

Neurolaw today – A systematic review of the recent law and neuroscience literature



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1. Introduction

We are in the midst of a resurgence of interest in the biological dimension of human behaviour and mental states, as exemplified by the rise of biosocial criminology and of biological psychiatry. Much of this work seeks to understand human behaviour and mental states at the level of the brain, and, in particular, the interaction of the biological substrate at various levels (genetics, cells, brain structures and circuits) with the environment (including the social and physical environments). This interest and this manner of understanding human behaviour and experience are much broader than criminology and psychiatry, of course. It is reflected in the proliferation of research sub-disciplines in the social sciences and humanities such as neuroeconomics, neuroethics, neuroaesthetics, neuromarketing, neuroeducation, neuropolitics, and neurotheology to name only a few.

The law too – as a social creation and institution – reflects the zeitgeist. Previous waves of biologically-oriented theories about behaviour and the mind have been incorporated into the legal sphere over the years (Shen, 2016d). The ebb and flow of the brain as an object of legal interest has been driven by the continuing evolution of biological theories of human behaviour and mental states, as well as by the technologies available for examining the brain (e.g. through electroencephalography and imaging) and intervening in the brain (e.g. chemically or physically).

In recent years, the number of scholarly publications situated at the intersection of law and neuroscience has increased (Shen, 2010; Shen, 2016d) and topics related to law and neuroscience also appear regularly in the popular media. In our view, it is time to take a systematic approach to characterizing the work in this field, in order to begin to identify the main themes and gaps in the work so far. In this article, we seek to describe the breadth of this literature by providing a systematic review of English language publications in the year 2016. We do not try to characterize the evolution of the field over time given our methodological choice to prefer a detailed and systematic review of one slice of time. Future work could broaden the inquiry into previous and subsequent years, as well as into other adjacent scholarly disciplines that study legal matters such as legal sociology, criminology, or philosophy, among others.

We have found that neuroscience is being cited in relation to many different domains of law and regulation, legal concepts and theories, as well as in relation to legal decision-making. The dominant themes at the intersection of law and neuroscience come from criminal law, health and public health law, and legal theory and decision-making. Other common categories are evidence law, public and human rights law and private law.

2. Method

2.1. Objective

The objective of our study is to conduct a systematic scoping review (Arksey & O'Malley, 2005; Levac, Colquhoun, & O'Brien, 2010; O'Brien et al., 2016) of the English-language legal literature that incorporates or is informed by insights from the neuroscientific literature. More specifically, we aim to map the areas of law influenced by the intersection between law and neuroscience and identify key themes arising within it, based on a "slice in time" consisting of publications from the year 2016.

2.2. Search strategy

Systematically reviewing the law and neuroscience literature presents a special challenge since the scope and the extent of this multidisciplinary area is still evolving and has yet to be rigorously described. The danger in devising a strategy intended to map a poorly-defined area of inquiry is that an a priori conception of its contents and scope will necessarily prejudice and shape the resulting map. We have nonetheless had to make certain initial choices. These were informed by reviewing

existing surveys of "neurolaw," as well as the MacArthur Law and Neuroscience bibliography (Shen, 2010) to understand the potential scope of what might constitute "law and neuroscience" literature.

We wish to capture work that explores the intersection of (1) knowledge or techniques from the brain sciences and technology with (2) concepts, rules, institutions and procedures of the law or justice system. This broadly-defined area of inquiry could potentially draw upon writing from a huge range of disciplines (e.g. legal sociology, criminology, philosophy), but we have chosen to restrict it to the legal literature, by which we mean articles whose predominant concern is a specific legal concept, rule, institution or procedure.

Given our focus on legally-oriented writing, we chose to search four leading legal databases: HeinOnline, Westlaw, LegalSource and LegalTrac. These four databases cover in total over 3000 journals and publications from more than 30 countries. These four databases provide extensive coverage of English language academic legal journal publications. We do not attempt to include literature in other languages in this scoping review.

While we originally intended to offer a systematic review from 1990 to 2017, we would have been forced to significantly narrow our search strategy to ensure a manageable number of results. Instead, we decided that we would prefer a comprehensive picture of a "slice in time" in this area of work rather than a narrower search that might reveal evolution over time. We thus limit our search to articles published in 2016.

Consistent with our attempt not to prejudge the contents of a field of inquiry, we have chosen a broad and inclusive search string (brain OR neuro!) (using "!" or the equivalent truncation character in each database). We did not include legal search terms since we were searching indices for legal literature.

The searches generated 5638 results (see Fig. 1). Abstracts and metadata were imported into reference management software (Citavi). Using automated and manual methods, we removed duplicates and non-English language results, leaving 3476 results.

2.3. Inclusion and exclusion criteria

All of the results were then screened by two reviewers on the basis of the title and abstract (or introductory paragraphs of the full text where no abstract was provided). Articles were included or excluded on the basis of the criteria described here. Disagreements were resolved by discussion between the two reviewers.

Our inclusion and exclusion criteria are based on an analytical choice that the law and neuroscience literature must include both legal content and neuroscientific content, and that there must be an engagement or intersection between the two. We made another choice to be more demanding about the level of legal content than about the neuroscientific content. This was because our objective is to examine a body of literature that is primarily emanating from and speaking to the legal world, and we are interested in how that world is making use of neuroscience. As a result, all articles retained must have considerable legal content, but neuroscientific content can vary in quantity and sophistication. However, there must always be some neuroscientific content, and it must be tied in some way to a legal matter.

We did not employ any formal method of quality assessment beyond attempting to include peer reviewed or scholarly journal articles. Many of the articles in our search results came from legal journals associated with US law schools, which employ variable selection procedures that do not always involve expert peer review. We excluded popular magazines, news media, policy documents from governments, professional organizations or NGOs etc., legal cases, book reviews, book chapters and books.

As noted above, we have used legal databases and have not attempted to search other literatures (e.g. criminology, sociology, philosophy) for relevant materials. Nevertheless, our search occasionally produced studies of legal concepts, rules, institutions or procedures from psychological, sociological, philosophical or other perspectives, such as psychological discussions of judicial decision-making or philosophical discussions of

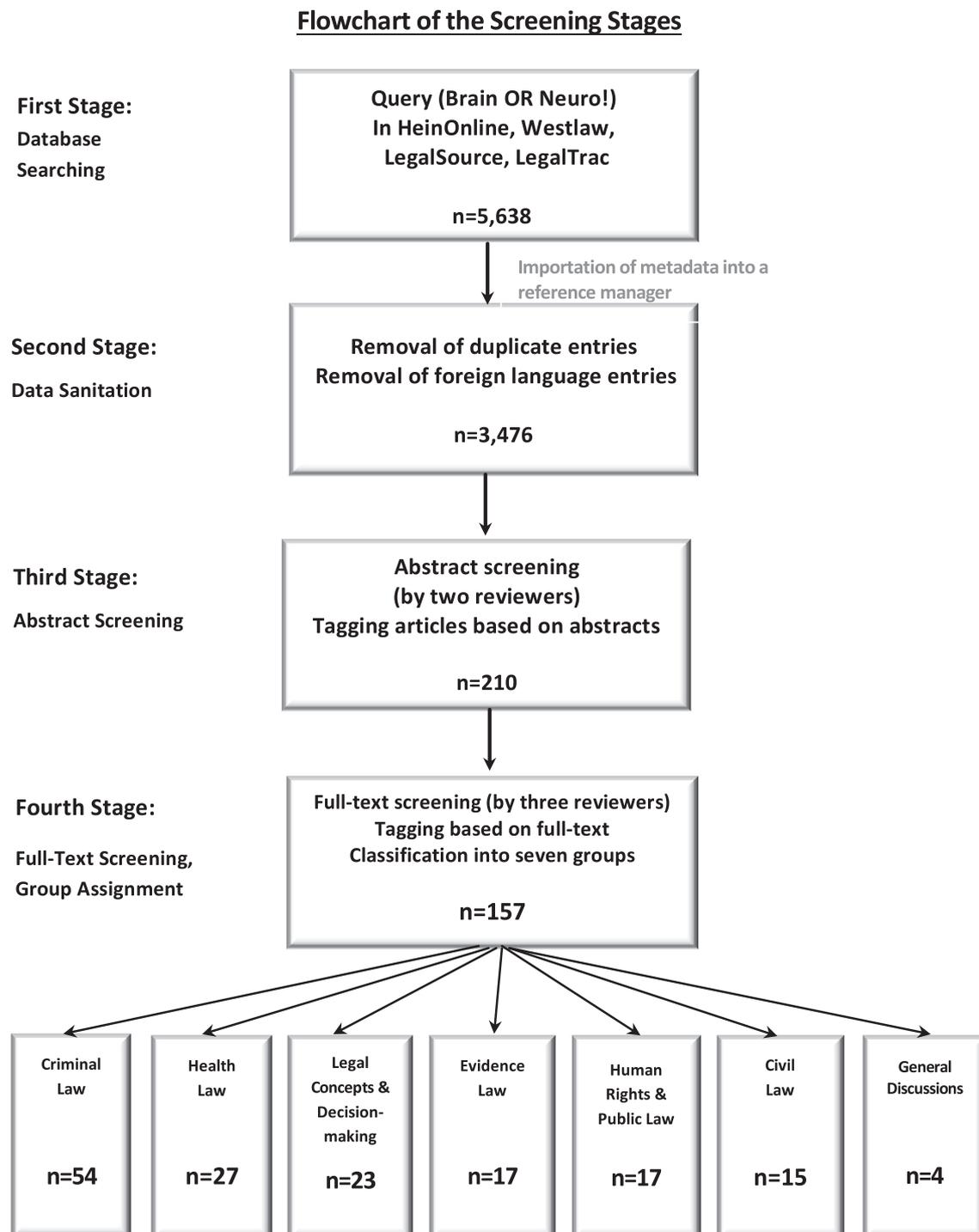


Fig. 1. Search strategy overview.

the theory of punishment. We have retained these where they satisfied our criteria for both legal and neuroscientific material.

For our purposes, legal content refers to discussions of legal or regulatory concepts, rules, institutions or procedures. We excluded “soft law,” such as customary rules and private ordering, where these are the sole “legal” content. Forms of professional self-regulation were, however, included. Note that we included articles dealing with legal education and pedagogy, considering these topics to be part of the institutional structure of the legal system.

Neuroscientific content, for our review, refers to scientific studies of human behaviour and cognition that focus in whole or in part on the nervous system, as well as techniques that operate at the level of the brain to

understand or detect aspects of human behaviour or cognition (via imaging or other methods of observing brain activity) or to manipulate aspects of human behaviour or cognition (via physical or chemical interventions on the nervous system). We exclude studies of human behaviour and cognition at the level of the mind (psychology), and interventions that operate via human perception, even if they bring about changes to the brain (e.g. cognitive behavioural therapy (CBT), conditioning, counselling).

2.4. Analysis

We analyzed the articles using the method of qualitative content analysis (Drisko & Maschi, 2015; Hsieh & Shannon, 2005). This form of

analysis is used to examine themes and core ideas in texts. Qualitative content analysis may be directed (theory-based and deductive), in which a set of codes are created a priori, or conventional (data-grounded and inductive), in which codes are derived from the texts themselves. Qualitative content analysis may also use a mix of both approaches (Drisko & Maschi, 2015; Hsieh & Shannon, 2005).

In our case, we used a primarily directed approach, while permitting the addition of new codes as we encountered them in the articles. We began with an ingoing set of codes suggested by the traditional and well-established substantive divisions of law (e.g. criminal law, law of civil procedure or evidence law). At the same time, we were aware from our own knowledge of legal scholarship and from detailed examination of the MacArthur Law and Neuroscience bibliography (Shen, 2010) that neurolaw literature is not always organized primarily according to areas of substantive law. On the basis of this preliminary work, we developed an ingoing set of codes reflecting four conceptual domains at the intersection of law and neuroscience: (1) legal – area of legal doctrine, practice, procedure or institution, (2) legal concepts and aspects of legal decision-making, (3) mental function or human behaviour, and (4) neurotechnologies.

Each article was read and coded by two authors, applying codes to identify all discussions in which neuroscience was raised in relation to the law. New subcodes could be created as needed within these four conceptual domains, and multiple codes were permissible for a given article. The coding of each article was done by two authors, and a third author verified consistency of coding among all of the set. As we went along, we found that some of the articles that were included on the basis of title and abstract did not have adequate legal or neuroscientific content, or the intersection between the two was insufficient. These were excluded on the basis of the full-text review.

Given the dominant focus on the legal aspect of these materials in our method, we ultimately chose to report our results according to the legal codes. We selected by consensus a dominant tag of “best fit”

from the first or second conceptual domains for each article. In a final step, the authors agreed on a reduction of the codes to seven major thematic categories, within which sub-categories allowed us to present the results in an organized manner.

2.5. Limitations

Our objective was to map a fairly loosely-defined area of research involving the intersection between the law and neuroscience for the year 2016. Limitations on our approach include the restriction to indices of legal literature only, incompleteness in the indices chosen, restriction to English-language publications, lack of consistent quality in the articles, subjectivity in interpretation and categorization, and the reduction in detail and complexity that was necessary to reduce the rich detail in the literature to a limited set of thematic categories for useful presentation.

3. Results

We present the results under seven thematic headings, made up of six domains of law and one cross-cutting domain addressing legal concepts and legal decision-making. They are presented in descending order by frequency (Fig. 2).

3.1. Criminal law (n = 54)

The largest group of articles (n = 54) in the set addressed questions related to criminal law. This included discussions of how neuroscience might bear upon criminal responsibility, criminal procedure, and criminal justice policy such as correctional approaches. Two predominant themes emerge in the articles dealing with the impact of neurosciences for criminal law: juveniles and criminal law, and sentencing.

Nearly two-thirds of the articles address these topics in the context of juveniles (n = 34 of the 54), likely as a result of interest in the

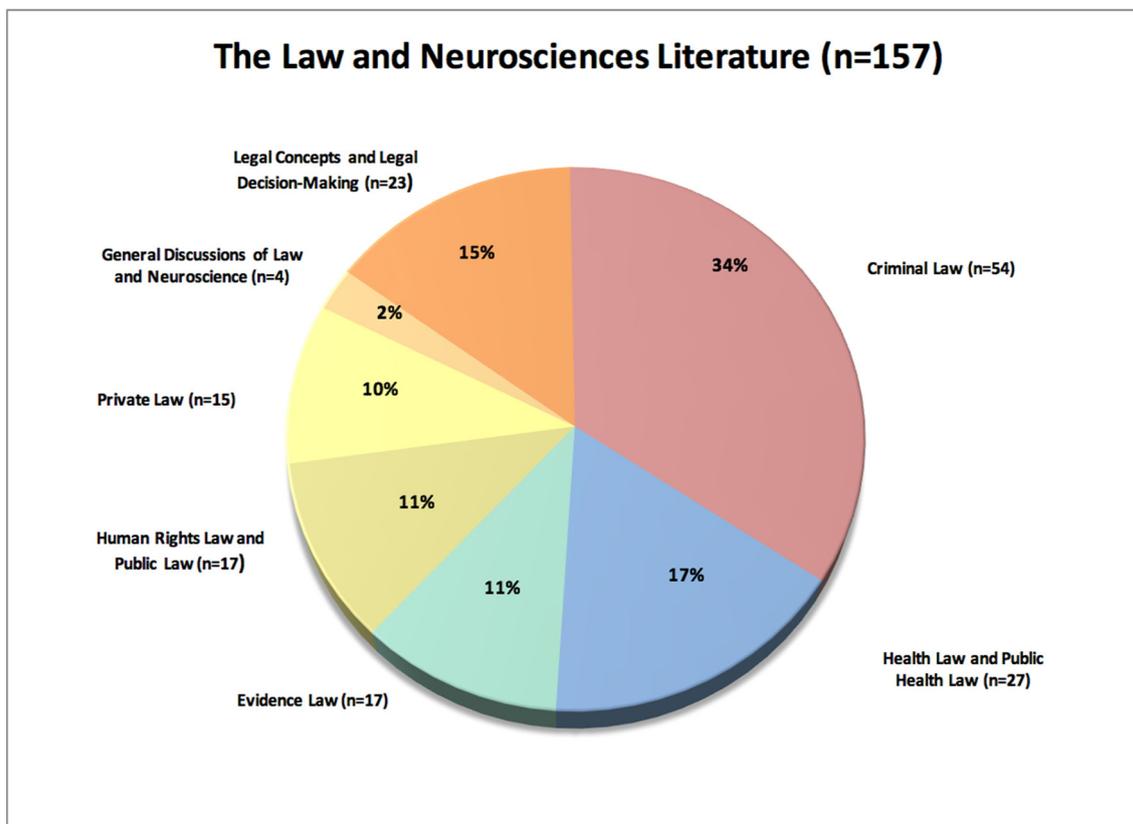


Fig. 2. Main themes in the law and neuroscience literature.

implications of the US Supreme Court's allusions to the science of juvenile brain development in *Roper v. Simmons* (2005), *Graham v. Florida* (2010) and *Miller v. Alabama* (2012). The other 18 address criminal law issues in general, or in relation to adults. Looking across both general discussions and juvenile-focused discussions, issues related to criminal procedure and correctional policies is also a major theme (n = 31 of 54) (Fig. 3).

3.1.1. Adults – criminal responsibility and sentencing (n = 12)

Articles on criminal responsibility and the brain sciences frequently considered how neuroscience might support a claim for a lighter sentence due to diminished capacity, and less frequently addressed neuroscience in the context of a more extreme and exculpatory level of incapacity (“insanity” defence) (Birkhoff, Garberi, & Re, 2016).

Several articles offered overviews of the ways in which neuroscience could be relevant to criminal sentencing, not just as supplying potentially mitigating or aggravating factors at sentencing, but also as shedding light on the neural underpinnings of how judges make sentencing decisions (Donald & Bakies, 2016; Gertner, 2016; Perlin & Lynch, 2016). Other articles looked specifically at the impact on criminal sentencing of advances in neuroscientific understanding of particular brain conditions (Berryessa, 2016 (frontotemporal dementia); Eme, 2016 (ADHD); Hermann, 2016 (FASD), Matuszewski, 2016 (“organic brain damage”); Hauser, 2016 (autism spectrum)) or neurogenetics (Segal, 2016), and the potential use of neuroscience in forensic risk assessment (Gaudet et al., 2016).

Although the focus of articles on the impact of neuroscience for criminal sentencing usually look at a criminal offender's brain, one article focused on the victim's brain, suggesting that the seriousness of offences against children was amplified by the developing knowledge about the neurodevelopmental impact of victimization on children (Beck, 2016).

3.1.2. Adults – procedural and correctional implications (n = 8)

Other themes addressed in relation to neuroscience and criminal law include the implications of brain sciences for the legal rules on competency to plead (Schehr & French, 2016) and the voluntariness of confessions and waivers of the right to remain silent (Sheldon, 2016; Fradella, 2016). The articles also considered the questions of whether and when evolving psychological and neurological research should constitute newly discovered evidence relevant to mental state that

entitles a convicted person to post-conviction relief (Robertson, 2016), and whether the neurocognitive impact of imprisonment justifies a continuing right to post-conviction legal representation for inmates (Strutin, 2016). Finally, articles also addressed the implications of neuroscience for correctional policy and practice, including segregation, conditions of confinement, and forms of rehabilitative therapies (Baskin-Sommers & Fonteneau, 2016; Berryessa, Chandler, & Reiner, 2016; Forsberg & Douglas, 2016).

3.1.3. Juveniles – criminal responsibility and sentencing (n = 11)

A large number of articles cited the neuroscience of juvenile brain development in relation to diminished decision-making capacity and culpability, increased vulnerability to adverse environmental influences, and increased capacity for change due to neurological plasticity.

Multiple articles considered the implications of developmental neuroscience for juvenile criminal responsibility (Carroll, 2015; Cohen et al., 2016; McDiarmid, 2016; Walsh, 2016b) and sentencing (Russell & Denholtz, 2016; Scott et al., 2016a), and one argued that the age of exemption from the death penalty should be raised to 20 years (beyond that set by the US Supreme Court in *Roper v. Simmons*) (Michaels, 2016).

Another point made in the articles is that attention to the criminal justice implications of developmental immaturity is incomplete if it is based on an idealized trajectory of adolescent brain development. Instead, the implications for criminal justice policy should consider the additional neurodevelopmental impact of widespread childhood trauma, and other forms of social and economic disadvantage among juvenile offenders (Buckingham, 2016; Ferrer, 2016; Glennon, 2016).

An interesting question of litigation strategy also arose. In particular, one article discussed the strategic challenges of using developmental neuroscience in potentially conflicting ways in simultaneous cases before the South African constitutional court. One case claimed diminished adolescent capacity due to immaturity, and the other claimed sufficient capacity to warrant the decriminalization of consensual sex between 12 and 16 year olds (Skelton, 2016).

3.1.4. Juveniles – procedural and correctional implications (n = 23)

Many argued for an extension to other aspects of the juvenile criminal justice system of the logic of the US Supreme Court's decisions cited above. Some articles offered an overview of multiple potential criminal

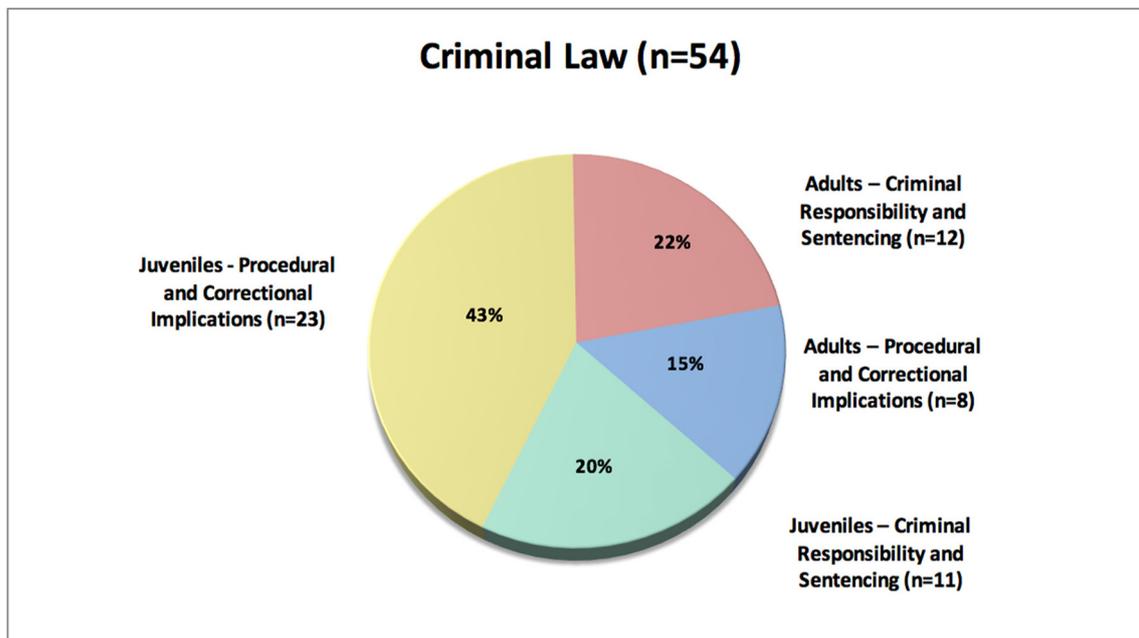


Fig. 3. Distribution of criminal law sub-categories.

justice reforms to which developmental neuroscience has and may contribute, including raising the age jurisdiction of juvenile courts, increasing the use of fitness hearings, altering the standards for culpability, reducing automatic transfers to adult criminal justice system, reducing the use of secure confinement and in particular in adult institutions, expedited parole, protection of procedural rights, improved screening for and treatment of mental health problems, and tailored correctional programs (Geraghty, 2016; Scott et al., 2016b; Shah, 2016a; Walsh, 2016a).

Other articles took a narrower focus on whether or not the neurodevelopmental sciences ought to inspire one (or a few) modifications to aspects of criminal procedure and correctional practices including the rules around police interrogations, confessions and guilty pleas (Alberts, 2016; Brobst, 2016a; Stowers, 2016), the use of sex offender registries in the case of juvenile sex offenders (Grisso & Kavanaugh, 2016; Levick & Shah, 2016; Najdowski, Cleary, & Stevenson, 2016; Pestalozzi, 2016), the transfer of juveniles from the juvenile to the adult criminal justice systems (Flynn, 2016; Roan, 2016; Weston, 2016) the expungement of juvenile criminal records in certain cases (Puzone, 2016), the juvenile parole system (LaHaie, 2016; Lee, 2016; Trahos, 2016), the juvenile probation system (Goldstein, 2016), the placement of juveniles in solitary confinement (Kysel, 2016; Muir, 2016), and the existence of a right to mental health care and rehabilitation programs within the juvenile correctional system (McDermott, 2016; Weekley, 2016).

3.2. Health law and public health law ($n = 27$)

The second most common focus for articles exploring the intersection of law and neuroscience was health law. A major focus of these articles was the public health issue of addiction. Another major focus was the regulation of neurotechnologies being used for therapeutic and enhancement purposes. A range of other health and public health legal issues were raised by one or two authors each, and we have grouped them together in a miscellaneous health law sub-category (Fig. 4).

3.2.1. Addiction ($n = 11$)

This set of articles addressed a range of legal issues related to the criminalization of addiction, coerced addiction treatment, and legal

steps to expand addiction treatment. Five articles addressed the neuroscience of opiate addiction, using it to comment on the wisdom and ethics of coercive treatment (Steffen, 2016; Uusitalo & van der Eijk, 2016), or the pharmacological treatment of addiction using drugs like methadone or buprenorphine (Andraka-Christou, 2016a, 2016b; Gordon & Gordon, 2016).

Tovino considered the neuroscience of gambling addiction in three articles looking at legal issues related to health insurance, disability insurance, discrimination, tort law, professional responsibility and discipline and criminal law (Tovino, 2016a, 2016b, 2016c).

Two articles considered potential interventions to address prenatal drug use, using neuroscience to explain the effects on the developing brain and to support a therapeutic rather than punitive response to addiction as a “brain disease” (Soderberg, 2016; Weisberg & Vandervort, 2016).

One article considered developmental neuroscience in relation to decision-making capacity and the age limit for purchasing tobacco (Morain, 2016).

3.2.2. Regulation of neurotechnology ($n = 9$)

Articles grouped in this subcategory address different aspects of regulating neurotechnologies, including their therapeutic and enhancement uses. Some articles focus on specific technologies such as an EEG-based ADHD assessment tool (Arns et al., 2016), or transcranial direct current stimulation (tDCS) (Bikson, Paneri, & Giordano, 2016; Kuersten & Hamilton, 2016; Wexler, 2016; Zettler, 2016). Other more general articles situate neurotechnologies within broader discussions about the regulation of robotics (Holder et al., 2016) and medical devices or interventions in general (Lamkin, 2016; Mathieu & Williams-Jones, 2015–2016). Parasidis (2016) considers research ethics and the regulation of research in military veterans, including research involving the brain.

3.2.3. Miscellaneous health law ($n = 7$)

The remaining health and public health law and policy articles address legal rights to access certain forms of care for people in a minimally conscious state (Samanta, Yelden, & Sargent, 2016; Wright & Fins, 2016); the prevention of traumatic brain injury in contact sports through changes to criminal and civil laws related to assault (Brobst,

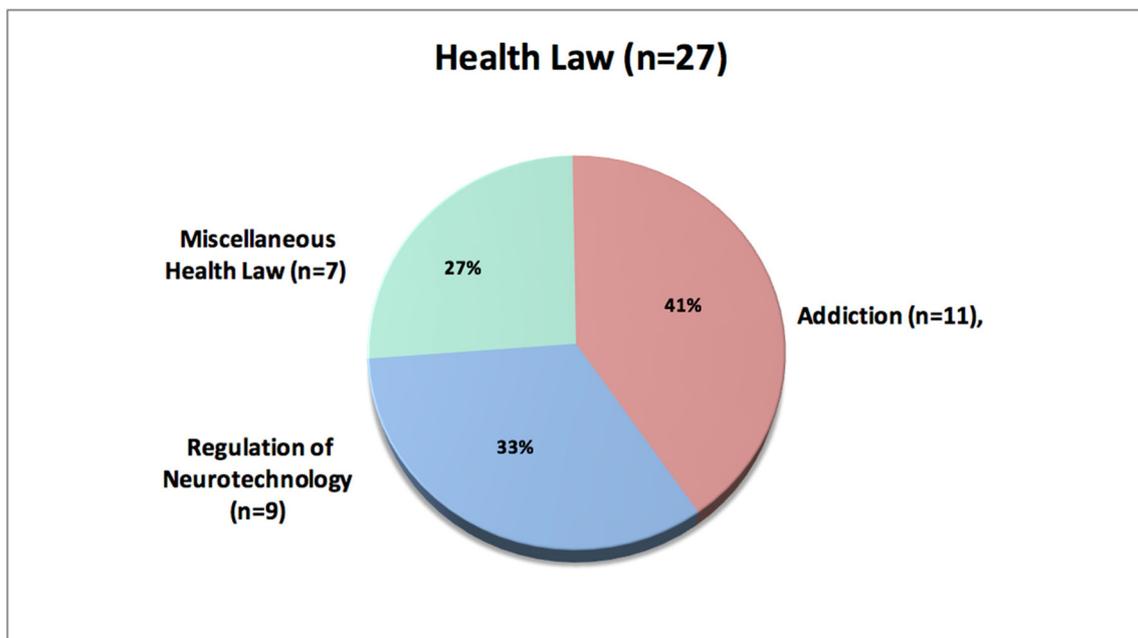


Fig. 4. Distribution of health law and public health law sub-categories.

2016b), the law relating to the determination of brain death (Harper, 2016; Sarbey, 2016), and capacity to consent and capacity assessment (Manian, 2016; Owen & Martin, 2016).

3.3. Legal concepts and legal decision-making (n = 22)

The third most common category was one that focuses on theoretical and conceptual issues such as legal responsibility or the scope of the insanity defence, as well as on aspects of legal decision-making and thinking (Fig. 5).

3.3.1. Moral and legal responsibility (n = 11)

One of the themes often raised in law and neuroscience is the question of whether deterministic neuroscientific explanations of behaviour should affect theories of moral responsibility and punishment. The articles in our set approached this question from the perspective of moral and legal philosophy, or instead from the perspective of the legal doctrine of mens rea. Note that discussions of the impact of neuroscience on responsibility discussed here were primarily theoretical or philosophical, while practical applications related to sentencing and conviction were assigned to Section 3.1 above.

The articles considered neuroscientific accounts of behaviour in relation to the question of free will and determinism and its connection to moral responsibility, as well as to the legal theoretical justifications for punishment including retributive and utilitarian theories (de Caro, 2016; Mammarella, 2016; Moore, 2016; Taggart, 2016).

In addition to these, multiple articles looked at legal doctrinal requirements for criminal responsibility. In particular, these articles considered how neuroscience might shed light on disturbances of cognition and volition, and how these might relate to legal capacity (Bastani & Gavaghan, 2016; Bennett, 2016; Lacey, 2016; Maoz & Yaffe, 2016; Moriarty, 2016; Santa Rosa et al., 2016). One article, written from a forensic psychiatric perspective, addressed these themes using a case study of a defendant with obsessive-compulsive and paraphilic traits, with impaired impulse control and executive capabilities (Santa Rosa et al., 2016).

3.3.2. Moral and legal reasoning (n = 6)

The section above considered whether and how neuroscience might shed light on a person's moral and legal responsibility for certain behaviour. Another set of articles focuses instead on the brain of the person who is making a moral or legal judgment about another person, considering what neuroscience might say about our practices of moral and legal reasoning in light of that science.

Several articles discuss how neuroscientific explanations of behaviour may affect legal actors' and the public's attributions of moral responsibility as an empirical matter (rather than whether these explanations should so affect attributions of moral responsibility) and the social and policy consequences of this type of interpretation (Sharpless, 2016; Seear & Fraser, 2016).

Another group of articles draws looks at research on the neural underpinnings of moral and legal decision-making. These articles address topics such as the role of emotional and rational processes in punishment decisions (Johnson et al., 2016; Taylor, 2016), and the problem of implicit bias among law enforcement personnel and legal decision-makers (Alexander, 2017; Salmanowitz, 2016).

3.3.3. The psychology of legislation and regulation (n = 3)

Three articles considered neuroscientific explorations of human emotion, perception and decision-making in relation to public responses to regulation in the area of disaster response (Keller, 2016), the use of visual (as opposed to solely textual) materials to develop and promote regulations (Porter & Watts, 2016), and governmental efforts to guide or "nudge" public behaviour (Stern, 2016).

3.3.4. Legal education (n = 3)

A small number of articles addressed legal education, exploring how the science of learning might affect legal pedagogy (Levy, 2016; Meyer, 2016), and discussing the psychological impact of legal education and legal careers on students and the obligation of law schools to foster law students' well-being (Peterson, 2016).

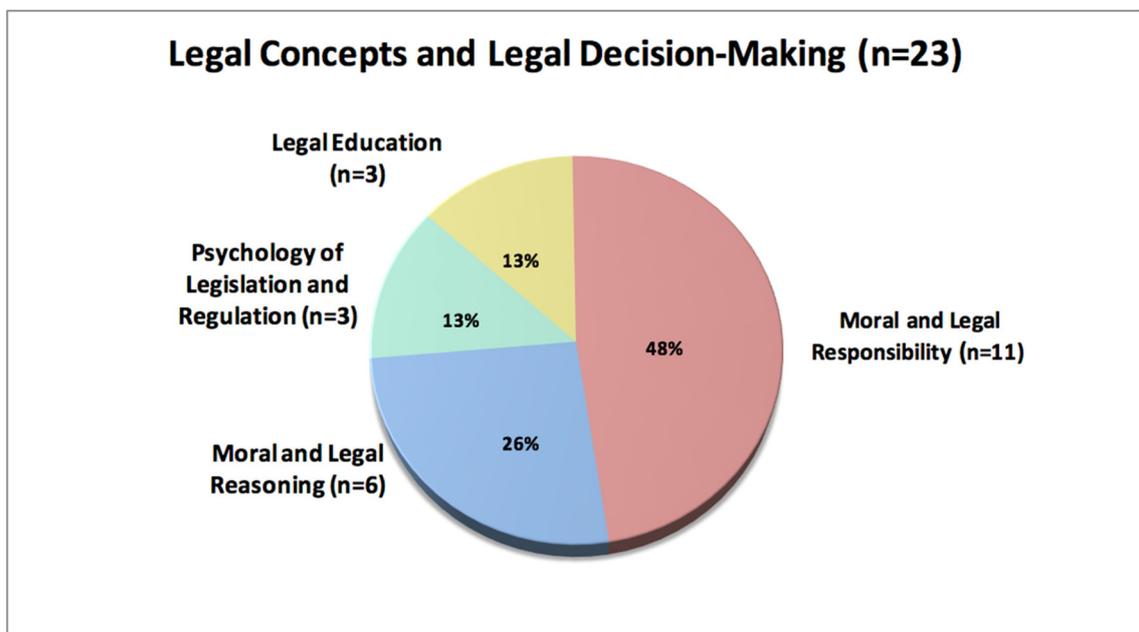


Fig. 5. Distribution of legal concepts and legal decision-making sub-categories.

3.4. Evidence law (n = 17)

Another major set of articles considered legal questions related to neuroscientific evidence. Most frequently, the articles considered potential novel uses of neuroscientific evidence as well as the limitations of their use and whether or not they would satisfy legal standards for the admissibility of novel scientific evidence. Another set of articles presented or commented on previously-published attempts to describe the actual use of neuroscientific evidence in a systematic manner. Finally a couple of articles addressed the impact of neuroscientific evidence on legal decision-makers (Fig. 6).

3.4.1. The uses, limitations and admissibility of neuroscientific evidence (n = 10)

Four articles consider the types of novel neuroscientific evidence that are or might be proposed for use in court, and evaluate their admissibility under the rules of admissibility for novel scientific evidence (Gur, 2016; Kerkmans & Gaudet, 2016; Murphy, 2016). Faigman, Slobogin, and Monahan (2016) consider the general problem of determining the admissibility and weight to be given to scientific evidence in court, illustrating their arguments with multiple examples drawn from brain sciences. Pallarés-Dominguez and González Esteban (2016) offer a social and philosophical critique of the use of neuroscientific evidence. Another four articles evaluate particular proposed uses of neuroscientific evidence including biomarkers (including neuroscientific biomarkers) to establish PTSD (Grey, 2016), detection of deception (Bard, 2016; Shapiro, 2016), dangerousness assessment (Gkotsi & Gasser, 2016), and evidence of pain and suffering (Somers, 2016).

3.4.2. Systematic reviews of the use of neuroscientific evidence (n = 5)

Two articles presented the results of systematic studies of published judicial decisions involving neuroscientific evidence (Denno, 2016; Gaudet & Marchant, 2016). Another three articles (Ginther, 2016; Meixner, 2016; Shen, 2016c) offer comments on recently published systematic studies of this type (Catley & Claydon, 2015; Chandler, 2015; de Kogel & Westgeest, 2015; Farahany, 2015).

3.4.3. Impact of neuroscientific evidence on judicial or jury decision-making (n = 2)

Two articles address the impact of neuroscientific evidence on legal decision-makers, including discussions of whether such evidence has disproportionate influence (Kuersten, 2016) and whether jurors' political orientation might affect their response to neuroscientific evidence in the criminal context (Mowle et al., 2016).

3.5. Human rights law and public law (n = 17)

In this section, we group together articles that address questions of human rights and public law. The articles raise neuroscience in relation to human rights topics like disability rights, a proposed right to educational, racial and other forms of discrimination, and freedom of thought and mental privacy. In addition, several domestic and international public law matters are also addressed, including child protection law, immigration law and international humanitarian law (laws of war and armed conflict). As with preceding section on criminal law, there was a pronounced focus on the science of juvenile brain development, with nine of the seventeen articles in this section addressing legal issues related to juveniles.

3.5.1. Human rights law (n = 10)

Four articles discussed the topic of disability law and rights, including neurological disabilities and disability insurance claim adjudication (Yang, 2016), rights to rehabilitative treatments for those with severe brain injuries (Wright & Fins, 2016), the applicability of the disability law framework to cognitively enhanced children (Krutzinna, 2016), and the application of disability discrimination laws to children with behavioural problems (O'Connell, 2016).

A set of four articles (two commentaries and the response of the authors) considered human rights violations related to ethnic and racial discrimination from a neuroscientific perspective. Murrow and Murrow (2016) discussed possible neurological links between implicit biases against out-groups, dampened empathetic responses, dehumanization, and human rights violations. The ensuing discussion from critics touched upon the policy implications in relation to hate speech and the ability of the science to support the hypothesized linkage (Hoffman, 2016; Roginsky & Tsesis, 2016). A fourth article also considered brain processes

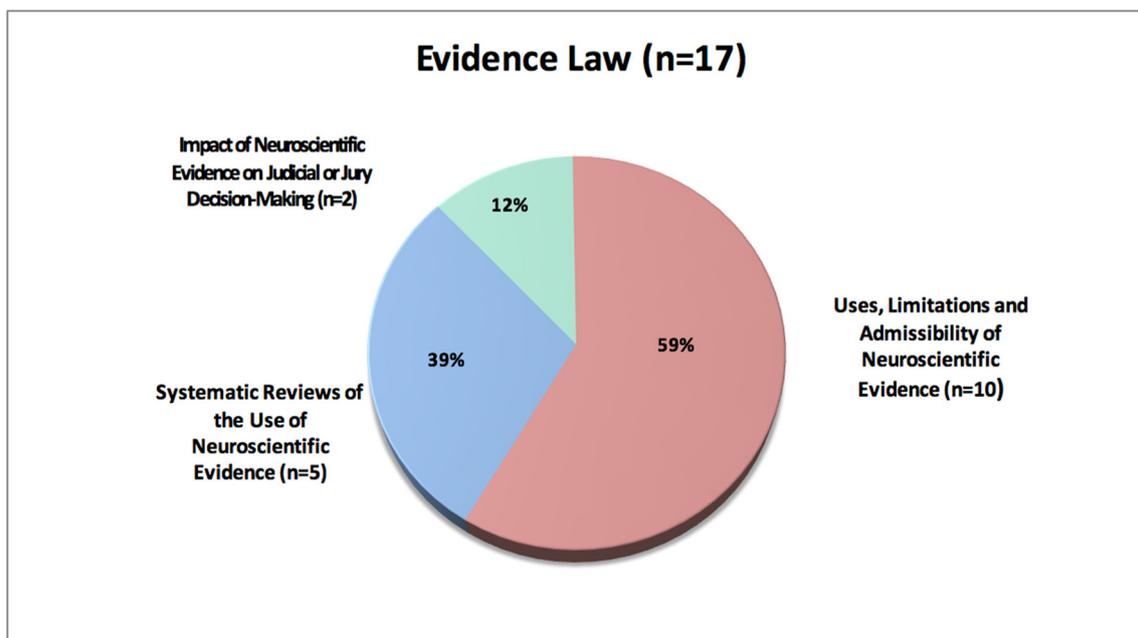


Fig. 6. Distribution of evidence law sub-categories.

in the context of implicit racial bias, and possible educational mechanisms to reduce this bias (Killenbeck, 2016).

Other human rights issues raised in this set of articles were constitutional human rights protections against potentially intrusive “mind-reading” technologies (Kolber, 2016), and a proposed constitutional right to education, supported in part by neuroscience of brain development (Shah, 2016b).

3.5.2. Domestic and international public law (n = 7)

Two articles in the group address questions relating to child protection laws. Both articles invoke the developmental neuroscience in discussing the harmful impacts of child abuse, and in making recommendations about the rules and procedures of child protection law (Gochnour, 2016; Shah, 2016c).

Another two articles considered brain development in childhood in the context of immigration law, exploring legal protections for children in immigration proceedings (Wolozin, 2016) and an age sensitive approach to the refugee applications of former child soldiers (Carmichael, 2016).

Three articles explore international law related to armed conflict in one way or another. Two consider the status of novel technologies under this law, including speculation about the use of biological enhancement and nanolaser technologies to manipulate the brain function of combatants (Leins, 2016; Sawin, 2016). A third article considers the culpability of child soldiers under international criminal law, drawing on developmental neuroscience (Fagan, Hirstein, & Stifferd, 2016).

3.6. Private law (n = 15)

Authors have also considered the intersection of private law topics and the brain sciences, and we have divided them into articles on alternative dispute resolution, tort, and a miscellaneous set of articles focused on business, commercial and employment legal issues. We have also grouped together articles addressing civil legal issues related to children (Fig. 7).

3.6.1. Tort law (n = 5)

Two articles consider the legal standard of care in quite different ways. One considers whether intraoperative neuromonitoring should

be the standard of care in surgical medicine (Brook & Irle, 2016), while another considers the possibility of personalizing the general “reasonable person” standard of care in negligence law using neuroscientific information about a defendant (Ben-Shahar & Porat, 2016). Three articles consider civil damage awards, addressing the traditional distinction between “emotional” and “physical injuries” (Persad, 2016), damages for brain injury in professional football (James, 2016), and the use in legal contexts of methods to detect malingered neurocognitive dysfunction (Monaci & Wood, 2016).

3.6.2. Alternative dispute resolution (ADR) (n = 4)

The ADR articles discuss ways to understand and improve outcomes in mediation and negotiation, drawing upon neuroscientific knowledge (Bader, 2016; Conklin, 2016; Pincock & Hedeen, 2016). Roberts (2016) focuses on gender differences in negotiation styles, strategies and outcomes, drawing on neuroscientific studies along with social and biological explanations for gender differences.

3.6.3. Children in a civil law context (n = 4)

Four articles use developmental neuroscience in various civil law contexts, including child custody determination (Bantekas, 2016), the risks of sharing personal information online and the capacity to contract in the online context (Costello, McNeil, & Binder, 2016), statutes of limitations for lawsuits arising from child abuse (La Puma, 2016), and the use of civil lawsuits for child sex trafficking (Smith, 2016).

3.6.4. Business and commerce law (n = 2)

This category focusing on commercial legal matters includes an article addressing the theory of trademarks and discussing neuroimaging research on brand recognition (Manta, 2016), as well as an article on the neuroscience of moral emotions, exploitative behaviour and the unconscionability doctrine in contract law (Keren, 2016).

3.7. General discussions of law and neuroscience (n = 4)

In this section, we group together articles that offer a broad view of the intersection of law and neuroscience, cutting across multiple domains of law. Francis Shen published three articles in 2016 of this type. These include a review of the preceding decade of neurolaw research and sketching out future directions for this area of research

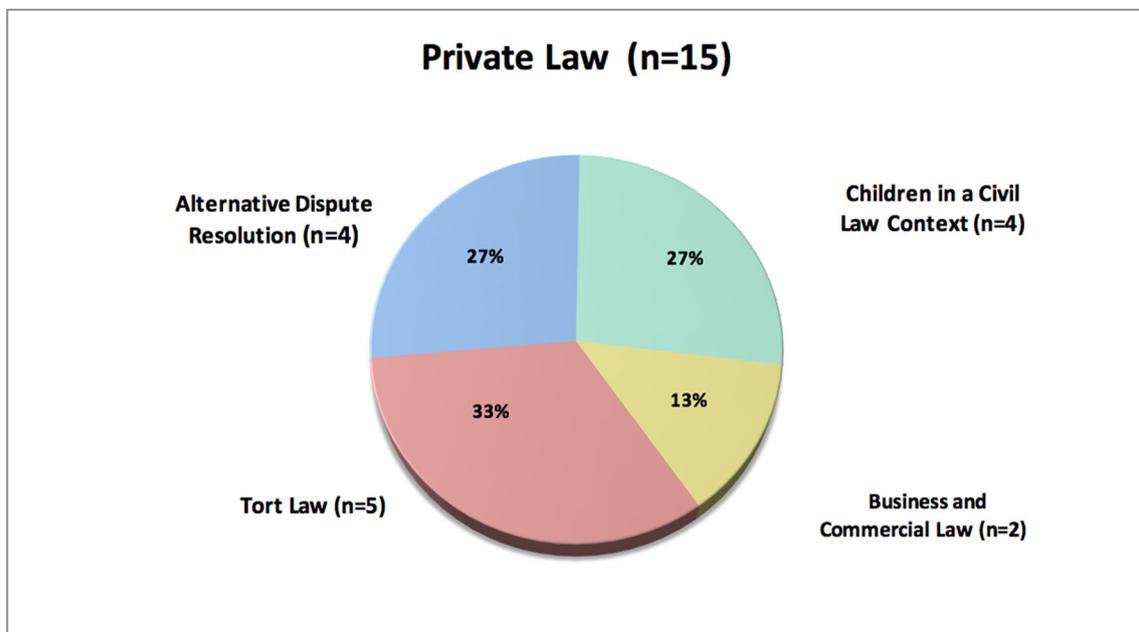


Fig. 7. Distribution of private law sub-categories.

(Shen, 2016a), a study of “neurolegislation” (“legislation that explicitly mentions the brain or brain sciences...including bills aimed at improving brain health and funding brain research, as well as those bills aimed at changing policies in domains such as education and criminal justice in part on the basis of brain science”) (Shen, 2016b) and a history of neurolaw in which Shen looks backward to historical developments in neurolaw from the late 19th century to the present (Shen, 2016d).

The fourth article is aimed at forensic psychiatrists providing expert testimony in civil and criminal contexts, and reviews the relevance and limitations of neuroscience in forensic practice (Fozdar, 2016).

4. Discussion

One clear cross-cutting tendency within our set of articles is the focus on developmental neuroscience and the particular implications of immaturity for decision-making capacity, responsibility and vulnerability to harmful (or openness to positive) environmental influences. This preponderance of attention to the developing brains of children, adolescents and even young adults is perhaps explained by two factors. First, several recent decisions of the U.S. Supreme Court (*Roper v. Simmons* (2005), *Graham v. Florida* (2010) and *Miller v. Alabama* (2012)), were prominent legal statements about the treatment of juveniles as a category within the American criminal justice system but were also noteworthy for relying, in part, on developmental neurosciences in their reasoning. Subsequently, many authors have extended the logic of those decisions, which pointed out the diminished responsibility as well as increased plasticity and capacity for change of juveniles, to multiple other legal contexts. Given that many of the articles in our set were by American authors publishing in American legal journals, it is thus unsurprising that this was a prominent theme in 2016. There is a second reason for the frequent appearance of developmental neuroscience in legal analysis. The phenomenon of developmental immaturity is universal and its characteristics fairly predictable and obvious. This is different from other forms of impairment that may or may not occur either in childhood or adulthood, and where there may be disagreement on the presence and characteristics of a neurological “impairment.” As a result generic legal rules can more easily be made for juveniles as a class, while a more individualized assessment is made for other types of conditions.

There is, of course, a serious tension underlying this enthusiasm for developmental neuroscience. The issue is the apparent inconsistency between legal efforts to expand liberty and autonomy rights for juveniles while at the same time emphasizing their diminished capacity in order to reduce retributive criminal responses. The article by Skelton (2016) illustrates this beautifully. She discusses the strategic decisions of child justice advocates in South Africa who were pursuing two constitutional cases simultaneously. One case dealt with minimum sentences for 16 and 17-year olds, while the other dealt with the criminalization of consensual sex between 12 and 16-year olds. Advocates were aware that neuroscientific evidence about diminished capacity would support an argument against a tough sentencing regime but would undermine efforts to decriminalize consensual sex among 12–16 year olds on the basis of the protection of their autonomy.

Our study also shows the continuing interest in the theoretical implications of biological causal explanations of behaviour. This discussion, which takes up long-standing themes related to existence or not of free will and the significance of free will or determinism for moral responsibility, has been voluminous. The interest remains, perhaps because of the seductiveness (for some) of an argument that would support a rehabilitative or at least more humane incapacitative criminal justice system rather than retributive criminal justice system. The shift between retributive and consequentialist justifications for the criminal justice system has been ongoing over the decades, and is likely to continue. Other themes that were raised less frequently in our dataset and, we think, in general, are the questions of (1) the extent, as an empirical matter, to which biological causal explanations of problematic behaviour affect the actual practices of judgment and blame of the public, legislators and

judges, (2) whether the legal reasoning of these groups can be shifted in some way through different framing of neuroscientific information or public education, and whether we should do so, and (3) whether neuroscience furnishes more knowledge and techniques with which to achieve retributive, rehabilitative, incapacitative and potentially preventive objectives (and, of course, the normative questions of whether we should use these methods to do so).

Articles addressing criminal law topics were more common than those addressing private law topics. This is perhaps due to the central importance of responsibility and diminished capacity in criminal law. It is true that some articles classified within evidence law were relevant to civil litigation. However, it appears that there is scope for expansion of the scholarship in the so far under-represented areas of private law as well as civil mental health law.

Our final observation is that the actual scope of the literature addressing the intersection of law and neuroscience is of course broader than the snapshot of 2016 provided by this systematic scoping review. Some 2016 articles were not captured by our indices, and other work is available from before and after 2016. Readers interested in this broader literature could take advantage of the useful online “Law and Neuroscience Bibliography” prepared by Francis Shen and the MacArthur Foundation Research Network on Law and Neuroscience (Shen, 2010). In addition to many other legal fields, authors have also written about law and neuroscience from the perspectives of cross-cutting schools of legal theory such as “law and economics,” including “behavioral law and economics.” We also note the interesting engagement between law and cultural neuroscience, which considers the linkages between culture, behaviour and neurobiology, and critical neuroscience, which considers the social production and social impact of neuroscience, in the literature.

5. Conclusion

It is clear that there is considerable interest in social, ethical and legal implications of the brain sciences. Here we have presented a “slice in time” summary of the peer-reviewed journal literature in English that addresses the intersection of the law (legal institutions, rules and procedures) with the brain sciences. Our objective was to describe the breadth of this literature and its dominant themes. Commentators are invoking neuroscience in an extremely broad array of legal contexts, even within one year alone. Future work could extend this analysis to examine shifts in the legal fields of interest over time, or into adjacent related literatures such as criminology or legal sociology. It seems likely to us that the continued public and scientific interest in the brain will continue to fuel scientific and technological developments in the area. The law, along with other social institutions and practices, will have to consider the legal significance of these developments.

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