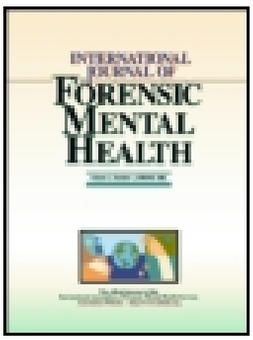

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REVIEW ARTICLE

Neurolaw in Latin America: Current Status and Challenges

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ABSTRACT

Despite several decades of growing interest in the concept of neurolaw in English-speaking countries, it is only a recent area of focus in Latin America. The objective of this article was to facilitate evidence-informed public policy by examining the current state of neurolaw in Latin America. To achieve this goal, this systematic review summarizes published articles, books, and book chapters, and discusses seminal legal cases in order to identify the current state of neurolaw in Spanish-speaking Latin American countries. In total, 61 publications were identified, with the majority coming from Mexico ($n = 17$), Argentina ($n = 15$), and Colombia ($n = 12$). None of the published work identified presented empirical research, but many publications discussed complex topics such as criminal responsibility, free will, and neuroethics. The scant literature base and high concentration of publications emanating from three countries suggest that despite its growing impact abroad, more work is needed in this area in order to influence Latin America legislation and on the development of public policies. Future areas of research and policy related implications are discussed.

KEYWORDS

Neurolaw; Latin America; neuroscience; criminal law

The relationship between black robes (law experts) and white coats (psychology experts) has a fascinating history (García-López, 2010) and is referred to in numerous historical texts, including the Hammurabi Code (1750 BCE), the Talmud Law (3rd century), Digesto (533 AD), the Fuero Juzgo (previously the *Forum Iudiciorum* or *Liberludiciorum*, 654 AD), HsiYüan Lu (1247), and the *Constitutio Criminalis Carolina* of 1532 (Esbec & García-López, 2016). As for the relationship between the law and neuroscience, there are several historical events that are of importance, including (according to Shen, 2016a) the first use of electroencephalography (EEG) in the courts in the mid-20th century, the use of psychosurgery for the prevention of violence in the 1960s and 1970s, and the development of neurolaw in the 1990s. These early neurolaw cases focused on the use of neuropsychology and neurohabilitation testimony as evidence in the personal injury litigation cases of people who suffered a cranio-encephalic trauma (Shen, 2016a; Taylor, Sherrod, & Anderson, 1991). Morse (2017) has noted that neuroethics and neurolaw have only recently become subjects of attention and investigation, and there is an increasing possibility that neuroscientific research may be used to clarify and refine legal mental state categories (e.g., *mens rea* and mental disorder). Today, neurolaw is a growing interdisciplinary area that integrates neuroscience research on legal standards and practice (Goodenough & Tucker, 2010), uniting individuals from several disciplines, including social scientists, neuroscientists, lawyers, and philosophers (Vincent, Hall, & Kennett, 2013). However, the state of the field is still under construction, because—as Morse highlighted—Neurolaw could reach its aims if a "proper framework for the relevance of neuroscience to law is established and if a cautious approach to the science is adopted" (Morse, 2017, p. 40).

In recent years, the intersection of neuroscience and law has generated great interest all over the world (Spranger, 2012). Neuroscience in this context has been defined as the multidisciplinary scientific study of the brain that aims to understand the biological mechanisms and nervous system associated with mental activity and behavior (Albright, Jessell, Kandel, & Posner, 2000; Bloom, 2008; Kandel, 2013). The use of

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neuroimaging, as it is applicable to criminal cases, has captured the attention and interest of legal and psychological professionals internationally, and discussion of this topic can be found in multiple countries, including Italy (Corda, 2016; Santosuosso & Bottalico, 2013), France (Bourgeois, 2015; Pignatel & Oullier, 2014), Mexico (García-López, 2016a), Argentina (Silva, Mercurio, & López, 2008), and the United States (Shen, 2016a). Furthermore, over the past decade, neurolaw is beginning to demonstrate relevance in legal, research, and applied settings. For example, in 2014, in Spain, the *Instituto de Medicina Legal de Aragon* opened a unit of Forensic Neuroscience which aimed to evaluate the cognitive function of the brain through the evaluation of event-related potentials (ERPs). In the United States, the U.S. Court of Appeals for the Sixth Circuit (*United States v. Semrau*, 2012) held the first *Daubert* hearing to determine the admissibility of functional magnetic resonance imaging (fMRI) for lie detection (Shen, 2010). Recent reports also show rapid growth in the use of neurobiological evidence in American courtrooms. For example, Farahany (2016) examined 1,800 judicial opinions that included reference to neurobiological evidence. In fact, the use of neurobiological evidence in criminal cases has increased from only 100 judicial opinions including reference to neurobiological evidence in 2005 to up to 300 opinions in 2012 (Farahany, 2015). Although most neurobiological evidence is used in an attempt to reduce criminal sanctions, it has limited success. The second most common use of neurobiological evidence is to challenge competency in criminal cases, including competency to stand trial. The number of law review articles that include neuroscience is also increasing, demonstrating a growing interest in this field for legal professionals (Shen, 2010, 2016a).

Despite several decades of interest in the concept of neurolaw in English-speaking countries, it has only recently become an area of focus in Latin America, with the concept emerging in Latin American scholarship in the mid-2000s. In 2005, a group of lawyers, anthropologists, and psychologists from Brazil and Spain published the first Latin American article on the topic in *Ludus Vitalis,* a Mexican philosophy journal. In their paper, Fernández, Marty, Nadal, Capó, and Cela-Conde (2005) examined how cognitive neuroscience influences the theoretical and methodological structure of jurisprudence. Since the mid-2000s, several recurrent themes in neurolaw have continued to emerge in Latin American publications, typically focusing on the presence of mental disorders or an individual's age as they relate to criminal responsibility, volitional capacity, and neuroethics.

It is important to highlight that several publications have covered the significance of neuropsychological evaluations in the forensic field within the international context (e.g., Seruca & Silva, 2016; White, Batchelor, Pulman, & Howard, 2012). These publications emphasize the relevance of forensic psychology in the elaboration of public policies and in care and treatment programs in both civil and criminal contexts, as well as offenders' cognitive processes more generally (e.g., Roesch & Cook, 2017). Although interest in the intersection of neuroscience and law in Latin America is growing, this region has yet to create its own research agenda for problems that may be specific to Latin America, such as the high rate of violence (Heinemann & Verner, 2006) or the impact of poverty on behavior and cognition. For example, although the global homicide rate is 5.3 per 100,000 (The World Bank, 2016), the homicide rate is much higher in Latin American countries: 90.4 per 100,000 in Honduras; 53.7 per 100,000 in Venezuela; 30.8 per 100,000 in Colombia; 25.2 per 100,000 in Brazil; and 25 per 100,000 in Mexico (Instituto Nacional de Estadística y Geografía, 2018; United Nation Office on Drugs and Crime (UNODC, 2014). These high rates of violence influence the problems researchers analyze in the field of law and neuroscience in each country. Although it may appear more urgent to examine the effectiveness of criminal sanctions, criminal responsibility, and the effectiveness of the penitentiary system, more effort should likely be invested in the study of restorative justice programs that may prevent crime from reoccurring. Prevention programs and evidence-based public policies are needed in Latin America, as these programs can be more effective than punishment in reducing violent crime. Studying the complex relationship between the brain and violence may be an important step in reducing rates of violence in Latin American countries. It follows, however, that neuroscientists, lawyers, and policy makers must communicate with one another in order to apply what is learned from research on the scientific basis of human behavior to inform policy and criminal justice legislation.

This article is an important step in identifying the current state of neurolaw in Latin America. It aims to review the existing research and philosophical discussions that have taken place and analyze the current legislative law and judicial decisions as they relate to neurolaw. Neurolaw is an internationally important concept and analyses already exist of its current state

in several continents, such as North America, Europe, Oceania, and Asia (Spranger, 2012). As law is a cultural practice, this article will provide information to help understand how the field of neurolaw is understood and applied in Spanish-speaking Latin America countries, in order to compare these findings with other countries and regions. For a review of the intersection of neuroscience and Brazilian law, see Prata and Sabino de Freitas (2012).

Method

Sample and inclusion criteria

A systematic literature review was conducted to identify research and scholarship that explored the intersection of neuroscience and law (neurolaw) in Latin America. To be included in this review, the publications must have been written in Spanish and published in Latin America (i.e., printed and produced by a Latin American journal or book publisher). The purpose of this inclusion criteria was to identify all relevant work completed in Latin America and available to Latin American professionals (e.g., mental health clinicians, neuroscientists, lawyers, and policy makers) in the Spanish language. The countries included in this review were Argentina, Bolivia, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela. Forensic neuropsychology[1] papers were excluded from this analysis because that field goes beyond the scope of neurolaw used in this article.

Online databases were electronically searched for articles and books relevant to neurolaw by searching for titles, abstracts, and keywords which contained the terms *neurociencias y derecho* [neuroscience and law], *neuroderecho* [neurolaw], or *neurolaw* and *Latin America*. The search parameters included literature up until the date of the search (June 2018) in order to identify all potentially relevant documents. Several databases were searched, including international online databases (i.e., Annual Reviews, EBSCO, Scopus, ProQuest, PubMed, PsycNET, Thomson Reuters, Web of Science, Google Scholar), and Latin American and Spanish online databases (i.e., Dialnet, LatIndex, REDALyC, Scielo). Other resources were also searched including university library databases and online legal institutions in Latin America (e.g., court websites and local university law libraries). For the purpose of this study, five data variables were coded for all publications that met inclusion criteria: reference details, year, type of publication (article, book, or book chapter), area of focus (e.g., neuroscience, law, psychology, philosophy), and country of publication.

Figure 1 presents the four-phase search strategy flow diagram for this review (Moher, Liberatti, Tetzlaff, Altman, & The PRISMA Group, 2009). An initial 651 publications matched the study's search terms. Titles and abstracts were screened by both the first and second author, and 526 publications were excluded as duplicates or for not meeting the inclusion criteria. The majority of studies excluded did not address issues relevant to neurolaw, were duplicates, or did not meet the inclusion criteria (e.g., were published in Spain or Brazil). Full-text articles ($n = 141$) were then reviewed, and a further 80 texts were excluded (e.g., articles and books published in Spain, topics outside area of focus). This left 61 publications that met the inclusion criteria.

Seminal legal cases were also reviewed and included in this study's results section to described how neuroscience has been used in legal cases in Latin America. In order to identify the legal cases where neurobiological evidence was used to inform legal decisions, internet searches were completed for all included Latin American countries in order to identify relevant newspaper articles and/or legal decisions. Furthermore, cases that were referenced in the publications identified in this systematic review are also discussed in the results section.

Results

The 61 articles, books, and book chapters included in this article were published between 2004 and 2018 (see Table 1). As mentioned above, the first neurolaw article in Latin America was published in Mexico in 2005 (Fernández et al., 2005), although García-López (2004) mentioned the importance of neuroscience for determining the age of criminal responsibility one year prior. There was an average of 4.5 publications per year, with wide variability in the rate of publications across the time frame (see Figure 2). For example, between 2004

[1] There are several interesting forensic neuropsychology studies produced out of Latin American research programs, including studies that examined the attention, memory, and executive functions of forensic populations, such as prisoners (Arias & Ostrosky, 2010), empathy levels of violent psychopathic offenders (Díaz, Ostrosky, & Romero, 2015), orbitofrontal functioning among psychopaths (Díaz, Ostrosky, Ortega, & Pérez, 2013), serial murderers (Ardila & Ostrosky, 2009), and the neurobiology of morality (Ostrosky & Vélez, 2008). However, these studies do not specifically analyze the relationship between neuroscience and law. Instead, they concentrate their efforts on neuropsychological evaluation, and their conclusions are closer to forensic neuropsychology than to neurolaw. In the realm of Philosophy of Law, research from Mexico addresses mental models of judicial reasoning (Cáceres, 2011; 2012; 2017) which is more related to neuroethics than to neurolaw.

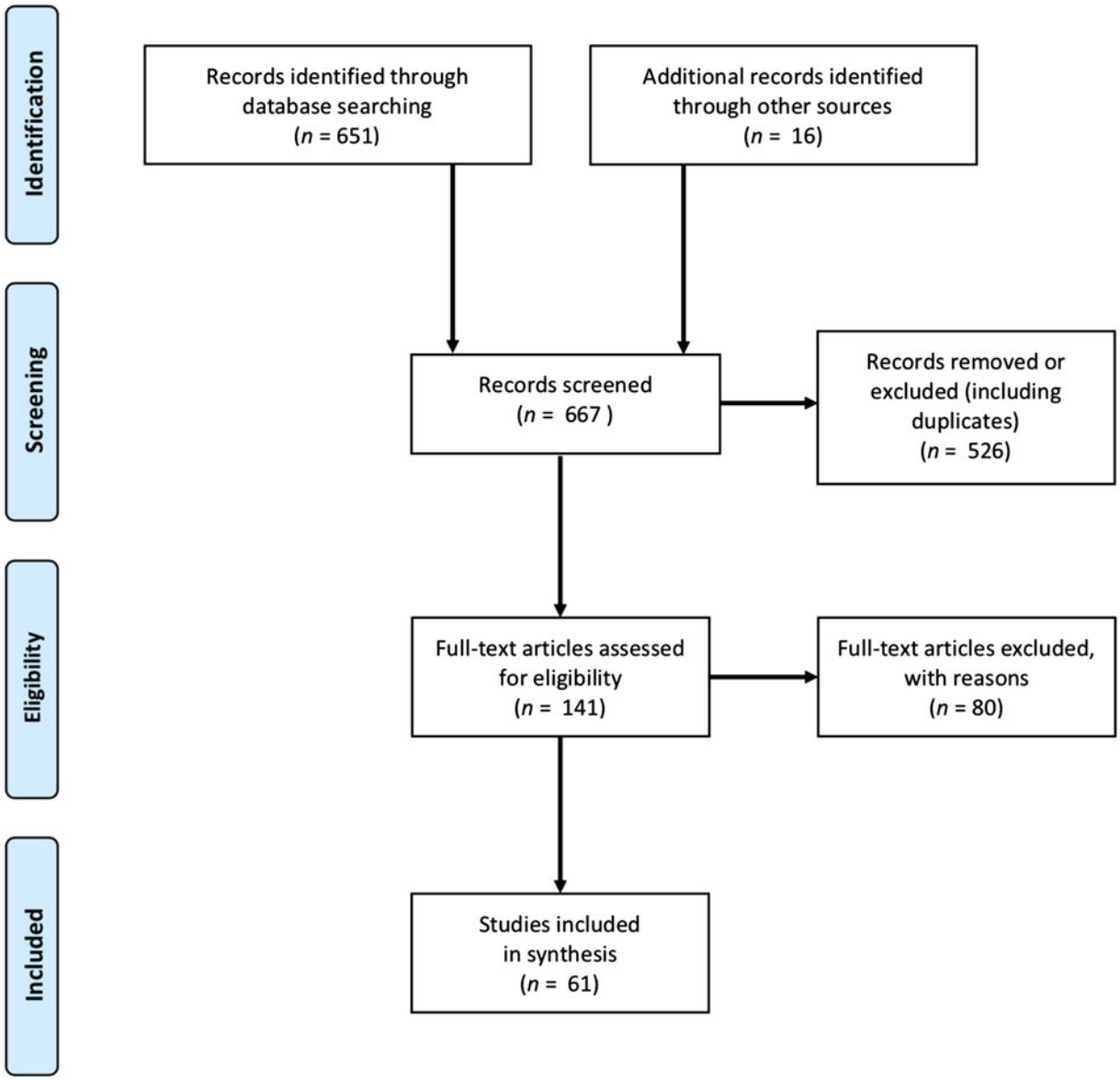

Figure 1. PRISMA four-phase search strategy flow diagram.

and 2007 only one article was published per year, but by 2008, the number of publications increased to about two or three per year until 2016, which peaked with a total of 11 publications.

The majority of the publications were in academic journals ($n = 37$, 60.6%) and the rest were either books ($k = 14$, 22.9%) or book chapters ($k = 10$, 16.3%). Of the 61 articles, books, and book chapters, 40 (65.5%) were published in legal journals or law books, whereas 9 (14.7%) were published in texts relating to the field of psychology. Several publications were published in journals or books from other disciplines, including philosophy ($k = 3$, 4.9%), psychiatry ($k = 3$, 4.9%), and political science ($k = 1$, 1.6%). Articles in law journals were the most common publication type ($k = 27$, 44.2%), demonstrating the high level of interest in this field among law professors and legal scholars, with somewhat less interest in other areas like forensic psychology and forensic psychiatry ($k = 4$, 6.5%). All publications presented theoretical discussions, typically drawing on research from other parts of the world, with no publications analyzing original neuroscience data collected in Latin America.

The most frequent topic of discussion was criminal responsibility ($k = 25$, 40.9%), free will ($k = 21$, 34.4%), and the culpability of adolescents ($k = 8$, 13.1%). Although three quarters of the publications were from three countries: Mexico ($k = 17$, 27.8%), Argentina ($k = 15$, 24.5%), and Colombia ($k = 12$, 19.6%), a handful of publications identified were from Chile ($k = 6$, 9.8%), Peru ($k = 5$, 8.1%), Costa Rica ($k = 3$, 4.9%), Uruguay ($k = 2$, 3.2%), and Paraguay ($k = 1$, 1.6%). No

Table 1. Neurolaw publications in Latin America (2004–2018); $N = 61$.

Author	Year	Country	Discipline	Publication Type	Publication Format	Topic
Ariano	2016	Peru	Law	Theoretical discussion	Journal Article	Criminal responsibility; Free will
Arocena, Balcarce, & Cesano	2015	Argentina	Law	Theoretical discussion	Book	Criminal responsibility; Free will
Balbuena	2013	Paraguay	Law	Theoretical discussion	Book	Criminal responsibility; Free will
Balcarce	2014a	Colombia	Law	Theoretical discussion	Journal Article	Criminal responsibility; Free will
Balcarce	2014b	Argentina	Law	Theoretical discussion	Book	Criminal responsibility Free will; Enhancement; Punishment
Cancio	2016	Uruguay	Law	Theoretical discussion	Journal Article	Criminal responsibility of psychopaths
Capó, Nadal, Ramos, Fernández & Cela-Conde	2006	Mexico	Philosophy	Theoretical discussion	Journal Article	Neuroethics and punishment
Cárdenas	2017	Mexico	Bioethics	Theoretical discussion	Journal Article	Free will
Carvajal	2015	Costa Rica	Humanities	Theoretical discussion	Journal Article	Neuroethics
Causillas	2017	Peru	Law	Theoretical discussion	Journal Article	Admissibility; Lie detection; Neuroimaging
Chan	2011	Costa Rica	Law	Theoretical discussion	Journal Article	Adolescent brain and reduced criminal responsibility
Chan	2013	Costa Rica	Law	Theoretical discussion	Journal Article	Criminal responsibility; Free will
Demetrio	2014	Mexico	Law	Theoretical discussion	Journal Article	Criminal responsibility; Free will
Demetrio	2017	Uruguay	Law	Theoretical discussion	Book	Criminal responsibility; Free will
Díaz	2015	Colombia	Law	Theoretical discussion	Journal Article	Free will; Philosophy of the mind
Díaz, Giordano & Mercadillo	2017	Mexico	Bioethics	Theoretical discussion	Book	Neuroethics
Espinosa	2016	Mexico	Law	Theoretical discussion	Journal Article	Neuroethics
Etchichury	2015	Chile	Political Sciences	Theoretical discussion	Journal Article	Poverty and cognitive development
Fernández	2007	Mexico	Philosophy	Theoretical discussion	Journal Article	Neuroethics
Fernández, Marty, Nadal, Capó & Cela-Conde	2005	Mexico	Philosophy	Theoretical discussion	Journal Article	Neuroethics
García-López	2004	Mexico	Psychology	Theoretical discussion	Journal Article	Adolescent brain and reduced culpability
García-López	2012	Mexico	Psychology	Theoretical discussion	Book Chapter	Criminal responsibility
García-López	2016b	Mexico	Psychology	Theoretical discussion	Journal Article	Criminal responsibility
García-López, Ostrosky, Laveaga & Esbec	2016	Mexico	Law	Theoretical discussion	Book	Criminal responsibility; Free will; Neuroimaging
Gómez	2016	Colombia	Law	Theoretical discussion	Book	Criminal responsibility; Free will; Neuroimaging
Gómez & Gutiérrez de Piñeres	2017	Colombia	Law	Theoretical discussion	Book	Criminal responsibility; Free will; Nuroimageing, Social cognition; Lie detection
Gómez-Mont	2017	Mexico	Law	Theoretical discussion	Journal Article	Criminal behavior; Gender violence; Punishment
González, Rivarola, Crovetto & Rozas	2014	Peru	Law	Theoretical discussion	Journal Article	Bias; Decision making
Gutiérrez de Piñeres	2017	Colombia	Psychology	Theoretical discussion	Book Chapter	Free will; Moral behavior; Decision making
Ibañez	2016	Peru	Law	Theoretical discussion	Journal Article	Criminal responsibility; Free will
Jiménez	2016	Colombia	Law	Theoretical discussion	Journal Article	Criminal responsibility of psychopaths
Jiménez & Robledo	2011	Colombia	Law	Theoretical discussion	Journal Article	Brain functioning and aggression
Leyton	2014	Chile	Law	Theoretical discussion	Journal Article	Criminal responsibility; Free will
Lorenzo & Agustina	2016	Chile	Law	Theoretical discussion	Journal Article	Criminal responsibility of psychopaths; Dangerousness
Madera & Zarabozo	2010	Mexico	Neuroscience	Theoretical discussion	Book Chapter	Brain functioning and aggression
Medina	2015	Colombia	Law	Theoretical discussion	Journal Article	Culpability; Free will; Neurocriminology; Punishment

(*Continued*)

Table 1. Continued.

Author	Year	Country	Discipline	Publication Type	Publication Format	Topic
Mercurio	2008	Argentina	Psychiatry	Theoretical discussion	Journal Article	Neurocriminology
Mercurio	2009b	Argentina	Psychiatry	Theoretical discussion	Journal Article	Culpability
Mercurio	2011	Argentina	Law	Theoretical discussion	Journal Article	Adolescent brain and reduced culpability
Mercurio	2012a	Argentina	Law	Theoretical discussion	Book	Adolescent brain and reduced culpability
Mercurio	2012b	Argentina	Law	Theoretical discussion	Journal Article	Drug abuse; Culpability
Mercurio	2012c	Argentina	Psychiatry	Theoretical discussion	Book Chapter	Culpability; Neuroimaging
Mercurio	2013	Chile	Law	Theoretical discussion	Book	Culpability; Neuroimaging
Mercurio	2014	Chile	Law	Theoretical discussion	Book Chapter	Adolescent brain and reduced culpability
Mercurio & García-López	2017a	Argentina	Law	Theoretical discussion	Journal Article	Adolescent brain and reduced culpability; Minimum age of criminal responsibility
Mercurio, García-López & Ostrosky	2018a	Mexico	Psychology	Theoretical discussion	Book Chapter	Adolescent brain and reduced culpability
Mercurio, García-López & Ostrosky	2018b	Mexico	Psychology	Theoretical discussion	Book Chapter	Adolescent brain and reduced culpability
Morales	2010	Mexico	Psychology	Theoretical discussion	Book Chapter	Neurocriminology
Morales & García-López	2014	Colombia	Psychology	Theoretical discussion	Book Chapter	Neurocriminology
Narváez	2014	Argentina	Law	Theoretical discussion	Journal Article	Neurophilosophy; Dualism mind-body
Olano	2013	Colombia	Law	Theoretical discussion	Journal Article	Criminal responsibility
Palmero	2012	Argentina	Law	Theoretical discussion	Journal Article	Criminal responsibility; Lie detection. Privacy; Free will
Rocha	2013	Colombia	Law	Theoretical discussion	Book	Criminal responsibility; Moral behavior
Sacco	2016	Peru	Law	Theoretical discussion	Book	Philosophy of law; Mirror neurons; Legal innatism
Silva, Mercurio & López	2008	Argentina	Law	Theoretical discussion	Book	Criminal Responsibility
Slachevsky, Silva, Prenafeta & Novoa	2009	Chile	Medical	Theoretical discussion	Journal Article	Neuroethics
Symington	2012	Colombia	Law	Theoretical discussion	Journal Article	Free will; Criminal responsibility
Tovar & Ostrosky	2013	México	Psychology	Theoretical discussion	Book	Criminal responsibility; Moral behavior; Psychopathy
Valente	2014	Argentina	Law	Theoretical discussion	Journal Article	Drug abuse; Mental health; Neuroethics
Van Weezel	2011	Argentina	Law	Theoretical discussion	Journal Article	Free will; Criminal responsibility
Zavadivker	2016	Argentina	Law	Theoretical discussion	Book chapter	Free will; Neurophilosophy

publications were identified from the other Spanish-speaking Latin American countries such as Bolivia, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, or Venezuela.

As the majority of the identified publications were from Mexico, Argentina, and Colombia, the following sections will provide a deeper examination and analysis of the state of neurolaw in these three countries rather than the other Latin American countries which have fewer publications on the topic. Each section begins with a review of relevant criminal cases that have used neuroscience evidence, followed by a brief review of the types and focus of neurolaw literature identified in the systematic search.

Background of neurolaw in Latin America

Mexico

One of the first cases to use neuroscience in Mexico was the case of Gilberto Flores Alavez, who was accused of the double homicide of his grandparents in 1978 (Leñero, 1985). This was perhaps the first case in Mexico in which neurological tests were carried out for an assessment to aid in a criminal defense. During this case, Flores's father employed a team of forensic experts (e.g., experts in criminalistics, hematology, orthopedic surgery) to opine on the legal issues (Leñero, 1985). The defense requested two neurological evaluations to examine the biological bases of the accused's aggressiveness. A cytogenetic study was also requested by the defense (Leñero, 1985). The forensic experts concluded that evidence from objective neurological, psychiatric, and psychological tests indicated that Flores met the criteria for a compulsive obsessive type, behavioral disorder, classified as a compulsive obsessive psychoneurosis under the World Health Organization's (WHO) classification of diseases (WHO, 1967). Despite the results of the evaluations, Flores was sentenced to 28 years in prison.

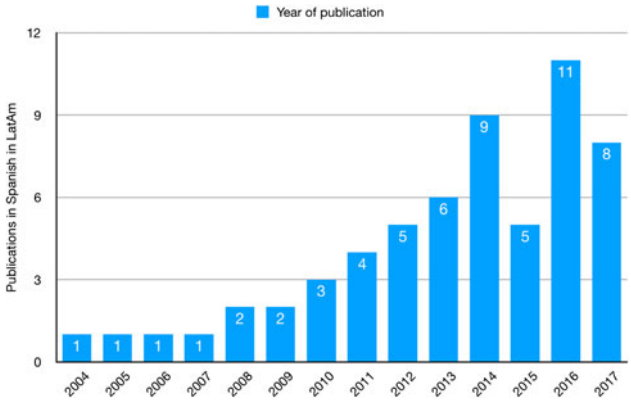

Figure 2. Number of publications on neurolaw in Latin America (2004–2017).
Note. By mid-2018, two additional texts were published, but are they are not included in this figure as the 2018 full calendar year would not be represented.

However, after an appeal to the Supreme Court of Justice of the Nation in 1989, he was set free for legal reasons that did not relate to his psychiatric diagnosis. This case demonstrated that despite the use of two neurological evaluations in Flores' defense, there was no evidence to suggest that neuroscience "triggered any type of criminal judiciary reflection" at that time (Gómez-Mont, 2017, p. 41).

Other than the Flores case, there are only a handful of recent legal cases in Mexico that emphasize the relationship between law and neuroscience. In Baja, California in 2016, Jesús N. was accused of attempted murder after attacking a random passerby (Vargas, 2017). Based on the results of a neurological evaluation, which included an interview, an EEG, and computed tomography (CT) and magnetic resonance imaging (MRI), the defendant was asserted to have a "permanent subcortical left frontal atrophy" (Vargas, 2017, p. 2). This atrophy could not be explained by the individuals age, and thus, based on this evidence, the defense successfully argued that he had a mental disability and the court opined that he was not guilty.

One of the most famous Mexican cases that admitted evidence from a neurological evaluation is that of Juana Barraza, a 48-year-old woman accused of 12 thefts and 16 murders in Mexico City between 1998 and 2006 (Ostrosky, 2008). In this case, neuropsychological testing was used to inform potential explanations of her behavior. Specifically, the goal of the evaluation was to understand the neuropsychological differences between those who are serial murders and those who only commit one crime, and was not intended to mitigate her criminal responsibility. During the evaluation, Barraza was presented with stimuli in order to determine how she processed each photo and specifically, her ability to assess the stimuli's content (pleasant/unpleasant), emotional activation (excited/calm), and moral content (low/high). The results suggested that Barraza assessed neutral stimuli with emotional impulses and overrated the unpleasant stimuli. In other words, she processed all stimuli (neutral, pleasant, unpleasant, with and without moral content) differently when compared to the average person. For example, she assessed a wastebasket as pleasant with moral content because "it is used to keep order and neatness" (Ostrosky, 2008, p. 95). Based on the results of the evaluation, experts opined that Barraza processed information more quickly and superficially than the average person and that this may be related to her high rates of violence. However, this information did not prevent Barraza from being sentenced to 759 years in prison.

In Mexico, there is a growing body of academic initiatives in the area of neurolaw, including specialized publications and scientific research activities. This review identified 17 publications from Mexico: 10 articles, 2 books, and 5 book chapters. These 17 documents analyzed the forensic relevance of neuroscience for criminal law (Demetrio, 2014; García-López, 2012; García-López, Ostrosky, Laveaga, & Esbec, 2016; Laveaga, 2016), adolescent brain and reduced culpability, the minimum age of criminal responsibility (opposing its reduction) (García-López, 2004; Mercurio, García-López, & Ostrosky, 2018a, 2018b), neuroethics (Capó, Nadal, Ramos, Fernández & Cela-Conde, 2006; Díaz, Giordano, & Mercadillo, 2017; Espinosa, 2016), and free will (Demetrio, 2014; García-López, Ostrosky, Laveaga, & Esbec, 2016; Laveaga, 2016). None of these publications presented novel empirical data, but instead used the results of international studies in the discussion of issues.

The books and articles identified ranged from broad examinations of the relevance of neuroscience for criminal law to more specific examinations. For example, chapters of García-López, Ostrosky, Laveaga, and Esbec's (2016) book on neurolaw reviewed topics such as criminal responsibility, free will, forensic psychology, neuropsychology, and legal implications of neuroimaging and the brains of psychopaths (Laveaga, 2016; Ostrosky, 2016). Conversely, some publications reviewed specific topics, such as the research on brain alterations found in violent subjects (Gómez-Mont, 2017; Madera & Zarabozo, 2010; Morales, 2010). Likewise, Mercurio, García-López, and Ostrosky (2018a, 2018b) analyzed and discussed adolescent brain development, growth, and maturation

and how this has impacted juvenile criminal justice policy in the United States.

Other publications identified in this review examined issues relating to neuroethics, neurodeterminism, and freewill. In one book, Díaz, Giordano, and Mercadillo (2017) compiled a series of articles on neuroethics, examining topics such as free will and the brain, moral emotions, awareness, and the ethical implications of neuroscience. Similarly, both Demetrio (2014) and Capó, Nadal, Ramos, Fernández, and Cela-Conde (2006) reviewed neuroethical arguments raised by German neuroscientists (e.g., Gerhard Roth, Wolfgang Prinz and Wolf Singer), while discussing the concepts of determinism, free will, culpability, and criminal responsibility. These texts raised questions such as whether freedom is an illusion or whether conclusions drawn from neuroscience eliminate the concept of guilt and criminal responsibility. Conversely, some authors discussed free will (Cárdenas Krenz, 2017; Espinosa, 2016) and referenced Gazzaniga's (2006) argument that individuals are agents with personal responsibility, free to make their own decisions, and thus, brain functioning cannot be blamed for the behavior they engage in. This debate was addressed in other publications as well, with examinations of the neurobiological bases of moral judgements (Fernandez, 2007; Fernández et al., 2005). For example, Fernandez (2007) examined how greater knowledge of how the brain is involved in moral reasoning can influence the legal field. Similarly, Tovar and Ostrosky (2013) reviewed neuroscience pathways and analyzed the brain circuits of moral judgment as it relates to criminal responsibility and psychopathic brains. Again, these arguments drew heavily on research and theoretical discussions conducted in other countries. In sum, while Mexico has benefited from a relatively large cohort of scholars writing (in Spanish) and synthesizing the research and theoretical arguments put forward by other researchers, there has not yet been any research applying neuroscience methodologies or techniques to forensic questions. Likewise, there is little evidence that these theoretical papers and books have impacted criminal justice policies.

Argentina

The intersection of neuroscience and law first appeared in the Argentinean courts in the 1996 murder case of Fabián Tablado (Tablado S/Homicidio, 1998). The Tablado case was the first in Argentina to introduce functional neuroimaging as evidence in the criminal justice system, and the first in all of Latin America in which structural and functional neuroimages were introduced as evidence for a plea of not guilty by reason of insanity (NGRI). In May 1996, Tablado, a 19-year old male, murdered his girlfriend by stabbing her 113 times in the Tigre province of Buenos Aires. The defense requested structural and functional neuroimaging techniques including EEG, brain mapping, MRI and single-photon emission computed tomography (SPECT). The imaging provided evidence of functional alterations, with two of the EEGs showing alterations in the temporal lobe, while the brain SPECT showed low perfusion in the frontal lobe.

In the Tablado trial, although defense and state experts agreed on Tablado's diagnosis of borderline personality disorder, they differed with regard to their opinions on its implications. Goldar, who participated as a forensic expert in this case, stated that even though the brain structure was normal, the outcome of the functional neuroimaging study showed an alteration in the regions responsible for inhibiting behavior (Tablado, Fabian S/Homicidio, 1998). Nevertheless, he argued that such results should be interpreted cautiously, as they only showed brain activity during the time the studies were completed, and may not reflect Tablado's actual brain functioning at the moment of the event, two years earlier. In December of 1998, Tablado was sentenced to 24 years in prison for murder in a divided verdict (Tablado Fabian S/Homicide, 1998). Thus, in this case, the neuroscientific evidence did not convince the court to decrease the sentence.

Functional neuroimaging was also presented in front of an Argentinean judicial court in 2005, in the criminal trial of Horacio Conzi, who was also accused of murder (Conzi, Horacio Santiago S/Homicidio, 2005). Conzi had a traumatic brain injury in 1986 and a history of severe alcohol consumption. During the trial, the debate focused on the culpability of the defendant, with the defense alleging he was experiencing psychosis at the time of the offense. The CT scan and MRI were normal, but the SPECT showed low perfusion in the frontal lobe. During the trial, the nuclear medicine expert identified the forensic limitations of functional neuroimaging by indicating that such findings did not imply a diagnosis *per se*. In fact, the expert opined that there was no evidence to link a specific brain activation pattern with criminal behavior. The trial ended with a 25-year sentence in prison for several counts of attempted murder (Conzi, Horacio Santiago S/Homicidio, 2005). As in the Mexican cases, the neuroscientific evidence did not

appear to reduce the length of the accused's sentence as it did not definitively demonstrate an impairment in the defendant's functioning.

More recently, some judicial sentences in Argentina have begun to rely on neuroscience evidence in their analyses and arguments regarding NGRI or competency to stand trial (T.G.D. S/Robo, 2014). References to neuroscience have also been included in cases that raise issues of addiction (Pereyra, Carlos Andres S/Robo, 2012). Such is the case in the recent decision of the 24th Buenos Aires Oral Criminal Court (Pereyra, Carlos Andres S/Robo, 2012). During the hearing, several forensic psychiatry experts opined that the defendant had a substance use disorder, although they disagreed as to whether it qualified as a disease according to the legal standard. The judges agreed with defense experts, concluding that the defendant had a complex and severe substance abuse disorder, and they had strong doubts as to the freedom of the defendants' actions. In their legal decision, the judges discussed the nature of a mental disease and their restrictive interpretation led them to conclude that the defendant experienced substance induced psychosis as a result of chronic, severe drug use.[2] The decision ended with a reflection on the use of neuroscience evidence in forming their opinions:

> "This is not about the Court assuming that all those who are under drugs fit an alleged morbid alteration and hence can be found not criminally responsible … this is about understanding that in exceptional scenarios such as that of C.A.P., in which the chronic consumption of drugs caused a severe impairment in his health which was considered as a personality disorder caused by the abuse of toxic substances, this corresponds to considering it as an alleged morbid alteration, *following modern currents of medical science, as it is about, in the end, a mental disease* [emphasis added]." (Pereyra, Carlos Andres S/Robo, 2012, p. 18)

In another recent case, neuroscience evidence was raised in defense of a subject accused of threats and robbery in 2013 (T.G.D. S/Robo, 2014). The accused had received several surgeries for fibrous dysplasia and cranial osteoma, and exhibited impulsivity and a lack of self-control. Structural (CT) and functional (SPECT) neuroimaging also demonstrated frontal lobe dysfunction. The three SPECT studies had been carried out in 2006, 2007, and 2009, and all showed functional alterations in areas of the frontal lobe, including the orbitofrontal cortex (T.G.D. S/Robo, 2014). As discussed above, a common critique and justification for the limited use of functional neuroimaging in the criminal law is that such images only show the brain activity at the time of the study, and conclusions cannot be drawn about previous brain functioning. Although this critique is valid, three functional neuroimaging tests for the accused conducted over three years demonstrated evidence of some stability in brain dysfunction and could be used to explain the accused's behavior (T.G.D S/Robo, 2014). In this sense, the increased impulsivity, lack of control and disinhibition observed in the aforementioned case could be clearly seen as related to the frontal lobe dysfunction. Given this context, the majority of experts concluded that the defendant showed a psycho-organic syndrome which impaired his ability to control his actions.

Despite the early legal cases involving neuroscience evidence, this current review did not identify neurolaw literature in Argentina that predated 2008. Since that date, 15 publications (9 journal articles, 4 books, and 2 book chapters) have been published. None of the publications identified reported empirical research, but rather, they incorporated international scientific research to theorize and discuss the implications of neuroscience for the criminal justice system. The topics of these publications primarily addressed neuroimaging in the criminal process, including its scope and limitations.

Most broadly, Mercurio (2008, 2012c) discussed the possible influences of functional neuroimaging on the criminal justice system by reviewing existing empirical research. This particular work examined the possibility of using functional neuroimaging completed post-offense to indicate functioning at the time of the crime, as well as the existence of functional impairment as a marker for certain mental disorders. Other Argentinian publications summarized neuroscience research and discussed its relevance for the insanity defense (Balcarce, 2014a, 2014b; Mercurio, 2009b). For example, the first book on neurolaw published in Argentina (Silva, Mercurio, & Lopez, 2008) reviewed Antonio Damasio's research and the hypothesis that somatic markers may have implications for one's guilt as it related to the Argentine Penal Code. In particular, the authors analyzed the functions of the frontal lobe in controlling behaviors and the ways in which frontal lobe alterations could mitigate criminal responsibility. Similarly, issues related to free will were discussed as they relate to the basic pillars of criminal law such as responsibility and freedom of action (Arocena, Balcarce, & Cesano, 2015). Another

[2] Consequently, the defendant in this case was absolved under the benefit of the doubt for several incidents that included different thefts and threats made in the context of a severe substance use disorder.

article reviewed drug abuse as a possible justification for the insanity defense, making the argument that the structural and functional alterations found among adults with substance use disorders could be grounds for an insanity defense due to the chronic alterations to brain functioning, especially in the frontal lobe (Mercurio, 2012b).

Other Argentinian publications have addressed adolescent brain development (Mercurio, 2011, 2012a, 2014; Mercurio & López, 2009). These articles used empirical research from other countries to make the argument that adolescents should have diminished culpability in the Argentinean criminal justice system. Although these arguments are not novel, they support the perspective that because the adolescent brain is still developing, a reduced level of culpability for adolescents in Latin America is justified. To support these arguments, internationally recognized cases were highlighted to demonstrate how neuroscience has impacted juvenile criminal law internationally, and particularly in the United States (e.g., Graham v. Florida, 2010; *Miller v. Alabama*, 2012; *Roper v. Simmons*, 2005). This argument led to a special expert commission that recommended the Argentine government should not reduce the minimum age of criminal responsibility for adolescents, drawing largely on neuroscience evidence demonstrating the trajectory of adolescent brain development (Mercurio, Garcia-Lopez, & Morales, 2018; Mercurio & García-López, 2017a, 2017b).

Legal experts in Argentina have also published books and articles on neurolaw beginning in 2011, examining topics such as free will, criminal responsibility, and the function of punishment (Arocena et al., 2015; Narváez, 2014; Palmero, 2012; van Weezel, 2011). For example, Arocena and colleagues (2015) provided a theoretical discussion of neuroscience contributions as they relate to criminal responsibility, free will, and the foundation of punishment. Similarly, other legal scholars have discussed the concept of freedom from the legal perspective, suggesting that new research on brain functioning should lead to revisions in our current understanding of these concepts (Narváez, 2014; Palmero, 2012; van Weezel, 2011). Zavadivker (2016) analyzed research on brain functioning as it relates to law and the concepts of free will, autonomy, and criminal responsibility. Zavadivker reviewed the brain mechanisms underlying moral judgments, specifically outlining the legal implications, as well as neuroimaging findings as they relate to diagnosis and lie detection in the criminal process. Valente (2014) provided a different perspective on neurolaw, analyzing the implications of brain functioning in the civil law, with a particular focus on legal capacity. For example, Valente reviewed the impact of substance use disorders on the brain pathways associated with decision-making. The author argued that a judge's awareness of the neural bases of behavior is important in civil cases where an individual's legal capacity may be diminished due to chronic substance use. This text demonstrated the need for collaboration between neuroscientists and legal scholars, as neuroscience may raise important ethical questions relating to legal issues.

In summary, while the research scholarship in Argentina is more recent than in Mexico, it appears that the courts have been more receptive to neuroscience testimony. In addition, Argentinian legal scholars appear to have developed a keen interest in this topic, and its application to a wide array of topics in both the criminal and civil law. Again, however, these publications rely on research originating from the United States and other countries, as no empirical research has been published using data from Argentina.

Colombia

The study of the relationship between neuroscience and law has received limited attention in the legal system in Colombia (Gutiérrez de Piñeres, 2017). No legal cases were identified that utilized neuroscience evidence in Colombian courts to inform legal decision making. Although some cases have requested structural MRIs to answer questions regarding criminal responsibility, the results of these tests do not appear to have been used to inform legal decisions (C. Gutiérrez de Piñeres, personal communication, September 12, 2017). For example, MRI imaging was requested by the defense team in the case of Jonathan Vega (C. Gutiérrez de Piñeres, personal communication, September 12, 2017). Vega had been convicted of attempted aggravated homicide for attacking a 34-year old woman with acid after harassing her for several years. The defense had intended to use the results of the MRI to inform the insanity defense, but as the testing demonstrated normal brain structures, it was not presented at trial. To this date, there appears to be no existing cases where functional MRI has been used to provide information for the court.

However, 12 publications were identified that addressed the topic of neurolaw in Colombia (seven articles, three books, and two book chapters). All of the articles and books were published as legal texts or in legal journals, whereas the two chapters were published in psychology books. These 12 documents

reviewed the impact neuroscience research has on the paradigm of free will, especially on issues that concern volition and criminal responsibility. Furthermore, none of the texts identified in the search described an empirical study or presented original data, but like the other Latin American publications, the authors cited the results of international research as they related to neuroscience and the law in Colombia. The theoretical reviews and published reflections suggest a growing interest in neurolaw, but the implications of neuroscience for the Colombian legal system have not yet been clearly identified.

One of the first publications relating to neurolaw in Colombia provided a brief theoretical review which referenced international neuroscience research on structural and functional brain differences in violent adults compared with nonviolent adults (Jiménez & Robledo, 2011). Following this publication, an average of two neurolaw texts were published per year between 2013 and 2018, the majority of which consisted of theoretical analyses and reflections about the implications of the knowledge derived from neuroscience on the law, specifically as it relates to criminal law.

Like researchers in other countries, some of these authors have provided broad overviews of the implications neuroscience has on the legal system (Gutiérrez de Piñeres, 2017; Symington, 2012). For example, Symington (2012) discussed controversial issues regarding the implications of neurosciences for Colombian law, such as the prediction of criminal behavior through neuroimaging, lie detection, and criminal responsibility. In light of the Colombian legal framework, this author noted the possible violation of constitutional rights to freedom of thought and conscience, which could be incurred by forcing a person to undergo neuroimaging studies (e.g., MRIs). Similarly, Gutiérrez de Piñeres (2017) published a theoretical review about the challenges and opportunities that neuroscience has within the accusatorial criminal justice system. In this review, the author introduced variables of social cognition such as emotional processing, social perception, and empathy, arguing that understanding cognition may inform the determination of guilt.

A few Colombian publications have addressed controversial issues relating to volition and freedom, relying on neuroscientific research to support their arguments (Jiménez, 2016; Medina, 2015). For example, Medina (2015) reviewed the concept of free will in the different criminological positions throughout history, warning that there are ethical concerns relating to the application of neuroscience in a country's criminal justice policy, criminal law, and penitentiary and prison policies. Díaz (2015) extended the discussion of free will, arguing from a functionalist approach. He stated that neuroscience does not need to question the concept of free will in law, although it may inform sentencing decisions based on knowledge of the particular conditions of those who commit a crime. Jiménez (2016) reaffirmed the importance of free will in criminal law, arguing that neuroscientific knowledge can make important contributions, but that neuroscience alone cannot explain the complexity of human beings and their behavior.

Similar to the publications arising in Mexico and Argentina, criminal responsibility was a common issue addressed in the Colombian publications identified (Balcarce, 2014a; Gómez, 2016; Morales & García-López, 2014; Olano, 2013; Rocha, 2013). For example, several authors discussed the repercussions and impact of neuroscientific evidence on criminal responsibility (Balcarce, 2014a; Olano, 2013). Similarly, a book written for legal specialists and laypersons posited that neuroscientific advances could be used as a means of proof or as the basis for making decisions regarding criminal responsibility (Rocha, 2013). Morales and García-López (2014) explained the advances in scientific research in neuro-criminology and its implications for the justice system, particularly in matters of criminal responsibility, the prevention of criminal involvement, and the treatment of delinquents. Lastly, Gómez (2016) and Gómez and Gutiérrez de Piñeres (2017) both published books on neuroscience and the law, and discussed the concept of freedom and its relevance as a central assumption in criminal law, particularly in relation to the issue of responsibility and culpability.

In summary, while several Colombian scholars have focused on the implications of neuroscience research, this literature has primarily focused on broad theoretical issues. There is little evidence that the legal system has embraced either the technologies or the principles raised by these scholars, although this may be due to the recency of these publications (all but one of which have been published in the last five years).

Chile

Perhaps the most famous use of neuroscience evidence in Latin America was based in Chile, in the high-profile criminal case of Augusto Pinochet (Sixth Courtroom for Appeals of Santiago, 2001), the Chilean dictator between 1973 and 1990. In his trial

for human rights violations committed during his reign, neuropsychological evaluations as well as structural (CT) and functional (SPECT) neuroimaging techniques were presented as evidence of a vascular cognitive impairment. This testimony resulted in a dismissal of charges, with the judge ruling based that "a person who is not in the full use of his mental capacities, is not competent [to stand trial]" (Centro de Estudios Públicos, 2002, p. 408). It should be noted, however, that Pinochet was later deemed competent to stand trial after doctors concluded that he was only suffering from "mild dementia" (Rohter, 2005), but he was never convicted of any criminal charges, as he died before resolution of these charges.

Despite this important use of forensic neuroscience testimony, only a small number of neuroscience publications have originated from Chile ($k = 6$), including four articles, one book, and one book chapter. Two of the four articles were published in a law journal, one in a medical journal, and the other in a political science journal. These publications have covered a wide range of topics, including neuroscience and moral behavior (Slachevsky, Silva, Prenafeta & Novoa, 2009), neuroscience and poverty (Etchichury, 2015), and psychopathy in the jurisprudence of the Spanish Supreme Court of Justice (Lorenzo & Agustina, 2016). Mecurio's (2013) book that examined the implications of neuroimages on criminal responsibility provided a comparison of the different perspectives on the insanity defense between Argentina and Chile and their relationship to neuroimaging research. In Mercurio's (2014) book chapter, the author discussed the potential implications of neuroscience research on juvenile justice policy. Another article, by Leyton (2014) reviewed the implications of neuroscience research on the brain and behavior, arguing that these findings question the most basic principle of criminal law, that one has free will and choice over his or her behavior. Instead of free will, Leyton Jiménez proposed new legal concepts based on neuroscience, such as guilt necessitating blameworthiness culpability. These papers demonstrate an emerging interest in neuroscience in Chile, but the extent of this scholarship is still modest, even in comparison to other Latin American countries.

Other Latin American countries

Like the research emerging from Mexico, Argentina, Colombia, and Chile, publications from countries such as Costa Rica, Paraguay, Peru and Uruguay have also analyzed the relationship between neuroscience and law (Ariano, 2016; Chan, 2013; Demetrio, 2017). These papers have also focused primarily on the problem of free will (Balbuena, 2013; Ibañez, 2016), and its impact on human rights (Carvajal, 2015) and criminal responsibility (Cancio, 2016; Chan, 2011). These texts have also addressed general issues relating to criminal responsibility in light of the existing neuroscience research. That is, they have argued whether the principles of criminal law and guilt should be revised based on the results of neuroscientific discoveries. For example, Balbuena (2013) and Ibañez (2016) theorized that neuroscientific findings jeopardize the legal concepts of free will and responsibility. One book from Peru (Sacco, 2016) analyzed the roots of law using a neuroscience approach. In this book, the author reviewed the meaning of mirror neuron theory, imitation, and empathy as they relate to legal innatism, the idea that the mind holds ideas and knowledge at birth. In another article, Causillas (2017) discussed the admissibility of neuroimaging data, including fMRI lie detection data, in the Peruvian legal system. No scientific or scholarly publications were found that originated from Bolivia, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, or Venezuela. Likewise, no legal cases were found that utilized neuroscience evidence in criminal cases.

Discussion

Over the last decade, interest in the intersection of neuroscience and the law has grown all over the world. In 2007, the MacArthur Foundation Research Network created the Law and Neuroscience project, a significant milestone in the study of the intersection of law and the study of the brain. Since 2007, this field has sustained significant growth, especially in the English language, with over 1,400 articles published between 1984 and 2015. In Latin America, interest in neurolaw only began in the mid-2000s, and the growth of publications in this area is much more modest than in the English language. This review identified only 61 publications (articles, books, and books chapters) in the Spanish language published in Latin America, with the vast majority (77%) of the publications coming from Argentina, Colombia, and Mexico.

Of the 61 publications identified in this review, none presented the results of empirical research, but rather most publications emphasized conceptual analyses of recurrent themes related to criminal law, such as free will, criminal responsibility, the adolescent brain and reduced culpability, and the use of

neuroimaging in expert testimony. The fact that no empirical research appears to exist from Latin America raises important questions and concerns regarding the application of research conducted elsewhere to Latin American populations. For example, while relatively little research has examined the extent to which ethnic, cultural, or linguistic differences may impact neuroimaging test results, a small literature has emerged showing "cross-cultural" differences (e.g., Chiao & Blizinsky, 2016; Han & Ma, 2014; Han & Northoff, 2008). Whether the differences occasionally observed in this literature have implications for the applications of neuroscience data to the legal system requires further investigation.

This review of the existing neurolaw literature also raises several questions about the state of research in this area in Latin America. Despite the existence of several research groups dedicated to examining issues of neurolaw, the number of publications in Latin America is minimal in comparison to the publications in English on the topic. Of course, there are far more English-language journals, which makes a comparison of the number of papers hard to interpret, but the opportunity for monolingual Spanish-speakers to participate in, or benefit from, this growing literature is clearly limited. The existing Latin American publications also do not equally represent Spanish-speaking countries, and the majority were published in legal journals, as opposed to fields specifically related to neuroscience or psychology. Perhaps the reason behind the limited research and publication reflects the investment of funds and resources dedicated to scientific research in Latin America. For instance, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) reported that in 2014 countries such as Denmark or Sweden invested more than 3% of their gross domestic product (GDP) to science, whereas Germany, Finland, the United States and England all spent at least 2% to 3% of their GDP on research and development (UNESCO, 2015). Together and individually, these resources are much greater than the funds provided for research and development in countries in Latin America, which invest less than 0.5% of their GDP to research: Nicaragua (0.1%), Peru (0.1%), Colombia (0.2%), Chile (0.4%), Mexico (0.5%), and Argentina (0.6%) (UNESCO, 2015).

In English-speaking countries, the applications of neurolaw appears to expand beyond court decisions, as it also impacts legislative decision and policy-making (Blank, 2013). This evolution from courts to legislation is critical because it can mean a true transformation of the justice system (Shen, 2016b). This expansion has also emerged in Latin America (e.g., in opposing legislation to lower the age for criminal prosecution in Argentina), but more emphasis has been placed on the need to strengthen the scientific scaffolding of the criminal justice system (García-López, 2010, 2011, 2014a,b) and on the importance of neuroscience for forensic psychology (García-López et al., 2016; García-López & Mercurio, 2019). However, it is even more important that the interaction between law and neuroscience has an impact on legislation and the implementation of public policies that apply to prosecutors and the court system. The reason this need is pressing in Latin America is that many countries have very high rates of violence and aggression. For example, the 2014 homicide rate in Mexico was 21.5 for every 100,000 people and it was 30.8 in Colombia (UNODC, 2017). In fact, the violence epidemic in Mexico is reaching a peak: October 2017 had the highest rate of homicides in the previous 20 years (2,764 according to the official figure of the National Public Security System, SNSP), with the total number of homicides in 2017 reaching more than 25,000 individuals (SNSP, 2017). This panorama of violence has a direct impact on the justice system, since it requires the investigation of the crime and the corresponding application of penal sanctions. However, the violence in Mexico is only an example; it is not the only Latin American country with a high rate of violence. For example, Honduras had 90.4 homicides per 100,000 inhabitants and Venezuela had 53.7 homicides per 100,0000 inhabitants, far exceeding the rates in Mexico and Colombia (United Nations Educational, Scientific and Cultural Organization, 2015). The extent of violence across Latin America is justification for further inquiry into whether neurolaw can or should impact policy decisions in Latin American countries.

Accompanying the high rate of violence in Latin American countries (Francis & Mauser, 2011; Imbusch, Misse, & Carrión, 2011; United Nations, 2016) is the social and financial inequality of this region (Latin America is the most unequal region in the world; López & Perry, 2008), and the limited access to education (UNESCO, 2014). Perhaps it is worth questioning the relevance of neurolaw for a region lagging so far behind in many other ways. Based on evidence from publications in English-speaking countries, neurolaw is a concept that has broad implications within the justice system that go beyond the forensic repercussions of understanding human behavior. For example, it can influence judicial decisions through the presentation of neuroscientific

evidence (Farahany, 2015), provide evidence to inform debates around the age of criminal responsibility (Buchen, 2012; Dahl & Spear, 2004), and pose challenges such as neuroprediction (Aharoni et al., 2013), and inform lie detection (e.g., Farah, Hutchinson, Phelps, & Wagner, 2014; McCabe, Castel, & Rhodes, 2011). However, the depth of analysis and application of neurolaw in English-speaking countries is far more extensive than its current state in Latin America.

The large discrepancy between the number of publications in English language vs. Spanish, and the content and nature of the publications, show that despite the relevance of neurolaw, Latin America does not benefit enough from the advances of the neuroscience in its application to legal issues. There is also little evidence that evaluations in forensic psychology used in legal cases are based on the knowledge gleaned from neuroscience, as this review has only identified a few legal cases throughout all of Latin America. Although other cases may exist, the lack of media coverage or legal scholarship based on these cases means that the implications of such applications are likely limited. However, despite the scarcity of publications or published legal decisions, our review has found that there is an upward trend in publications and discussions of neurolaw in Latin America (see Figure 2).

This article is a first step in understanding the application of neurolaw in Latin America. However, this study does have limitations. First, it is possible that relevant publications were missed due to the geographically specific inclusion criteria. For example, although some publications identified were by authors residing in Spain or Italy, publishing work on Latin America in Latin American journals (e.g., Ariano, 2016; Demetrio, 2017), it is also possible that other works that could be relevant were excluded based on the location of publication. For instance, the authors are aware of several Latin American researchers who published their works in European journals or texts originally published outside of Latin America that therefore did not meet inclusion criteria for this review (e.g., Cáceres, 2017;[3] Chan, 2012;[4] Demetrio & Maroto, 2013;[5] García-López, 2007;[6] Mercurio, 2009a).[7] Due to the difficulty in determining the place of origin of authors publishing outside of Latin America, the inclusion criteria for the publications included in this study remained geographically narrow.

It appears that similar neurolaw themes are being discussed among Latin American professionals as are discussed in other countries, but the topic is developing at a much slower rate. Several areas in which neurolaw is becoming more relevant in Latin America relate to the questions of free will, criminal responsibility, adolescent brain development and the minimum legal age for criminal responsibility. In general, there appears to be a common theme regarding the legal repercussions of advances in neuroscience within the criminal justice courts (García-López & Mercurio, 2019). However, the articles identified in this review rarely addressed other legal issues of relevance that fall beyond the scope of criminal law,[8] such as the impact of neuroscience findings on civil or family law. Interestingly, across Latin America, the publications reviewed here appeared unanimous in their opposition to the reduction of the criminal age in their respective countries, citing the neuropsychological and neuroscience evidence that demonstrate that the brain does not reach maturity at 18 years. The publications reviewed also suggest that Latin Americans professionals working in the field of neurolaw have philosophical concerns related to foundations of criminal responsibility, although they do not have local empirical studies to support their arguments.

Given the growing evidence for the influence of biological and environmental agents on decision-making and behavior internationally, the discussion of this paradigm and its implications are unavoidable. There remains no scholarly or clinical discourse with regard to the appropriate consequences or treatment for individuals with structural and functional brain disorders who commit crimes, or how to present brain imaging or neurological evidence in the criminal justice system to ensure that it is considered adequately and consistently in the criminal justice systems in Latin America. Furthermore, neuroimaging technology is not as easily accessible in Latin America, even for medical

[3] From Mexico, published in England.
[4] From Costa Rica, published in Germany.
[5] From Spain, published in Argentina.
[6] From Mexico, published in Spain.
[7] From Argentina, published in Spain.

[8] For example, in 2009, the Mexican Supreme Court of Justice of the Nation resolved two appeals. The first case involved the analysis of epilepsy as a cause for military retirement under "bar from military service," and whether removal due to epilepsy or other forms of seizures would violate the equality and non-discrimination principle of the Federal Constitution. One of the Ministries of Court requested advice from the Instituto Nacional de Neurología in order to inform his judiciary reasoning for these cases (Cossío, 2011). Although four Supreme Court Ministers ruled that the provision was constitutional, Justice Cossío (2011) dissented and opined that the aforementioned provision was unconstitutional, since its excessively wide and undetermined language opened the door to declarations of "uselessness for the service" without ensuring this rests in every case in a genuine incapacity to develop a job in the Army (p. 362).

diagnostic reasons, as in other parts of the world (Mercurio, personal communication, June 12, 2018). Therefore, accessing this technology for research is next to impossible due to limited resources. Thus, authors publishing on neurolaw concepts are forced to rely on the impact of technological advances in neuroimaging, as opposed to developing their own original research.

Clearly, researchers in Latin American countries need to plan a research agenda in relation to neurolaw. It is unlikely that empirical studies on neurolaw will be generated in the short term, given the scarce budget allocated to Latin American science and research. However, given that it is legal scholars who appear interested in issues related to neuroscience and criminal responsibility, and free will, it is likely that defenses and discussions about criminal responsibility and the frontal lobe will become more and more frequent. Furthermore, although Latin America has shown a reduction in poverty in the last decade (from 42.8% to 23.3%), 40% of households are still vulnerable to fall into poverty in the future (Báez, Fuchs, & Rodríguez-Castelán, 2017). Considering the extent of poverty in Latin America, future areas of research in Latin America could examine the impact of poverty on brain development, as it relates to the criminal justice system (Lipina & Colombo 2009; Segretin et al., 2014, 2016).

There are also several interesting publications coming out of Latin America that did not meet the specific criteria established in this systematic review of neurolaw literature. These excluded texts reviewed closely related themes, such as neuroscience of the adolescent brain, dementia and criminal behavior, or moral responsibility. For example, some authors (García-López, 2007; García-López & Morales, 2014; Morales & Greathouse, 2016) have studied adolescent brain development, noting that hyper-excitability of the limbic system and incomplete frontal lobe development increases the probability of engaging in risk taking behaviors. They argued that this stage of development offers significant opportunities for positive learning within the framework of restorative justice. Along slightly different lines, Morales, Fresán, Muñoz, and Greathouse (2017) reviewed the relationship between affect recognition and criminal behavior in adolescents, noting differences between adolescents who commit serious crimes and those who do not. Several papers coming out of Latin America have also examined the influence of dementia on behavior and moral responsibility. For example, Darby, Edersheim, and Price (2016) discussed the extent of moral responsibility when there is evidence of frontotemporal dementia (FTD). Similarly, several other authors in Latin America have also argued that people with FTD should be eligible for the insanity defense in criminal cases, and the diagnosis should be considered in legal decision-making areas during civil cases (e.g., property transactions) (Castex & Mercurio, 2007, Lopez & Mercurio, 2008). Once again, although these publications did not generate empirical research, they appear to provide novel discussions on forensic psychiatric issues and topics not usually addressed in local forensic psychiatry publications.

Some challenges for neurolaw in Latin America

Because neurolaw appears to be an important concept that is just beginning to emerge in Latin America, there is a need to further integrate this concept into Latin American judicial systems. Although there is no simple answer on how to best integrate neurolaw into policy decisions and criminal justice legislation, we recommend the following goals to improve the interactions between the field of neuroscience and the law in the Latin American criminal justice system. First, specialized training is needed across several disciplines such as law, medicine, and psychology. This reform should extend to both undergraduate and postgraduate studies and should not be limited to neurolaw, but should also address forensic psychology (García-López, 2016b; García-López & Morales, 2014). Providing the next generation of professionals in law and psychology foundational knowledge on these concepts will inform and improve their professional practice and criminal justice policies going forward.

Specialized training will also aid in the achieving the second goal: to strengthen the interaction between neurolaw and forensic psychology within the justice system. Although this objective seems obvious, it is far from being achieved in Latin America, as demonstrated by the limited publications addressing this topic and infrequent application of neuroscience to criminal cases. This is exemplified by the fact that the Attorney General's Office in Mexico[9] reports only four accredited experts in forensic neuropsychology and 50 psychologists (Monroy & García-López, 2017), numbers that seems very low considering that 1,675 psychological evaluations were completed in over a 10-month span (Procuraduría General de la República, 2013).

[9] The department of forensic psychology was founded in 2002 (PGR, 2013).

Third, there is a need for a formalized process for the certification of experts in the forensic sciences. The problem is recurrent: there is not enough continuing education courses for professionals to update their training, and therefore the forensic reports typically maintain the same archaic structures of decades ago, which prevent the prosecutors, judges, psychologists and psychiatrists from benefiting from the knowledge of current advances in neuroscience (García-López, 2013; García-López & Morales, 2017).

Lastly, there is a strong need for more resources to finance empirical research on neurolaw and forensic psychology. It is critical to develop reliable data that is specific to the people of Latin America. For example, in the last decade, how many cases have used neuroscientific evaluations in the courts? What are the effects of violence on the victims' cognitive processes? How do judges make decisions in Latin America, and are their decisions different depending on the legislation they interpret? Research that aims to answer these questions, and that is conducted and analyzed in Latin America with local samples, will strengthen the generalizability of the findings to Latino cultures and strengthen the argument to use neuroscience in the criminal justice system in Latin America.

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