial opinions issued in U.S. courts between 2005 and 2012 include some neurobiological evidence, such as pictures of a person's brain structure, its level of functioning, or the presence of abnormalities [52]. Given that judges are required to take important decisions based on objective pieces of evidence, in a U.S. sentence of 2009 (2009 WL 424583 United States District Court, D. Hawai'i. United States of America, Plaintiff, vs. Naeem J. Williams, Defendant. N0. CR 06 –00079 DAE-KSC, Feb 20, 2009), the judge wrote: "*the Government does contend, however, that Dr. X (the name of the consultant has been removed in this paper) failed to conduct crucial tests that have a significant impact on the reliability of her overall methodology. (…) The Government now asserts that Dr. X methodology remains inadequate and unreliable as a result of her failure to support her opinions with results from functional MRI*".

We strongly believe that the utilization of neuroscience in court is so controversial in Italy because there are concerns that neuroscience may be strictly reductionist and may point to replace clinical psychiatry *tout-court*. These concerns arise from miscommunication and misinterpretation of the potential complementary role of neuroscience. The aspects discussed in the present paper clearly indicate that the aim of neuroscience should be to run side by side with classical forensic psychiatry, as the core of the insanity evaluation is and will always be the psychiatric assessment [8]. We explained that neuroscientific methods should be applied in forensic settings only to provide additional and supporting evidence, useful to reduce controversies and to understand more deeply the crimino-genetic and crimino-dynamic aspects of an act. As we have already stated elsewhere [8], neuroscientific data may be able to inform forensic assessment only when used in combination with standardized clinical measures, using the principle of convergence of evidence. We claimed that decisions to fully or partially excuse an individual (according to the Italian penal code, art. 88, 89) should take into account all the relevant pieces of information, including both neurobiological and environmental data, and should proceed on a careful case-by-case analysis before sentencing or offering treatment [47]. Indeed, we are aware that the use of neuroscience alone may be extremely dangerous. A typical mistake that one might end up with when using neuroscientific information in isolation from the clinical, environmental, psychiatric and behavioral data is the one depicted in the Vincent Gigante case, described in the introduction [11]: by relying only on imaging data, without taking the clinical picture into consideration, one may end up with a wrong diagnosis, with deleterious consequences both for therapeutic and forensic decisions.

The specific case discussed here also shows how the critiques of the utilization of neuroscientific methods were unfounded and not based on scientifically acceptable data. Indeed, two diametrically opposed conclusions were reached by the experts. On the one hand, the consultants for the defense demonstrated the presence of an impaired mind in the defendant (characterized by deficits in moral reasoning, emotional attribution, impulse inhibition, etc.), both using the classical psychiatric/neurologic evaluation and a neuropsychological assessment. Furthermore, because of the findings that emerged from clinical and neuropsychological examinations, they requested a brain structural MRI scan that revealed the presence of a tumor inside the skull that compressed and dislocated structures within the defendant's brain that were crucial for modulation of behavior and sexual drive. On the other hand, the judge's consultants concluded that the defendant should be considered responsible for his actions since, according to them, he deliberately adopted a pedophilic behavior in order to revitalize his sexual life that was declining due to senescence; furthermore, they interpreted the other findings (including tunnel vision) as of hysterical origin.

The neuroscientific evaluation contributed to disentangle this controversy: the whole constellation of symptoms, both legally relevant and not, can be explained in light of the size and location of the tumor, providing support to the defense conclusion. As a more general consideration, we ought to emphasize that the burden of symptoms per se does not necessarily imply a causal link between a given brain state and the criminal behavior, but rather between an impaired mind and the criminal behavior. In this specific case, however, the defendant's impaired mental state is indeed the result of an impaired brain. On the contrary, the judge's consultants came to their conclusion by not taking into adequate consideration the results of the neuropsychological tests, by ignoring the legally irrelevant symptoms (i.e., diplopia, tunnel vision, spastic crying, subtle personality and behavioral changes), ignoring the

conclusions drawn by the neuroradiologist and those from the neurological examination, denying the existence of acquired pedophilia, criticizing neuroscientists for reasoning backward and, above all, by ignoring the resolution of symptoms after the surgical resection of the tumor. Of note, the *restitutio ad integrum* after the tumor resection demonstrated unequivocally the causal link between the brain tumor and the complex symptomatology presented by the patient [19].

As a final point, the thesis of the defense has been subjected to the scrutiny of the scientific community and was published in a scientific peer-review international journal [19].

It is also worth to clarify that providing a biological explanation for an altered state of mind does not mean to believe in biological determinism. We do not deny the influence of cultural, educational, social and environmental factors, but we emphasize that the influence of these factors on behavior is constrained by specific biological structures within which they have to act. For instance, children born with mental retardation will never reach a normal intelligence level, even if they live in a high socio-cultural environment, because their biological substrate (i.e., their brain) would not allow for it. In the same way, in this specific case, one could not expect from the defendant the ability to exert inhibition over his sexual urges, because a biological constrain prevented his brain from properly functioning, leading to an alteration in mental status, regardless of his moral convictions.

Conclusions

The role of neuroscience in court is currently a topic of intense debate among specialists from different disciplines. We believe that the potential contribution of neuroscience in the forensic context to date has not been portrayed in the right perspective, as in many instances criticisms have been based on wrong premises and on misleading reports, as in the case discussed here [18, 53]. Overall, we believe that neuroscientific evidence should not be used in court in the attempt to establish a mere deterministic relationship between a given abnormality in brain structure or function and a given behavior. Therefore, the utilization of neuroscientific evidence is not finalized to change the rationale underlying the determination of criminal liability [1, 8, 34] nor challenge the traditional notion of responsibility, but rather to provide a solid and objective complementary contribution to the classical psychiatric assessment that, within the forensic context, suffers from many limitations. In this regards, we are aware that neuroscientific methods and findings are subjected to their own limitations as well [8, 48].

Thus, we think that the integration between of the two approaches may be a first step forward to overcome these shortcomings. Indeed, neuroscience can provide supporting and convergent information that, along with the psychiatric assessment, may strengthen the results of forensic psychiatric evaluations, thus reducing uncertainty in the forensic settings [8].

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