Neuroscience in Criminal Law

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An Overestimated Source of Evidence

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LIST OF ABBREVIATIONS AND ACRONYMS

ABCA: Alberta Court of Appeal
ABPC: Provincial Court of Alberta
ABQB: Court of Queen's Bench of Alberta
CASHRA: Canadian Association of Statutory Human Rights Agencies
AUC: Area Under the Curve
BCCA: British Columbia Court of Appeal
BCPC: Provincial Court of British Columbia
BCSC: Supreme Court of British Columbia
OCI: Office of the Correctional Investigator
BOLD: Blood-oxygen-level dependent
CA: Court of Appeal
CIUSSS: Centre intégré universitaire de santé et de services sociaux
CMR: Regional Municipal Court
C.S.C.: Supreme Court of Canada
Ct-Scan: Computed tomography
DACOR: Correctional administrative records
DPFC: Dorsal prefrontal cortex
DSM-5: Diagnostic and Statistical Manual of Mental Disorders (5th edition)
ECT: Electroconvulsive therapy
EEG: Electroencephalogram
GABA: Gamma-aminobutyric acid
GWAS: Genome-wide association study
HPA: hypothalamic-pituitary-adrenal
INSPQ: INSTITUT national de santé publique du Québec
MRI: Medical resonance imaging
LSPJA: Youth Criminal Justice Act
MMPI: Minnesota Multiphasic Personality Inventory
MPD: Default mode
MSSS: Quebec Ministry of Health and Social Services
NFCA: Newfoundland and Labrador court of appeal
NIMH: National Institute of Mental Health
NIRS: Near Infrared Spectroscopic Imaging
NLTD: Newfoundland and Labrador
NSPC: Provincial Court of Nova Scotia
NSSC: Nova Scotia Securities Commission

NSWSC: New South Wales Supreme Court (Australia)
NUCJ: Nunavut Court of Justice
ONCA: Ontario Court of Appeal
ONSC: Ontario Superior Court
ONCJ: Ontario Court of Justice
PCL-R: Psychopathy Checklist-Revised
FEP: First Episode Psychosis
PESCTD: Supreme Court of Prince Edward Island
PET scan: Positron emission tomography
QB: Queen's Bench
QCCA: Quebec Court of Appeal
QCCQ: Quebec Court/Cour du Québec
QCCS: Québec Superior Court
QCTAQ: Tribunal administratif du Québec
QEEG: Quantitative electroencephalography
IQ: Intelligence quotient
RAMQ: Régie de l'assurance maladie du Québec
RNR: Risk-Need-Responsiveness
R.C.S.: Supreme Court of Canada Reports
rCBF: Regional cerebral blood flow
RDoC: Research domaine criteria
RMN: Nuclear Magnetic Resonance
SASC: Supreme Court of South Australia
SBS: Shaken baby syndrome
DBS: Deep brain stimulation
SKCA: Saskatchewan Court of Appeal
SKQB: Court of Queen's Bench for Saskatchewan
SKPC: Provincial Court of Saskatchewan
SPECT: Single-photon emission
TAQ: Tribunal administratif du Québec
SAD: Social anxiety disorder
ADHD: Attention deficit disorder with or without hyperactivity
PET**:** Positron emission tomography
OCD: Obsessive-compulsive disorder
FASD: Fetal Alcohol Spectrum Disorder
PTSD: Post-traumatic stress disorder
VBM: Voxel-based morphometry
VPFC: Ventral prefrontal cortex
VRAG: Violence risk appraisal guide

GENERAL INTRODUCTION

The alliance between science and law has always been rich in mutual benefits. At the dawn of the last century, criminal law professor and lawyer René Garraud traced the practice of judicial expertise to the advent of the French magistracy: "Once there were judges, they needed men more competent than themselves to enlighten their consciences"[1]. In its 2012 annual report on evidence, the Cour de cassation (French Supreme Court) notes that expertise has been routinely used in civil and criminal proceedings since the 'Ancien Régime'"[2].

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[1] René Garraud, *Traité théorique et pratique d'instruction criminelle et de procédure pénale*, vol 1 (Paris: Sirey, 1907) at 597.

[2] France, *Cour de cassation*, *Rapport annuel 2012. La preuve dans la jurisprudence de la Cour de cassation*, Book 3 "Étude – La preuve" (Paris: La Documentation française, 2013) at 293, online:
<www.courdecassation.fr/IMG/pdf/rapport_ccassation_2012.pdf>
(accessed 5 September 2021).
This report notably references the *Ordonnance criminelle* of 1670, one of the earliest French criminal procedure codes, enacted under the reign of Louis XIV and registered by the *Parlement de Paris*. Best known for its infamous *lettres de cachet*, which, when signed by the sovereign, authorized the imprisonment of dissenters "until further notice," the ordinance also provided that injured persons could be visited by physicians and surgeons who would issue a report on their condition. A second medical examination could also be ordered by the judge. Furthermore, an accused person unable to "appear in court due to illness or injury" was required to provide an attestation including "a report from a physician belonging to an approved faculty, declaring the nature and symptoms of the illness or injury, and that the accused cannot travel without risk to life, with the truth of the report to be sworn to by the physician before the local judge, who shall draw up an official record." See also: *Ordonnance criminelle* of August 1670, issued at Saint-Germain-en-Laye, registered by the *Parlement de Paris* on 26 August 1670, entered into force on 1 January 1671. Notable excerpts from the preparatory conferences—presided over by Chancellor Séguier and based on the report by State Councillor Pussort—are available online:
https://ledroitcriminel.fr/la_legislation_criminelle/anciens_textes/ordonnance_criminelle_de_1670.htm (accessed 5 September 2021).

Forensic medicine, in particular, has "refined knowledge of the right to punish"[3] in the sense of sanctions that would not reproduce the irreversible nature of the crimes committed. The exercise of sentencing involves complex issues and perilous consequences; the judge must rely on a structured methodological framework, and consider a host of factors including, among others, the criminal profile, the mechanism of the passing of the act, the criminal's state of consciousness and the phenomenon of delinquency in the broadest sense.

Since the "decade of the brain", in the words of U.S. President G. Bush Sr. in the early 1990s[4], there has been no denying the importance of neuroscience research in understanding, treating and preventing nervous system pathologies. Whether it's measuring metabolic changes in the brain during behavioral tasks, mapping brain function using nuclear magnetic resonance (NMR), harnessing brain plasticity for continuous (neuronal) learning, or stimulating specific neurons with extreme precision[5], sophisticated neuroimaging and electrophysiology techniques are at work, and continually refining their power. In short, neuroscience is progressing towards an ever finer and, above all, more functional understanding of the human brain, even in real time - for example, during a sleepwalking[6] or hypnosis sequence[7], while uttering false statements[8], or even during the process of a criminal or even judicial decision[9].

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[3] Michel Porret, "La médecine légale entre doctrines et pratiques" (2010) 1:22 *Revue d'histoire des sciences humaines* 3.

[4] United States, *Library of Congress*, *Decade of the Brain: Presidential Proclamation 6158*, online: <www.loc.gov/loc/brain/proclaim.html> (accessed 5 September 2021).

[5] Serge N. Schiffmann, "Deux décennies de recherche en neuroscience : avancées et perspectives" (2013) 40:1 *Cahiers de psychologie clinique* 71, DOI: https://doi.org/10.3917/cpc.040.0071

[6] Invoked successfully as a defence (non-mental disorder automatism) to a charge of first-degree murder and attempted murder in *R v Parks*, [1992] 2 SCR 871.

[7] On the admissibility/reliability of post-hypnotic testimony, see *R v Trochym*, 2007 SCC 6, [2007] 1 SCR 239.

[8] Daniel D. Langleben et al, "Polygraphy and Functional Magnetic Resonance Imaging in Lie Detection" (2016) 77:10 *Journal of Clinical Psychiatry* 1372, DOI: https://doi.org/10.4088/JCP.15m09785.

[9] Anne Marchais-Roubelat, "Ontologie de la décision individuelle et neurosciences : enjeux méthodologiques et épistémologiques" (2011) 43:3 *Management & Avenir* 269, DOI: https://doi.org/10.3917/mav.043.0269

1. The contribution of neuroscience to criminal trials: An overview

The enthusiasm generated by the application of neuroscience to the law (neurolaw) extends the age-old alliance between science and law. The prodigious scientific advances in this vast field are shedding new light on, for example, hitherto unexplored aspects of how a criminal's brain works. Researchers have drawn up a quantitative portrait of the use of neuroscience in criminal proceedings in the USA, the UK (England & Wales), Canada, the Netherlands, Australia and in homicide trials in Slovenia.

1.1 United States

In the United States, neuroscientific expertise is increasingly used by criminally accused persons, to the point of creating the popular belief "*that neuroscience has become a mainstay of the US criminel justice system*"[10]. According to researcher Nita A. Farahany, the outcome of hundreds of American criminal cases over the past decade[11], has been influenced by neurobiological data. More than 1,585 court decisions published between 2005 and 2012 refer to neurobiological evidence used by defendants to support their defense in U.S. courts, both federal and state. For the purposes of Farahany's study, neuroscientific-type evidence was defined as including both medical history of brain injury and neuropsychological testing (e.g. interviews, assessment questionnaires) as well as imaging techniques per se, including PET scan, EEG, QEEG, fMRI, CT scan, MEG and near-infrared spectroscopic imaging (NIRS). Neuroscientific evidence focusing on the condition of victims was excluded from this sample. Hovering between 100 and 300 opinions per year, the number of opinions shows an upward trend, peaking in 2010 and 2011, before falling back to 250 opinions in 2012. A significant proportion of the cases counted concern homicide charges punishable by death, closely followed by other homicides and other serious crimes (other felonies), the proportion of which varies from year to year. Drug offences, assaults, sexual assault, theft and burglary are among the non-homicide crimes for which neuroscientific evidence concerning the accused was mentioned in judicial opinions. The existence of brain imaging was discussed in only 15% of cases. MRI (24%), CT scan (23%), PET (18%) and EEG (18%) were among the most commonly used imaging

[10] Nita A. Farahany, "Neuroscience and Behavioral Genetics in US Criminal Law: An Empirical Analysis" (2015) 2:3 *Journal of Law & the Biosciences* 485, DOI: https://doi.org/10.1093/jlb/lsv059

[11] *Ibid*.

techniques. fMRI was mentioned in only 2% of the 15%, and was not admitted as evidence in any of the cases studied. Neuroscientific evidence was most often invoked to mitigate the sentence (44%) - almost half of which concerned allegations of prosecutorial incompetence, questioning the defendants' fitness to stand trial (15%) or demonstrating the absence of *mens rea* (10%). Very few were in support of a defense of mental disorder or automatism (4%). In 20% to 30% of all cases where at least one piece of neuroscientific evidence was discussed, the defendants' appeals were allowed in part. Comparing her data with official statistics, Ms. Farahany notes that this success rate appears to be higher than that of all criminal cases appealed in 2010 (12%)[12]. In 2012, over 250 judicial opinions mentioned defendants claiming that "their brains compelled them to commit the irreparable". This was double the number in 2007. Nearly 5% of murder trials and a quarter (25%) of death penalty hearings involve defendants pleading for a lesser charge, mitigated responsibility or a lighter sentence, citing neurobiological data.

1.2 United Kingdom

Mirroring Ms. Farahany's (2015) study, Paul Catley and Lisa Claydon (2015)[13] traced, over the same period (2005 to 2012), a total of 204 cases published in UK criminal annals that reported the use of neuroscience-type evidence by defendants. This order of magnitude corresponds to approximately 0.80% of all published appeal decisions. In fact, only decisions handed down on appeal are published in England and Wales, which would explain the significant discrepancy between the number of cases recorded in the UK (204 decisions in total) and Ms. Farahany's figures (between 100 and 300 judicial opinions per year). Like Ms. Farahany's data, the increase in the number of cases reported in the UK appears to have peaked in 2010, with a total of 45 cases reported that year. Neuroscientific evidence was produced primarily to support an appeal against sentence (45.1%), or an appeal against conviction (29.9%), or both (9.8%). The remainder was split between opposing an extradition request (5.4%) and defending the Crown's appeal on the grounds that the sentence imposed at first instance was too lenient (3.9%). Neuroscientific expertise may have

[12] Citing Nicole L. Waters et al, "Criminal Appeals in State Courts", *Bureau of Justice Statistics Bulletin* 1 (2015), online: https://www.bjs.gov/content/pub/pdf/casc.pdf (accessed 5 September 2021).

[13] Paul Catley & Lisa Claydon, "The Use of Neuroscientific Evidence in the Courtroom by Those Accused of Criminal Offenses in England and Wales" (2015) 2:3 *Journal of Law & the Biosciences* 510, DOI: https://doi.org/10.1093/jlb/lsv025

been used to quash convictions, declare a lesser degree of guilt in respect of an offence, reduce a sentence on the basis of a mitigating circumstance, challenge bail conditions, encourage Crown appeals to vary excessively lenient sentences, or even to reject extradition requests. The issues in dispute that require such neuroscientific insight concern the causes of death or injury, the credibility of witnesses, the fitness to plead of convicted persons and the absence of *mens rea*. Interestingly, Catley and Lisa Claydon's (2015) study notes that neuroscientific evidence was primarily used by the prosecution to establish cause of injury and death. No reported cases involved a mental disorder defense.

As for the outcome of appeals, most conviction appeals are dismissed (70.2%), as are more than half of sentencing appeals (52.6%). That said, Catley and Claydon note that nearly 26.2% of successful conviction appeals could be attributed primarily to neuroscientific evidence. As for successful sentence appeals, nearly 6.1% could be attributed primarily to neuroscientific evidence, while 18.4% were allowed for a variety of reasons, including the existence of neuroscientific evidence. Like the data reported by Ms Farahany (2015), the use of imaging techniques in the UK is also relatively infrequent (49 cases out of 204): As reported in appeal decisions, no functional MRI appears to have yet been introduced into evidence in a criminal trial; mostly mentioned is the use of MRI (21) and CT scan (17), in addition to six (6) cases of EEG, one (1) case of SPECT scan as well as four (4) cases of unspecified brain imaging.

1.3 Canada

From 2008 to 2012, Professor Jennifer A. Chandler[14] identified 279 court decisions involving neuroscientific evidence in the "All Canadian Court Cases" database of the LexisNexis Quicklaw service. In 146 of these cases, the neuroscientific evidence was commented on or briefly mentioned, without affecting the outcome of the case. In the remaining 133 cases, the neuroscientific evidence most often related to prenatal alcohol exposure (including Fetal Alcohol Spectrum Disorder or FASD), head injury or neuropsychological testing to assess certain cognitive defects caused by some brain injuries. Most decisions were made at the stage of determining the appropriate sentence, or whether or not to designate an accused as a

[14] Jennifer A. Chandler, Neil Harrel & Tijana Potkonjak, "Neurolaw Today – A Systematic Review of the Recent Law and Neuroscience Literature" (2019) 65 *International Journal of Law & Psychiatry* 101341, DOI: https://doi.org/10.1016/j.ijlp.2018.04.002.

"dangerous offender", or a "long-term offender». This predominance of the use of neuroscience is not surprising, given that mental incapacity is a relevant argument in sentencing, and that the science offers a wider range of research objectives than simply the moral stance of the accused at the conviction trial. For, in addition to assessing the offender's moral culpability, societal considerations such as rehabilitation, deterrence and public protection can benefit from neuroscientific insight. Only a small number of decisions (n = 11) invoked neuroscientific evidence relating to the neurological origin of brain damage or cognitive dysfunction to justify not holding offenders criminally responsible.

1.4 Netherlands

In the Netherlands, Kogel and Westgeest (2015)[15] In the Netherlands, Kogel and Westgeest (2015) identified a total of 231 decisions, published in the twelve (12) year period following the creation of the *Rechtspraak.nl* legal database, that mentioned the existence of neuroscientific or behavioral genetic information produced by the defense in criminal trials. The trend is growing from just a few decisions a year to 57 decisions in 2012. Neuroscientific information includes brain imaging techniques (MRI, SPECT, PET) and EEGs, as well as neuroendocrine and neuropsychiatric assessments, including references to brain damage and neurobiological predispositions. The 231 decisions include 178 first-instance decisions, 45 Court of Appeal decisions and eight (8) rulings by the Dutch Supreme Court. Neuroscientific information has mainly been produced in connection with accusations of violent or sexual crimes, for which the defendants risk severe punishment. Neuroscientific evidence may have been invoked to support a defense of partial non-responsibility by reason of mental disorder (72), to refute the existence of *mens rea*, whether subjective intent, negligence or premeditation (36), or to assess the risk of recidivism (15). In the vast majority of cases, neuroscientific information has been introduced as a mitigating factor in sentencing.

[15] Catharina H. de Kogel & E.J.M.C. Westgeest, "Neuroscientific and Behavioral Genetic Information in Criminal Cases in the Netherlands" (2015) 2:3 *Journal of Law & the Biosciences* 580, DOI: https://doi.org/10.1093/jlb/lsv024.

1.5 Australia

Alimardani and Chin's (2019) study[16] of the use of neuroscientific evidence in Australia is more illustrative than quantitative. After reviewing over 779 criminal decisions reported in Australian legal databases and handed down by all levels of court, the researchers indicate five main fields of application for neuroscientific evidence: (1) when assessing defendants' fitness to stand trial, (2) in support of a defense of non-criminal responsibility by reason of mental disorder or diminished capacity to a murder charge, (3) to disprove the existence of *mens rea*, and as a (4) mitigating or (5) aggravating circumstance at the sentencing stage. Once again, a broad definition of neuroscientific evidence has been adopted, which includes both neuroimaging results and conventional neuropsychological tests.

1.6 Slovenia

Looking at homicide trials held in Slovenia between 1991 and 2015, Hafner (2019)[17] notes that neuroscience is discussed in roughly one-fifth (1/5) of the 495 cases from the country's eleven (11) district courts. Unlike the other studies presented above, which infer the existence of neuroscientific evidence from related keywords in judgment texts, Hafner obtained copies of all trial homicide files and considered as involving the existence of neuroscientific evidence all cases mentioning the existence of brain lesions, neurological disorders or dysfunctions, organic mental, personality or behavioral disorders. Mental or personality disorders not implying the existence of an organic cause, alcohol or drug dependency disorders, as well as offences allegedly committed under the influence of alcohol or psychoactive substances, were not retained for analysis. The application of these selection filters results in a total of 89 cases discussing neuroscience. Unlike what has been documented in the USA, the UK or the Netherlands, Hafner has not documented a significant increase in the use of neuroscientific evidence in homicide trials: the figures vary significantly from one year to the next, but the linear regression is marked by an almost horizontal line.

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[16] Armin Alimardani & Jason Chin, "Neurolaw in Australia: The Use of Neuroscience in Australian Criminal Proceedings" (2019) 12 *Neuroethics* 255, DOI: https://doi.org/10.1007/s12152-018-09395-z.

[17] Miha Hafner, "Judging Homicide Defendants by Their Brains: An Empirical Study on the Use of Neuroscience in Homicide Trials in Slovenia" (2019) 6:1 *Journal of Law & the Biosciences* 226, DOI: https://doi.org/10.1093/jlb/lsz006

Neuroscientific evidence most often consists of neuropsychological tests; much less frequent is the use of neuroimaging and electroencephalography (EEG). Head injuries (29%) and brain damage due to long-term excessive alcohol consumption (29%) are among the most discussed diagnoses, mainly in connection with a defense of non-criminal responsibility (11 cases) and substantially diminished capacity (49 cases), as well as at the sentencing stage (55 cases). At the latter stage, neuroscientific evidence was successfully invoked as a mitigating circumstance in 60% of cases, 19% of which were used to exceptionally justify a prison sentence of even less than the prescribed statutory minimum. Conversely, neuroscientific evidence does not appear to have ever been interpreted by the Court as an aggravating circumstance justifying the imposition of a longer prison sentence. That said, in almost 21% of cases, neuroscientific evidence has justified defendants' firm confinement to a hospital and compulsory psychiatric treatment on grounds of public safety.

This overview provides an instructive snapshot of the incursion of neuroscience into the criminal justice system. However, there are a number of issues that merit further analysis, particularly as regards the treatment of neuroscientific evidence by judges, juries and other decision-makers[18]. As in Chapter 1, we will pay particular attention to the impact of the introduction of neuroimaging techniques into evidence and their discussion by experts. This impact assessment will be based on the extent to which judicial decisions discuss the strengths and weaknesses of neuroimaging results. Neuropsychological tests will not be considered at this stage of our analysis.

***

These few statistical reminders[19] clearly illustrate the increasing openness of the courts to neuroscientific evidence, which is doubly effective since it informs both judges and juries. Before delving deeper into this crossroads between law and neuroscience, let's define what the term "neuroscience" encompasses (2), its possible intersections with Canadian criminal law (3) and the stages that have marked the advent of so-called rehabilitative justice (4).

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[18] John B. Meixner Jr., "The Use of Neuroscience Evidence in Criminal Proceedings" (2016) 3:2 *Journal of Law & the Biosciences* 330, DOI: https://doi.org/10.1093/jlb/lsw028.

[19] Jennifer A. Chandler, "The Use of Neuroscientific Evidence in Canadian Criminal Proceedings" (2015) 2:3 *Journal of Law & the Biosciences* 550, DOI: https://doi.org/10.1093/jlb/lsv026.

2. Neuroscience

The neurosciences are concerned with the study of the brain and nervous system, exploring their structure and function. They are able to detect brain lesions and dysfunctions, and thus understand their repercussions on behavior.[20]. In fact, a strictly observational approach to behavior assessment was unable to understand the neurological mechanisms underlying recidivism in certain offenders or in socially maladjusted individuals. The appeal of neuroscience is based on the premise that certain cognitive, perceptual, personality or behavioral dysfunctions derive directly or indirectly from structural or functional alterations in the brain, in addition to being determined by the individual's experiences and the environment in which he or she has evolved. This postulate is corroborated by behavioral changes observed in people with brain injuries, brain tumors and neurodegenerative diseases.

More than just the anatomical visualization of brain structures, anomalies and lesions, various functional exploration techniques (EEG, MEG, PET, MRI, fMRI) now enable us to observe a brain in action using physiological indices, i.e. to estimate in real time the activity of the nervous system, whether induced or spontaneous. Let's take a brief look at these different techniques.

Electroencephalography (EEG) measures cerebral electrical activity using electrodes placed on the skull. In each neuron of our brain, nerve impulses propagate along axons or nerve fibers when the electrical potential provoked by stimuli reaches a certain intensity called the threshold of excitation. The threshold of excitation is between 15 and 20 mV, while the

[20] David Freedman & Simona Zaami, "Neuroscience and Mental State Issues in Forensic Assessment" (2019) 65 *International Journal of Law & Psychiatry* 101437 at 2, DOI: https://doi.org/10.1016/j.ijlp.2019.03.006:
This broad definition of neuroscience is best able to address the key questions of how people function in, and make meaning of, the world; how they perceive and make sense of their immediate setting and context; why and how they act in response to these social and contextual stimuli; the processes that underlie perception, cognition, functioning, and behavior; and the complex interplay of genetic risks and life experience which shape decision-making and behavior. Understanding and explaining this complexity of functioning and behavior, how cognition and experience shape ways in which people make sense of the moment, the range of options perceived available to respond and act, and the executive functioning tools to weigh, determine, initiate, and carry out a course of action, are all within neuroscience's purview.

resting potential is between -50 mV and -55 mV. The action potential (AP) or nerve impulse thus produces a transient inversion of the neuron's electrical potential. It obeys the all-or-nothing law in that it propagates along nerve fibers with maximum intensity and without attenuation once the threshold of excitation is reached, and this independently of any subsequent amplification of excitation; conversely, no potential is detectable as long as the reversal of membrane potential remains below the threshold of excitation.

As early as 1875, the British physician Richard Caton (1842-1926) detected in his experimental studies a correlation between electrical activity measured in the brains of animals and certain of their activities, such as chewing, eyelid movement or head rotation[21]. Almost half a century later, the German neurologist Hans Berger (1873 - 1941) was the first to record the electrical activity of a human brain. His results, published in 1929[22], were greeted with scepticism by the scientific community of the time. The EEG signal captured by electrodes placed on the surface of the skull is believed to be altered as it passes through the meninges and scalp. This is why it is often difficult to precisely identify the brain regions from which an EEG signal originates. It's also worth noting that, due to the weakness of the cerebral electrical potential (in the microvolt range), the graphic representation of this cerebral activity, in the form of an electroencephalogram, results from an artificial amplification of the altered EEG signal. What's more, an EEG signal is often blurred by surrounding electromagnetic noise, or that of heartbeats and muscle contractions. For electroencephalography to be reliable, these noises must be removed, and the source of the EEG signals amplified and localized.

As for **magnetoencephalography**, developed in 1968 by physicist David Cohen of the University of Illinois, it measures variations in magnetic fields (MEG) induced by cerebral electrical activity. Similar to EEG, the intensity of induced magnetic fields is too weak for MEG to detect the activity of individual neurons, but thanks to the signal amplified by synchronous activity, it can measure the variation in magnetic fields of a group of neurons. What absolutely distinguishes MEG from EEG is its maximum screening of magnetic background noise, as it operates in a shielded chamber while repeatedly extracting the stimulus.

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[21] Richard Caton, "Electrical Currents of the Brain" (1875) 2:4 *Chicago Journal of Nervous & Mental Disease* 610.
[22] Hans Berger, "Über das Elektrenkephalogramm des Menschen" (1929) 87 *Archiv für Psychiatrie und Nervenkrankheiten* 527.

Positron emission tomography (PET)[23] measures changes in blood flow using a radioactive tracer injected intravenously. This involves labelling a substance metabolized by brain activity with a radioisotope emitting positively-charged radiation particles (positrons). The radiation emitted is recorded by the PET scanner from many different angles, then assembled by computer in the form of two- or three-dimensional color images. In general, PET scans can be used to identify damaged tissue, locate brain tumors and determine the activation patterns of certain brain regions handling certain types of activity.

In the 1970s, the advent of **Magnetic Resonance Imaging** (MRI) was a bombshell for the medical community. Exploiting the quantum properties of atomic nuclei, MRI is able to pinpoint the source of an electromagnetic signal, enabling two- and then three-dimensional reconstruction of the chemical composition of the biological tissues being explored. From the 1990s onwards, "[f]unctional imaging techniques innovatively analyzed the functional architecture of brain areas and their connectivity in vivo, providing new data in cerebral physiology and pathophysiology"[24]. **Functional Magnetic Resonance Imaging** (fMRI) measures magnetic fluctuations in resting and active neurons, resulting from the differential concentration of deoxyhemoglobin, a protein with paramagnetic properties. As with the EEG, the principle underlying this technique for exploring brain activity takes us back to the late 19th century: *blood-oxygen-level dependent* (BOLD). The BOLD signal reflects real-time, local and transient variations in oxygen metabolism, blood flow and volume during activity in different brain regions. However, interpretation of this signal is not always straightforward. The relationship between blood flow and synaptic activity is not straightforward, and "a wide variety of metabolic mechanisms"[25] are likely to interfere.

Now that the black box of our brains can be observed, restoring the intuition of behaviorism (stimulus-reaction) to its rightful place, fertile ground is available for investigating and pinpointing the precise location of various

[23] The history of this technique for exploring brain activity, see Ronald Nutt, "The History of Positron Emission Tomography" (2002) 4:1 *Molecular Imaging & Biology* 11, DOI: https://doi.org/10.1016/S1095-0397(00)00051-0.
[24] Fabrizio Andreelli & Helena Mosbah, "IRM fonctionnelle cérébrale : les principes" (2014) 8:1 *Médecine des Maladies Métaboliques* 13, DOI: https://doi.org/10.1016/S1957-2557(14)70677-7
[25] Ray Kurzweil, *Humanité 2.0. La bible du changement* (Paris: M21 Éditions, 2007) at 175.

cerebral functions (perception, intelligence, language, reasoning...). What about criminal consciousness?

Some people are very optimistic about the contribution neuroscience could make to criminal justice. They would reveal the neurological markers underlying complex criminal behavior and the way in which substance dependence, mental disorders, violence or stress impact brain development or maturation.[26]. Since the 2000s, developmental science research has been cited by the U.S. Supreme Court in support of several landmark decisions invalidating the imposition of sentences deemed too harsh on adolescent offenders and mentally disordered offenders; think the death penalty[27], life imprisonment without parole [28]. In general, the court considers it a mitigating circumstance that the brains of both adolescents and mentally disturbed offenders are not fully developed, resulting in a diminished moral responsibility incompatible with the imposition of extreme sentences. However, this remains one interpretation among many, given the results of numerous research studies on the tendency of adolescents to engage in risky behavior. In other words, mental problems do not always justify less moral responsibility for extreme acts of violence such as murder. This is illustrated by judge Scalia's dissent (*Roper v Simmons*, 2005), in which he disagreed with the constitutional prohibition on imposing the death penalty on offenders responsible for acts of extreme violence before the age of eighteen (18): Judge Scalia distinguished between impulsive acts committed by young people "often acting with impetuosity and lacking judgment" and murder involving an element of premeditation. An impulsive tendency, even generally observed in people of a certain age, would not be sufficient to justify the commission of premeditated crimes, which presuppose a thoughtful intention to commit them[29].

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[26] Cara M. Altimus, "Neuroscience Has the Power to Change the Criminal Justice System" (2016) 3:6 *eNeuro*, DOI: https://doi.org/10.1523/ENEURO.0362-16.2016

[27] *Roper v Simmons, 543 US 551 (2005) [Roper]; Atkins v Virginia, 536 US 304 (2002*).

[28] *Graham v Florida, 560 US 48 (2010*).

[29] *Roper, supra* note 7 (Scalia J, dissenting):

[…] the cited studies describe only adolescents who engage in risky or antisocial behavior. It is entirely consistent to believe that young people often act impetuously and lack judgment, but, at the same time, to believe that those who commit premeditated murder are – at least sometimes – just as culpable as adults. […] Though these cases are assuredly the exception rather than the rule, the studies the Court cites in no way justify a constitutional imperative that prevents legislatures and juries from treating exceptional cases in an exceptional way – by determining

The debate is not new. Since ancient times, the enigma of crime or vice has always challenged philosophers and judges: the presence of visible, organic clues likely to herald or betray a morally corrupt individual was already not to be ignored[30]. In the second half of the 19th century, the Italian phrenologist Cesare Lombroso (1835-1909) became famous for systematically associating the phenomenon of delinquency with certain physical characteristics, known as atavistic marks, which would testify to an innate tendency towards criminal behavior (*L'Homme criminel*, 1876). Although much criticized, this vision of the criminal actualizing his biological destiny nonetheless laid the groundwork for European scientific criminology.

Lombroso's organicist thesis stood in stark contrast to the so-called functionalist viewpoint of French sociologist Émile Durkheim (1859-1917) and Dr. Alexandre Lacassagne (1843-1924), who firmly insisted on the contribution of the environment to the development of moral deviance: "the social environment is the broth of the culture of criminality; the microbe is the criminal, an element that is only of importance the day it finds the broth that ferments it."[31]

Does the natural-born criminal exist? Or is crime merely the product of circumstances? But above all, what conclusions should we draw from this dilemma when it comes time for a judge to decide on the sentence or socio-judicial follow-up to be imposed on a particular offender? It was at this point that the *a priori* focus on criminal intent (i.e. whether the accused was aware of doing something wrong) began to benefit from neurological data exploring neurological predispositions to crime and the risk of recidivism. So what answers can neuroscientific evidence provide to this debate, which lies at the heart of our rehabilitative justice system? To answer this question, it is useful to recall the purpose of Canadian criminal law (3) and rehabilitative justice (4).

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that some murders are not just the acts of happy-go-lucky teenagers, but heinous crimes deserving of death.

[29] See Marc Renneville, "Le criminel-né : imposture ou réalité?" (2005) *Criminocorpus*, online: https://journals.openedition.org/criminocorpus/127 (accessed 5 September 2021).

[30] See Marc Renneville, "Le criminel-né : imposture ou réalité?" (2005) *Criminocorpus*, online: https://journals.openedition.org/criminocorpus/127 (accessed 5 September 2021).

[31] Marc Renneville, "La criminologie perdue d'Alexandre Lacassagne (1843–1924)" (2005) *Criminocorpus*, online: https://journals.openedition.org/criminocorpus/112 (accessed 5 September 2021).

3. Criminal law (Canada)

The Supreme Court of Canada has given considerable thought to what does and does not fall within the scope of Canadian criminal law, particularly in view of the division of legislative powers between the federal Parliament and the provinces. While "criminal law" is a matter for Parliament[32], the provinces have jurisdiction over "[t]he Imposition of Punishment by Fine, Penalty, or Imprisonment for enforcing any Law of the Province made in relation to any Matter coming within any of the of the classes of subjects enumerated in [section 92 of the Constitution Act, 1867]"[33].

Unlike criminal offences, which punish violations of provincial regulations, it is generally accepted that criminal law punishes conduct that violates the fundamental values of society: "to constitute a valid criminal law purpose, a law's purpose must address a public concern relating to peace, order, security, morality, health, or some similar purpose"[34]. Today, these fundamental values go beyond "conventional standards of propriety"[35], but also include evolving societal values. Indeed, far from being frozen in time, criminal law also evolves with society[36]. What was punished by criminal law yesterday may no longer be so today (e.g., medical aid in dying[37], prostitution[38], abortion[39]) and vice versa (e.g., environmental protection[40]), while other criminal law standards endure over time (e.g., culpable homicide, incest[41]).

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[32] *Constitution Act, 1867, 30 & 31 Vict, c 3, s 91(27) [Constitution Act, 1867*].
[33] *Ibid,* s 92(15).
[34] *Reference re Assisted Human Reproduction Act,* 2010 *SCC* 61, [2010] 3 *SCR* 457 at para 43.
[35] *R v Malmo-Levine; R v Caine,* 2003 *SCC* 74, [2003] 3 *SCR* 571 at para 77.
[36] *RJR-MacDonald Inc v Canada (AG)*, [1995] 3 SCR 199 at para 47 (Forest J, dissenting):
"[...] the definition of criminal law is not 'frozen at a particular moment in time.' It has long been recognized that federal jurisdiction over criminal law necessarily includes the power to define new crimes." (citations omitted).
[37] *Truchon v Canada (AG),* 2019 QCCS 3792*; Carter v Canada (AG),* 2015 SCC 5, [2015] 1 SCR 331; *Rodriguez v British Columbia* (*AG),* [1993] 3 SCR 519.
[38] *Canada (AG) v Bedford,* 2013 SCC 72, [2013] 3 SCR 1101.
[39] *R v Morgentaler,* [1988] 1 SCR 30.
[40] *R v Hydro-Québec*, [1997] 3 SCR 213; *Syncrude Canada Ltd v Canada (AG)*, 2016 FCA 160. See also Denis W. Boivin, "La criminalisation de la pollution environnementale" (1991) 20:3 *Manitoba LJ* 625.
[41] *R v RPF*, 1996 NSCA 72.

While Canadian courts do not have the jurisdiction to create new criminal offences - that is the exclusive prerogative of Parliament[42], they do have a duty to ensure that criminal law norms are "constitutionally up to date" with emerging societal values[43] and new scientific knowledge and possibilities. More than simply applying the law to proven facts, judges are also vested with the function of producing the law in the context of judicial review of constitutionality, a function which is recognized in both American[44] and Canadian law[45] and which has become, since the patriation of the Canadian Constitution, "an increasingly important element of the functions of the courts in Canada"[46].

4. Rehabilitative justice

These questions overlap with the development of a new penology focused on risk management and the care of dangerous offenders. The term "new penology", attributed to researchers Feeley and Simon (1992)[47], heralds a shift in institutional thinking from the punishment of the *individual* to the objective management of *systemic* risks:

> […] the new penology is markedly less concerned with responsibility, fault, moral sensibility, diagnosis, or intervention and treatment of the individual offender. Rather, it is concerned with techniques to identify, classify, and manage groupings sorted by dangerousness. The task is managerial, not transformative. It seeks to *regulate* levels of deviance, not intervene or respond to individual deviants or social malformations.[48]

Until then, the "tough on crime" policies implemented in the USA in the 1970s and 1980s in the name of public safety had resulted in longer, harsher

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[42] *Criminal Code*, RSC 1985, c C-46, s. 6.
[43] Stéphane Bernatchez, "Les traces du débat sur la légitimité de la justice constitutionnelle dans la jurisprudence de la Cour suprême du Canada" (2005–06) 36 *RDUS* 165.
[44] *Marbury v Madison*, 5 US 137 (1803).
[45] Stéphane Bernatchez, "Les traces du débat sur la légitimité de la justice constitutionnelle dans la jurisprudence de la Cour suprême du Canada" (2005–06) 36 *RDUS* 165.
[46] Danielle Pinard, "Le principe d'interprétation issu de la présomption de constitutionnalité et la Charte canadienne des droits et libertés" (1990) 35:2 *McGill LJ* 305 at 305.
[47] Malcolm M. Feeley & Jonathan Simon, "The New Penology: Notes on the Emerging Strategy of Corrections and Its Implications" (1992) 30:4 *Criminology* 449, DOI: https://doi.org/10.1111/j.1745-9125.1992.tb01112.x
[48] *Ibid* at 452.

sentences, tighter parole conditions and an increase in the prison population[49].

The new penology now focuses on optimized management of the needs and risks represented by offender populations, assessed from the angle - considered more efficient - of probabilities and statistics.

While some criticized this approach to delinquency based on statistical probabilities[50], criminology has rapidly evolved towards actuarial justice, which also aims to provide a more structured assessment of offenders' criminogenic and non-criminogenic needs, with a view to developing appropriate intervention strategies[51].It can now be said that, whatever the approach to crime, the ultimate goal of rehabilitation is now aimed at the offender's social adaptation. This new perspective on rehabilitation can only be enriched by the psychiatric expertise already applied to criminal justice.

Psychiatric expertise, which really took off in the twentieth century, has seriously shaken the dominant paradigm of rational man inherited from the Enlightenment. The all-powerful Cartesian reason, capable of discerning right from wrong in all circumstances,[52] inspired Kant to elevate criminal law to the rank of categorical imperative, a corollary of justice as our ethical vocation[53]. As for Bentham, a spirit frankly liberated from Kantian and religious principles, he proposed to base justice on the principle of fundamental liberty, equal rights and the pursuit of happiness. Less revolutionary but nonetheless a precursor, Beccaria founded modern

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[49] Judith Greene, "Getting Tough on Crime: The History and Political Context of Sentencing Reform Developments Leading to the Passage of the 1994 Crime Act" in Cyrus Tata & Neil Hutton, *Sentencing and Society: International Perspectives* (Hampshire: Ashgate, 2002) 4, online: https://www.justicestrategies.org/sites/default/files/Judy/GettingToughOnCrime.pdf (accessed 5 September 2021).

[50] Marion Vacheret, Jean Dozois & Guy Lemire, "Le système correctionnel canadien et la nouvelle pénologie : la notion de risque" (1998) 22:1 *Déviance & Société* 37.

[51] Thibaut Slingeneyer, "La nouvelle pénologie, une grille d'analyse des transformations des discours, des techniques et des objectifs dans la pénalité" (2007) IV *Champ pénal*, DOI: https://doi.org/10.4000/champpenal.2853

[52] René Descartes, *Discours de la méthode. Pour bien conduire sa raison et chercher la vérité dans les sciences* (1637). See also Élodie Cassan, "La raison chez Descartes, puissance de bien juger" (2007) 1:28 *Le Philosophoire* 133, DOI: https://doi.org/10.3917/phoir.028.0133.

[53] Emmanuel Kant, *Éléments métaphysiques de la doctrine du droit*, translation by Jules Barni (Paris: Auguste Durand, 1853) at 199, online: https://fr.wikisource.org/wiki/Doctrine_du_droit (accessed 5 September 2021).

criminal law and wrote the first arguments against the death penalty. He established the foundations and limits of the right to punish, and recommended that punishment be proportionate to the crime. Although he was a religious man, he completely disengaged himself from the Christian principles of natural morality[54].

Naturally, socio-psychiatric expertise was to upset all these philosophical and legal advances, by focusing attention on that which escapes Kantian or Cartesian reason, but above all free will: the unconscious[55]. New factors now surround the phenomenon of crime[56]: genetic predispositions, a particular upbringing, a personality type, a temperament, uncontrolled impulses, cognitive deficits, buried traumas... in short, a whole range of factors over which individuals have no control. Today, this point of view underpins the Risk-Need-Responsivity (RNR) model, recognized as the most convincing intervention model for preventing offender recidivism in general[57]. Developed in the 1980s as a reaction to the ultra-repressive "*Tough on Crime*" penal policies of the "*Nothing Works*"[58], the RNR model emphasizes the acquired nature of the criminal act, like any other social learning process, and proposes three key principles to guide the management of the delinquent population: the principles of risk, need and responsiveness[59]. The principle of risk calls for a proper assessment of offenders' level of recidivism, in order to adapt the intensity of their care. On the one hand, so-called static risk factors refer to the relatively immutable attributes that characterize an offender, and which are not likely to be remedied by treatment. These include age, gender and criminal history. On the other hand, dynamic risk factors or criminogenic needs are inherently

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[54] Philippe Audegean, *La philosophie de Beccaria: savoir punir, savoir écrire, savoir produire* (Paris: Vrin, 2010) at 151.

[55] Paul-Laurent Assouin, "L'inconscient du crime. La "criminologie freudienne"" (2004) 2:2 *Recherches en psychanalyse* 23.

[56] *Cf.* António Damásio, *L'erreur de Descartes : La raison des émotions*, Odile Jacob, Paris, 1995.

[57] Massil Benbouriche, Olivier Vanderstukken & Jean-Pierre Guay, "Les principes d'une prévention de la récidive efficace : le modèle Risque-Besoins-Réceptivité" (2015) 21:3 *Pratiques psychologiques* 219.

[58] Robert Martinson, "What works? – Questions and answers about prison reform" (1974) 35 *The Public Interest* 22.

[59] Donald A. Andrews, James Bonta & Robert D. Hoge, "Classification for effective rehabilitation: Rediscovering psychology" (1990) 17:1 *Criminal Justice and Behavior* 19, DOI: https://doi.org/10.1177/0093854890017001004; Donald A. Andrews & James Bonta, *The Psychology of Criminal Conduct*, 5th ed (Albany (NY): Lexis Nexis/Anderson Publishing, 2010).

more amenable to intervention. For example, personality traits such as impulsivity, pro-criminal or antisocial attitudes, and difficulty controlling emotions are ideal therapeutic targets for reducing the risk of recidivism. In addition to criminogenic needs, non-criminogenic needs and any other variables likely to influence an offender's receptiveness to intervention must also be taken into account. This includes both the socio-professional, demographic and psychological dimensions characterizing a particular group of offenders (e.g. ethnicity, aboriginality, mental health) and individual idiosyncrasies such as personality, resources, motivation, learning styles, strengths and vulnerabilities. These are not factors linked to recidivism *per se*, but rather obstacles to the curability of offenders or to proposed interventions. In this way, the R-N-R model contributes to the shift towards rehabilitative justice, now recognized by the highest international authorities, according to which "the rehabilitation of offenders and their successful reintegration into society must be among the fundamental objectives of criminal justice systems"[60].

Rather than determining guilt or criminal intent, rehabilitative justice focuses on the defendant's future, and, at the sentencing stage, on the person of the offender (rehabilitation) rather than on the crimes committed. Given the multi-dimensional nature of this exercise, Canadian judges have a certain amount of discretion when it comes to carefully considering all the elements required to make a decision, including the new light that neuroscientific evidence could shed.

In many respects, criminal law offers ample scope for the exercise of judicial discretion. Let's not forget the ancient saying "*actus reus non facit reum nisi mens sit rea*", which makes an individual's state of mind a *sine qua non* for determining guilt. Over time, however, this requirement has branched out into several modern avatars involving, on the one hand, the criminal responsibility of the individual (cf. the defence of mental disorder and automatism) and, on the other hand, different degrees of *mens rea* (from simple negligence to subjective intent) as prescribed by different legislative provisions creating the offence. In short, a trial on guilt today gives the trial judge many opportunities to assess the state of mind or mental health of the accused at the time of the commission of the offence charged. While the state of the accused's mental health and criminal intent are paramount in trials of guilt, there is another fundamental issue at stake throughout the

[60] United Nations Office on Drugs and Crime, *Introductory Handbook on the Prevention of Recidivism and the Social Reintegration of Offenders*, Criminal Justice Handbook Series (Vienna: United Nations, 2019) at 3.

procedural phases and at the sentencing stage: the risk posed by the accused's mental state to himself or herself and to the public.

Sentencing - In Canada, the adoption of Bill C-41, assented to on July 13, 1995, represents a major reform in that it codifies the objectives and principles that should guide sentencing decisions. This reform "marking the first codification […] in the history of Canadian criminal law"[61]. In addition to the essential objective of contributing "to respect for the law and the maintenance of a just, peaceful and safe society", just sentencing may also be intended to "to assist in rehabilitating offenders"[62].

Until then, Canadian jurisprudence had emphasized the need for deterrence, both specific (with regard to the offender) and general (with regard to the population): "[…] rehabilitation itself is a relative late-comer to the sentencing analysis, which formerly favoured the interests of the state almost entirely"[63]. Subject to mandatory minimum sentences [64], the precise way in which the objective of rehabilitation will be implemented, as well as its weighting in relation to the competing objectives of denunciation and deterrence, is left to the discretion of judges, on a case-by-case basis. As a general rule, the constitutional principle of proportionality [65] dictates that sentences should be adapted "to the gravity of the offence and the degree of responsibility of the offender"[66]. This fundamental principle is underpinned by a number of aggravating or mitigating circumstances relating to the commission of the offence (e.g. with or without a firearm), the type of offence (e.g. terrorism offence or offence against a vulnerable person), the consequences of the offence (e.g. bodily harm or death of the victim), the offender's situation (e.g. criminal record or length of pre-trial detention), the victim's situation and the relationship between the offender and the victim. e.g. bodily harm or death of the victim), the offender's situation (e.g. criminal history or length of pre-trial detention), the situation of his victims and the relationship between the offender and his victims (e.g. situation of dependence or authority, conjugal violence). These various circumstances, notably listed in sections 718.01 et seq. of the *Criminal Code*, justify a more or less severe sentence, depending on whether they are seen as meeting the objectives of denunciation and deterrence (aggravating circumstances) or rehabilitation (mitigating circumstances). Due to the individualized nature

[61] *R v Gladue*, [1999] 1 SCR 688 at para 39 [*Gladue*].
[62] *Criminal Code*, RSC 1985, c C-46, s. 718.
[63] *Gladue,* supra note 11 at para 42.
[64] *Cf.* R v SA, [1997] RJQ 1848 (CA).
[65] As recognized in *R v Ipeelee*, 2012 SCC 13, [2012] 1 SCR 433.
[66] *Criminal Code*, *supra* note 12, s. 718.1.

of the sentencing process, the assessment of this heterogeneous set of circumstances remains fundamentally discretionary [67] and is primarily the responsibility of the trial judge, subject to the principle of harmonization of sentences, which comments on "imposing a similar sentence […] for similar offences committed in similar circumstances"[68]. In exercising this discretion, the court may enlist the help of probation officers to decide on the appropriate level of sentence in the light of a pre-sentence report that takes into account the offender's character and behaviour[69]. This pre-sentence report is produced at the request of the judge "to assist the court in imposing a sentence or in determining whether the accused should be discharged under section 730"[70]. The court takes cognizance of all relevant evidence presented by the parties and may require on its own initiative other relevant elements [71], including the appearance of any person likely to provide useful information, even if hearsay is admissible at this stage of the process [72].

As the Honourable judge Gonthier points out, a particular feature of the sentencing process is the importance of opinion evidence:

> At the sentencing stage, judges must often consider reports prepared by probation officers, correctional service officers, psychologists or psychiatrists reporting their opinions concerning the personality of the accused, and his or her chances of rehabilitation and risk of reoffending.[73]

In practice, adapting the sentence imposed to the seriousness of the offence and the moral responsibility of the offender calls for a holistic examination of all relevant and available information, from the circumstances of the offence, the background - psychiatric, social and relational - of the victim and the accused, to the systemic or historical factors underlying the over-representation of certain groups of offenders in the courts, including aboriginal offenders [74].

In addition to an offender's moral responsibility or state of mind, it is relevant to ask whether he or she presents a high risk of reoffending, and if so, under what conditions. The answer to this question will not only guide the imposition of a sentence that is appropriate for both the offender and his

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[67] *Ibid*, s. 718.3.
[68] *Ibid*, s. 718.2(b).
[69] *Ibid*, s. 721.
[70] *Ibid*, s. 721.
[71] *Ibid*, ss. 723, 726.1.
[72] *Ibid*, s. 723(4)–(5).
[73] *R v Lévesque*, [2000] 2 SCR 487 at 31.
[74] *Criminal Code*, s. 718.2(e).