NEUROSCIENCE AND THE LAW — SCIENCE AND SOCIETY

The influence of neuroscience on US Supreme Court decisions about adolescents' criminal culpability

Laurence Steinberg

Abstract | In the past 8 years, the US Supreme Court has issued landmark opinions in three cases that involved the criminal culpability of juveniles. In the most recent case, in 2012, a ruling prohibited states from mandating life without parole for crimes committed by minors. In these cases, the Court drew on scientific studies of the adolescent brain in concluding that adolescents, by virtue of their inherent psychological and neurobiological immaturity, are not as responsible for their behaviour as adults. This article discusses the Court's rationale in these cases and the role of scientific evidence about adolescent brain development in its decisions. I conclude that the neuroscientific evidence was probably persuasive to the Court not because it revealed something new about the nature of adolescence but precisely because it aligned with common sense and behavioural science.

The judicial system of the United States treats adolescents who have committed serious crimes more harshly than any other industrialized country. Because the treatment of juveniles has historically been so different in the United States compared with the rest of the industrialized world, this article focuses on the ways in which scientific studies of the adolescent brain have influenced legal decision-making in America. Neuroscience is likely to influence the ways in which other countries view adolescents' criminal responsibility too, but the most highly publicized cases to date are several US Supreme Court cases, and these are the focus of this article.

Before 2005, 16- and 17-year-olds who were convicted of homicide could receive the death penalty, and until very recently, individuals under the age of 18 years could be sentenced to life without the possibility of parole for homicide and other crimes. Although few Americans under the age of 18 years have been sentenced to death in recent history, several thousands have received life sentences, and as of 2012, there were about 2,500 individuals serving sentences of life without parole for crimes they committed when they were teenagers[1].

In a series of court cases during the past decade, the US Supreme Court has issued rulings that have banned or limited the use of capital punishment or life without parole in cases involving juveniles who are convicted of serious crimes[2–4]. The Court's decisions have been increasingly influenced by findings from studies of brain development to support the position that adolescents are less mature than adults in ways that mitigate their criminal culpability, and that adolescents' diminished blameworthiness makes it inappropriate to sentence them in ways that are reserved for individuals who are deemed fully responsible for their criminal acts. These cases were not the first ones in which the Court acknowledged that adolescents and adults are different in legally relevant ways, but they were the first to look to neuroscience for confirmation of what "any parent knows" (REF. 3), as Justice Kennedy put it in his majority opinion in *Roper v. Simmons* (from here on referred to as *Roper*), the 2005 case that abolished the death penalty for juveniles.

References to neuroscience in the Supreme Court's thinking about adolescent culpability have become more frequent (TABLE 1), just as neuroscience has become more influential in legal policy and practice more generally. Before *Roper*, neuroscience had not played any part in decisions about developmental differences between adolescents and adults, which was understandable, given how little published research there was on adolescent brain development before 2000. In *Roper*, adolescent brain development was mentioned during oral arguments[5], but it was never referenced in the Court's opinions, which instead emphasized behavioural differences between adolescents and adults. In the 2010 case *Graham v. Florida* (from here on referred to as *Graham*) (TABLE 1), which banned the use of life without parole for juveniles who are convicted of crimes other than homicide, adolescent brain development was mentioned in the opinion — but mainly in passing, in a remark about the maturation in late adolescence of brain regions important for "behavior control" (REF. 4). By the time the Court decided *Miller v. Alabama* and *Jackson v. Hobbs* (these two cases were joined, and the ruling, which concerned both of them, is referred to as *Miller*) (TABLE 1) — the 2012 cases in which the Court found it unconstitutional for states to mandate life without parole for juveniles — neuroscience warranted an entire paragraph in the majority opinion. The justices noted that the behavioural science had become even stronger since *Roper* and *Graham*, pointed out that the Court's conclusions in those earlier cases continued to be strengthened by neuroscience and went into greater detail about the findings from neuroscience, specifically mentioning adolescent immaturity in higher-order executive functions such as impulse control, planning ahead and risk avoidance. The justices cited *amicus curiae* briefs filed in these cases by scientific organizations such as the American Psychological Association, the American Psychiatric Association, the American Academy of Child and Adolescent Psychiatry and several others, which summarized the literature on adolescent brain development and connected it to the legal issues facing the Court[6].

Table 1 | **The US Supreme Court's rationale in several cases concerning adolescents' criminal culpability**

Case	Year decided	Ruling	Rationale	Refs
Thompson v. Oklahoma	1988	Capital punishment is found unconstitutional for individuals under the age of 16 years	"Contemporary standards of decency confirm our judgment that such a young person is not capable of acting with the degree of culpability that can justify the ultimate penalty."	8
Roper v. Simmons	2005	Capital punishment is found unconstitutional for individuals under the age of 18 years	"As any parent knows and as the scientific and sociological studies… tend to confirm, [a] lack of maturity and an underdeveloped sense of responsibility are found in youth more often than in adults and are more understandable among the young."	3
Graham v. Florida	2010	Life without parole is found unconstitutional for individuals under the age of 18 years convicted of crimes other than homicide	"No recent data provide reason to reconsider the Court's observations in *Roper* about the nature of juveniles….Developments in psychology and brain science continue to show fundamental differences between juvenile and adult minds. For example, parts of the brain involved in behaviour control continue to mature through late adolescence."	4
Miller v. Alabama	2012	States may not mandate life without parole for individuals under the age of 18 years, even in cases of homicide	"The evidence presented to us … indicates that the science and social science supporting *Roper*'s and *Graham*'s conclusions have become even stronger… It is increasingly clear that adolescent brains are not yet fully mature in regions and systems related to higher-order executive functions such as impulse control, planning ahead, and risk avoidance."	2

The legal issues

The central legal issue in *Roper*, *Graham* and *Miller* was whether the application of a particularly harsh sentence to a juvenile — such as the death penalty or life without the possibility of parole — violates the Eighth Amendment of the US Constitution, which prohibits "cruel and unusual" punishment, even if the same sentence is not a constitutional violation when applied to an adult.

How can it be that a punishment is cruel when applied to a juvenile but not when applied to an adult? The answer is found in what is referred to as a 'proportionality analysis', in which a punishment is considered cruel if it is judged to be excessive given the nature and circumstances of the crime. According to a core principle of the American justice system known as 'penal proportionality', fair criminal punishment is based not only on the harm caused by the crime but also on the blameworthiness of the perpetrator[7]. To take an extreme example, imagine that an individual drops a stone from an overpass and that the stone shatters the windshield of a car, causing the driver to lose control, crash and suffer a severe injury. Now consider the individual's age in deciding how he or she ought to be punished. Few of us would conclude that an 8-year-old and a 26-year-old should be held equally responsible for this act, and few would think it fair to punish an 8-year-old child to the same degree that we might punish a young adult, despite the fact that the crime and the resultant harm are the same in each case. A proportionality analysis would probably conclude that a severe punishment for a young adult who committed such an act of reckless endangerment might be entirely appropriate but that the same sanction would be disproportionate and excessive — in the language of the Eighth Amendment, "cruel" — when applied to a young child.

At issue in the three Supreme Court cases (*Roper*, *Graham* and *Miller*) — which involved juveniles (all male) who ranged in age from 14 to 17 years — was whether an adolescent's developmental immaturity mitigates his blameworthiness to the extent that the punishment in question is disproportionate and, as such, a violation of the Eighth Amendment. The question in these cases was not whether a juvenile's criminal act should be completely excused because of immaturity — normally developing individuals are assumed to be capable of forming criminal intent by the age of 7 years. Rather, the issue before the Court was whether the sentence the juvenile received was excessive relative to the degree of responsibility he had for his behaviour. It is easy to see why these cases were controversial; the distinction between 8-year-olds and fully mature adults with respect to their judgement, capacity to imagine the consequences of their actions and ability to control themselves is obvious, but the difference between adolescents and adults is not so clear-cut.

Before *Roper*, the Court had relied on common sense and other laws regarding adolescents' behaviour to draw legal boundaries between adolescents and adults for the purpose of determining criminal blameworthiness and had set the dividing line between the ages of 15 and 16 years, at least with respect to eligibility for the death penalty. Two rulings laid much of the legal groundwork for *Roper* and the cases that followed. The first was *Thompson v. Oklahoma*[8] (from here on referred to as *Thompson*) (TABLE 1), a 1988 case that prohibited capital punishment in cases involving individuals younger than 16 years of age. The second was *Atkins v. Virginia*[9] (from here on referred to as *Atkins*), a 2002 case in which the Court found the imposition of capital punishment on individuals with mental retardation to be unconstitutional on the grounds that even if a person knows the difference between right and wrong, mental retardation compromises their decision-making in ways that make them less than fully responsible for their conduct.

Although the ultimate conclusion that was reached in *Roper* was not logically different from the conclusions reached in *Thompson* or *Atkins*, *Roper* was important because here, unlike in the prior cases, the Court grounded

Amicus curiae brief
Literally, a brief submitted by a 'friend of the court'. It is a document filed by a person, group or organization that is not a party to the case but that seeks to influence the court's opinion.

Dissenting justice
One of the justices whose vote is not with the majority of the justices. A dissenting justice may write an opinion explaining the rationale behind his or her disagreement with the majority.

Majority opinion
A judicial opinion (in the United Kingdom, it is referred to as a 'judgement') agreed to by more than half of the members of the court, setting forth the court's decision and an explanation of the rationale behind it.

US Supreme Court
The highest court in the United States, which is composed of the Chief Justice of the United States and eight Associate Justices. It has ultimate jurisdiction over all federal courts and over all state court cases involving federal law.

its reasoning in developmental science and not just in common sense. In *Graham* and *Miller*, which built on *Roper*, the Court similarly looked to developmental science for guidance. This was partly because much more relevant science was available in 2010 than had been available in 1989 (the last time the Court had considered the death penalty for a juvenile), and partly because advocates for the abolition of the death penalty for juveniles made a concerted effort to bring the relevant research to the Court's attention through the numerous *amicus curiae* briefs that were filed. Of note, in *Stanford v. Kentucky*[10], a case decided a year after the *Thompson* decision, the Court ruled that setting the minimum age for death penalty eligibility at 16 years of age was consistent with "evolving standards of decency" by virtue of the large number of states that permitted capital punishment for 16- and 17-year-olds. Thus, by abolishing the death penalty for juveniles, *Roper* actually overturned a prior ruling on the matter.

These cases raised another important issue concerning adolescent development, although neuroscience did not have a significant role in the Court's analysis of this second issue. This issue was whether the punishments in question should be categorically prohibited for all adolescents or considered on a case-by-case basis depending on individual assessments of a defendant's maturity. (Arguably, this was really the central question in these cases.) Some dissenting justices argued that although most adolescents were likely to be less mature than adults and therefore both less culpable and more amenable to rehabilitation, surely not all of them were. Should judges and juries therefore not have the option of identifying individuals for whom capital punishment or life without parole was an appropriate sanction? In *Roper* and *Graham*, the Court's answer was 'no'; in *Miller*, it left open the possibility of a life sentence without parole for a juvenile but barred states from making this a mandatory sentence and noted that its imposition would probably be uncommon.

How did behavioural and brain science influence the Court's analysis of whether the developmental immaturity of adolescents is sufficient to diminish their criminal responsibility? Writing for the Court's majority in *Roper*, Justice Kennedy explicated three characteristics of adolescents that distinguish them from adults in ways that mitigate their culpability[3]. First, citing evidence of adolescents' over-involvement in reckless behaviour, Justice Kennedy concluded that adolescents are characterized by immaturity and an underdeveloped sense of responsibility, which leads them to make impetuous and ill-considered decisions. Second, he noted that adolescents are more susceptible than adults to external influences, especially peer pressure, which makes it difficult for them to extricate themselves from "criminogenic" situations. Last, referencing theories of identity development, Justice Kennedy wrote that the personality traits of adolescents are less fixed than they are in adults and that this makes it difficult to infer that even heinous criminal behaviour during adolescence is evidence of an "irretrievably depraved" character and stressed the fact that adolescents are better candidates for rehabilitation. In response to arguments that the death penalty serves a deterrent function, Justice Kennedy argued that the same characteristics that diminish adolescents' blameworthiness make it less likely that people this age will be deterred by the possibility of capital punishment: individuals who commit crimes impulsively do not pause to consider the consequences they might face if they were to be arrested and convicted.

Graham and *Miller* extended the logic of *Roper* to non-capital cases. In both cases, the Court's majority opinion explicitly referenced the arguments made in *Roper*. It argued that the scientific evidence in support of Justice Kennedy's characterization of adolescents had become stronger over the ensuing years and, importantly, that there was growing neuroscientific evidence that patterns of brain development supported the conclusions drawn from psychological studies. This evidence is summarized below.

Brain and behavioural development

In general, adolescents and individuals in their early 20s are more likely than either children or somewhat older adults to engage in risky behaviour; most forms of risk-taking follow an inverted U-shaped curve with age, increasing between childhood and adolescence, peaking in either mid- or late adolescence (the peak age varies depending on the specific type of risky activity) and declining thereafter. Involvement in violent and non-violent crime also follows this pattern[11] and is referred to as the 'age–crime curve' (FIG. 1). As FIG. 1 illustrates, although the overall crime rate in the United States dropped between 1990 and 2010, the relationship between age and crime remained the same and was virtually identical across three very different types of offences (robbery, burglary and rape).

From a psychological perspective, it is useful to view adolescents' involvement in criminal activity as a specific instance of risk-taking more generally, both because patterns of age differences in criminal activity are similar to those of many other types of risky behaviour[12] — including those that have nothing to do with crime, such as self-inflicted injury or accidental drowning (FIG. 2) — and because many of the hallmarks of juvenile offending are similar to those that characterize adolescent recklessness more generally. Most juvenile crimes, like most forms of adolescent risk-taking, are impulsive acts that are committed without full consideration of their possible long-term consequences.

In recent years, several psychologists have theorized that the relationship between age and risk-taking is best understood by considering the developmental trajectories of sensation-seeking and impulse control[13].

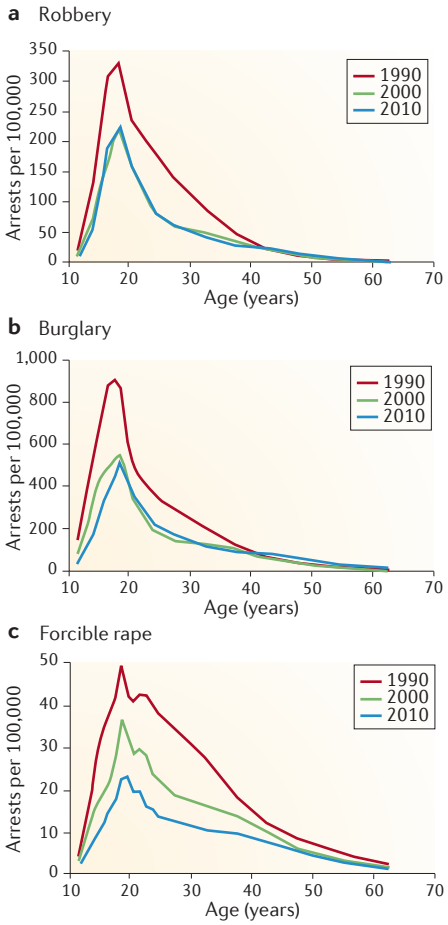

Figure 1 | **The age–crime curve.** Federal Bureau of Investigation data on crime in the United States show a consistent relationship between age and crime, which is referred to as the age–crime curve. Despite a drop in the overall crime rate between 1990 and 2010, the shape of the curve is the same and is similar across different types of offence, including robbery (**a**), burglary (**b**) and forcible rape (**c**). Data from Bureau of Justice Statistics)

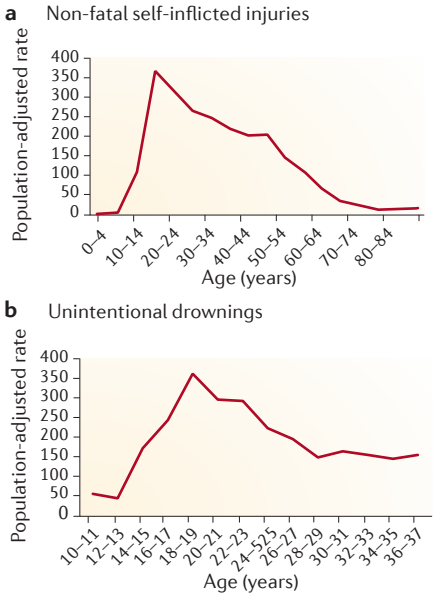

Figure 2 | **Age and risk-taking.** The relationship between age and many types of risk-taking is similar to that between age and crime. Risky behaviour, including non-fatal self-inflicted injuries (**a**) and unintentional drownings (**b**), increases between childhood and adolescence, peaks sometime in mid- or late adolescence and declines during the 20s. Data from the Web-based Injury Statistics Query and Reporting System (WISQARS).

Sensation-seeking — the tendency to pursue novel, exciting and rewarding experiences — increases substantially around the time of puberty and remains high well into the early 20s, when it begins to decline. Impulse control is low during childhood and improves gradually over the course of adolescence and early adulthood. Mid-adolescence, therefore, is a time of high sensation-seeking but still developing impulse control — a combination that predisposes individuals towards risky behaviour. Before adolescence, individuals are typically impulsive, but they are not especially prone towards sensation-seeking. In young adulthood, sensation-seeking is still relatively high, but by then, individuals have developed a more mature level of impulse control (FIG. 3).

Scientific data in support of this account formed part of the basis for Justice Kennedy's characterization of adolescents in the *Roper* decision, and research findings that were consistent with this perspective had become even more extensive by the time *Graham* and *Miller* were argued. Numerous self-report and behavioural studies showed that, compared with adults, adolescents are more impulsive, less likely to consider the future consequences of their actions, more likely to engage in sensation-seeking and more likely to attend to the potential rewards of a risky decision than to the potential costs[14]. Other studies provided support for the contention that adolescents are indeed more vulnerable to coercive pressure than adults[15] and that the presence of peers increases risky decision-making among adolescents but not older individuals[16]. The evidence with respect to the relatively unformed character of adolescents was more limited, although numerous reviews had been published showing that more than 90% of all juvenile offenders desist from crime by their mid-20s[17] and that the prediction of future violence from adolescent criminal behaviour, even serious criminal behaviour, is unreliable and prone to error[18].

Over the period that spans *Roper*, *Graham* and *Miller*, the *amici* who assembled and summarized the scientific evidence showing differences between adolescents and adults in psychological capabilities and capacities that are relevant to judgements of blameworthiness[19] incorporated more and more neuroscience into their briefs, as evidence of significant structural and functional brain maturation during adolescence began to accumulate[20]. Scientific organizations differed somewhat in the extent to which they made neuroscience a central part of their briefs, with some organizations, such as the American Medical Association, putting neuroscience at the forefront, whereas others, such as the American Psychological Association, using neuroscience mainly to supplement an argument that was primarily grounded in behavioural evidence.

Regardless of whether the neuroscience had a leading or supporting role, the relevant evidence that was brought to the Court's attention in the *amicus curiae* briefs described a maturational imbalance during adolescence that is characterized by relative immaturity in brain systems that are involved in self-regulation during a time of relatively heightened neural responsiveness to appetitive, emotional and social stimuli[21]. With respect to self-regulation, structural imaging studies using diffusion tensor imaging indicate immaturity in connections within a fronto–parietal–striatal brain system (localized primarily in the lateral prefrontal cortex, inferior parietal lobe and anterior cingulate cortex) that supports various aspects of executive function[22–24]. These connections become stronger over the course of adolescence as a result of both maturation and experience, and the strength of these connections is positively correlated with impulse control[25]. Maturation of structural connectivity in this brain system is paralleled by increases in functional connectivity[26] and by changes in patterns of activation during tasks that measure working memory, planning and response inhibition (all of which are important for impulse control and thinking ahead), as revealed by functional MRI (fMRI)[27,28].

By contrast, numerous fMRI studies show relatively greater neural activity during adolescence than in childhood or adulthood in a brain system that is located mainly in the ventral striatum and ventromedial prefrontal cortex. This system is known to have an important role in the processing of emotional and social information and in the valuation and prediction of reward and punishment[29,30]. According to what has been referred to as a 'dual systems model'[31] (FIG. 4), the heightened responsiveness of this socioemotional, incentive-processing system is thought to overwhelm or, at the very least, tax the capacities of the self-regulatory system, compromising adolescents' abilities to temper strong positive and negative emotions and inclining them towards sensation-seeking, risk-taking and impulsive antisocial acts[32,33]. Although it is less well developed, a growing literature on the development of the 'social brain', which was presented to the Court in *Miller*, provides evidence of functional changes that are consistent with heightened attention to the thoughts of others, which may be linked to adolescents' greater susceptibility to peer influence[34]. Although the dual systems model has recently been criticized as an oversimplification that ignores occasional inconsistencies in the literature[35,36], it was, and continues to be, a useful heuristic that conveys to non-scientists the basic story of adolescent brain development in a fashion that helps to explain many important differences between juveniles and adults that are relevant to our treatment of young people under the law.

Was neuroscience important?

Because the Supreme Court justices' deliberations are never made public, it is impossible to know just how much neuroscience findings influenced the Court's decision-making above and beyond the impact of the behavioural evidence. Nevertheless, a close reading of the transcripts of the oral arguments and opinions makes it clear that the attorneys and justices involved in these cases certainly paid attention to the neuroscience. At times they even insinuated that it was somehow more compelling than the behavioural evidence (as one attorney stated during oral arguments in *Roper*, "I'm not just talking about social science here, but the important neurobiological science")[5], that it was the fundamental driver of the development of maturity ("as the years go by and neurological development

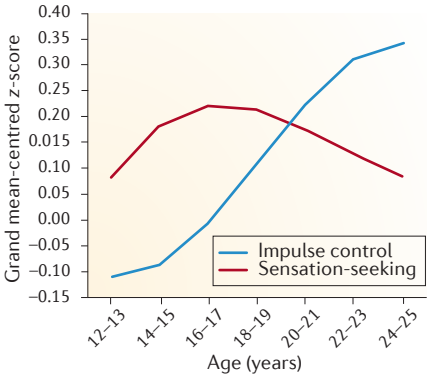

Figure 3 | **Sensation-seeking and impulse control.** The different developmental trajectories of self-reported sensation-seeking and impulse control[13] based on an analysis of data from National Longitudinal Study of Youth (NLSY79) Children and Young Adults (CNLSY), a longitudinal, nationally representative survey of over 7,000 American children and young adults ranging in age from 12 to 24 years (see National Longitudinal Surveys)[43].

occurs, [adolescents'] 'deficiencies will be reformed'")[2] or, at the very least, that neuroscience added validity to an argument that was based solely on common sense and developmental psychology.

For better or worse, neuroscience may have played a part in persuading the justices that the psychological differences between adolescents and adults as described in *Roper* were genuine and indisputable. Over the course of the three cases, there was a decrease in the amount of time during oral arguments that was devoted to discussions of where to draw the legal line between adolescents and adults. Indeed, this issue occupied a fair amount of discussion in *Roper* but was barely raised 7 years later in *Miller*. In addition, a review of the dissenting opinions in each case shows that the justices who voted with the minority clearly moved from a position of some scepticism about whether adolescents were inherently different from adults to one in which the matter was no longer even contested. For example, in his dissenting opinion in *Roper*, Justice Scalia pointed out that the American Psychological Association, whose *amicus curiae* brief characterized adolescents as too immature to be exposed to capital punishment, had taken the stance 15 years earlier, in *Hodgson v. Minnesota*[37], that adolescents should be able to obtain abortions without parental involvement on the grounds that psychological research showed that adolescents were just as mature as adults. The implication of this was that the developmental immaturity argument advanced by social scientists in *Roper* was just a convenient fabrication concocted by soft-hearted child psychologists to suit their political aims.

By the time *Miller* was decided, things had clearly changed. In his dissenting opinion, Chief Justice Roberts noted that "[*Roper* and *Graham*] undoubtedly stand for the proposition that teenagers are less mature, less responsible, and less fixed in their ways than adults — not that a Supreme Court case was needed to establish that." (REF. 2) We do not know whether the Court's ultimate acceptance of this characterization of adolescents was influenced by neuroscience. Nevertheless, there is a good chance that it was, as the only substantive change in the argument that adolescents are less mature than adults that had taken place between *Roper* and *Miller* involved an increased reliance on neuroscience. The period between these two cases was also characterized by growing coverage of research on adolescent brain development in the popular media.

Was neuroscience appropriate?

Whether neuroscience should have influenced the justices' reasoning is a different question. Certainly, neuroscientific evidence does not make the behavioural differences between adolescents and adults any more real. It only makes them seem more real to non-scientists who view psychological research on children as little more than the confirmation of what 'any parent knows' and who, like most of us, are more easily impressed by science we do not understand well enough to critique than by science that has more familiar methods. Several studies, including a recent one in which judges were the subjects, showed that adding just one or two sentences referring to the brain to a description of behavioural findings makes the behavioural findings that much more compelling[38,39]. A cynical reader may conclude that the introduction of the neuroscience of adolescence into the Supreme Court's deliberations about the juvenile death penalty or juvenile life without parole did little more than exploit the scientific ignorance of laypersons. However, I think it did more than this.

The contribution of neuroscience to discussions of adolescent blameworthiness lies not in what neuroscience tells us about differences in the ways in which adolescents and adults act but in what it implies about the source of these differences[40]. For example, findings of structural and functional differences between adolescent and adult brains that are plausibly linked to differences in individuals' ability to control their impulses and to stand up to peer pressure suggest that these aspects of adolescent immaturity are not merely reflective of juveniles' poor choices or different values but that they are at least partly due to factors that are not entirely under an individual's control, which makes immaturity a more convincing mitigator. Identifying the neural underpinnings of age differences in legally relevant capabilities and capacities does not indicate that these differences are immutable (indeed, adolescence is thought to be a time of heightened neuroplasticity). However, to the extent that brain maturation during adolescence follows a specific and predictable pattern that is consistent with predictable patterns of behavioural changes, the neuroscientific evidence bolsters the basic argument that adolescents are inherently less mature than adults. Moreover, the knowledge that individuals will almost always become more deliberate and self-possessed as they gain experience and as their brains mature, without any special interventions designed to facilitate this process, adds strength to the argument that adolescent offending is unlikely to reflect irreparable depravity. This last point is important, because it provides justification for distinguishing between adolescents, whose immaturity is by definition transient, and fully developed but callow adults, whose immaturity undoubtedly also has neural correlates but is more likely to be an enduring part of their character.

Conclusions and future directions

By all indications, the influence of neuroscience on legal decision-making is growing rapidly, and references to adolescent brain development are appearing regularly in lower court decisions. As scientists, we should welcome the use of scientific evidence in important legal deliberations. However, I believe that in discussions of where we should draw legal boundaries between adolescents and adults, neuroscience should continue to have a supporting role, and behavioural science should continue to carry the weight of the argument. Ultimately, the law is concerned with how we behave and not with how our brains function. As a concrete example, it makes far more sense to rely on a driving test than on a brain scan to decide whether someone should be issued a driver's licence.

Further neuroscientific research on three specific issues would be especially helpful in future discussions of adolescents' criminal responsibility. First, as critics of the use of neuroscience in these court cases have pointed out, few studies have linked changes in brain structure or function between adolescence and adulthood to changes in the legally relevant behaviours, especially as they

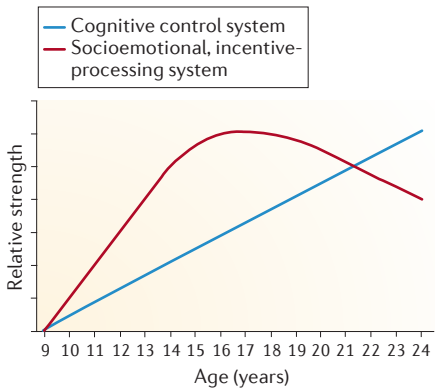

Figure 4 | **The dual systems model.** Hypothetical changes that occur during adolescence in two brain systems according to the dual systems model. The combination of an easily aroused socioemotional, incentive-processing system and a still maturing cognitive control system creates a period of heightened vulnerability to risk-taking during adolescence.

pl ay out in the real world[35]. It is certainly reasonable to speculate that adolescents who commit crimes make more impulsive decisions than their adult counterparts because their prefrontal lobes are less fully developed or because their ventral striatum is more responsive to rewards or emotional stimuli. However, this remains largely a matter of what I would characterize as sensible conjecture. More research that directly links age differences in brain structure and function to age differences in legally relevant capacities and capabilities is needed. Second, although it is often assumed that adolescents are more amenable to rehabilitation than are adults (in part because adolescence is thought to be a time of heightened neuroplasticity), there is very little neurobiological research that has examined this proposition directly. In fact, considerable evidence indicates that brain plasticity does not end at adolescence[41]. Last, there is growing interest in whether neurobiological data, either alone or in combination with other types of data, can improve the prediction of future behaviour at the individual level, either with respect to recidivism or responses to intervention. Although there are studies that have compared juvenile offenders' brain structure or function with that of non-offenders[42], using neuroscience to predict individuals' future behaviour is a different (and more difficult) matter.

Although neuroscience appears to have influenced the Supreme Court's deliberations, it is important to recognize that the essential logic of these decisions is based primarily in a description of the ways in which adolescents' behaviour and thinking differs from that of adults, and only secondarily in differences in their brain structure and function. And that is as it should be. This way, the neuroscience complements and corroborates the behavioural science, but it does not make the behavioural findings any more real. In some regards, the most convincing evidence that adolescents are different from adults is what 'any parent knows'. Indeed, the neuroscientific evidence was probably persuasive to the Court not because it told us something new but precisely because it aligned with common sense and behavioural science.

Laurence Steinberg is at the Department of Psychology, Temple University, Philadelphia, Pennsylvania 19122, USA.

e-mail: laurence.steinberg@temple.edu

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FURTHER INFORMATION
Laurence Steinberg's homepage: http://www.temple.edu/psychology/lds
Bureau of Justice Statistics: http://bjs.ojp.usdoj.gov
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