White Paper on the Science of Late Adolescence

A Guide for Judges, Attorneys, and Policy Makers

Neuroscience continues to be a rapidly evolving domain of research. This document reflects at the time it was produced the mainstream of developmental neuroscience of adolescence, late adolescence, and emerging young adulthood.

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Special thanks to members of the Research Network on Law and Neuroscience, supported by the John D. and Catherine T. MacArthur Foundation, and others who participated in the working meeting: “The Science of Emerging Adulthood: What do we know and how might this knowledge be appropriately applied in the law?” virtually convened at Harvard on September 30, 2020. We are particularly grateful to those who offered their consultation and review during drafting this document.

Grateful acknowledgement to the CLBB Advisory Board whose support made this project possible. We especially thank Jim Joslin who has generously contributed to support CLBB and its work to advance juvenile and emerging adult justice.

Finally, our thanks to Emily Rehmet, BA, Cognitive Neuroscience and Public Policy, Brown University; Project Manager, Massachusetts General Hospital Center for Law, Brain and Behavior, whose organizational skills, patience, input and supports in keeping us focused substantively contributed to completion of this project.

Cite as:
Center for Law, Brain & Behavior at Massachusetts General Hospital (2022). White Paper on the Science of Late Adolescence: A Guide for Judges, Attorneys and Policy Makers (January 27th, 2022). https://clbb.mgh.harvard.edu/white-paper-on-the-science - of-late-adolescence/

Errata Corrected: January 31, 2022

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Executive Summary

The United States Supreme Court decision in *Jones v. Mississippi* (2021)[1] almost certainly signals the end of further expansion at this time by SCOTUS of Eighth Amendment protections to juveniles.[2] *Jones v. Mississippi* held that a sentencing court need not make a specific finding that a youth is "permanently incorrigible" or even articulate a specific *Miller v. Alabama* rationale for a sentencing decision guided by factors provided in *Miller v. Alabama*.[3] It was enough that the sentencing judge understood that he or she had discretion to consider the *Miller* factors and made an individualized sentencing decision—a very low bar.[4]

In addition, the legal framework established by the *Roper-Graham-Miller-Montgomery* line of SCOTUS cases in barring execution for juvenile capital offenses,[5] Life Without Parole (JLWOP) for juvenile non-homicide cases,[6] and mandatory LWOP for juvenile homicide cases[7] has been incorporated to varying degrees into state statutes and case law and offers at least the possibility for a more robust application of *Miller*. The *Miller* approach also remains viable for pursuing expansion of those categorical protections to age 18 and beyond, and perhaps for raising the age of full criminal culpability.

The *Miller* framework's focus on "transient immaturity" also offers a way of asserting protections for young offenders in individual cases.[8] Arguably, shifting the focus from "permanent incorrigibility" (which cannot be predicted in a scientifically reliable manner) to "transient immaturity" (which is already established by robust developmental research and neuroscience) may provide opportunities for counsel and courts at trial/sentencing phases and upon appellate review. It may also encourage prosecutors to consider research-based diversion and community-based intervention programs as alternatives to traditional charging decisions and sentencing recommendations.

Similarly, the explicit reliance in these SCOTUS cases upon developmental neuroscience and behavioral science offers models for using science to advance broad evidence-based law and policy reforms regarding juveniles and emerging young adults. This White Paper reports the latest developmental and brain science to inform judges, attorneys, and policy makers about

1 *Jones v. Mississippi*, 141 S. Ct. 1307 (2021).
2 For purposes of this White Paper, the following terms are used to describe young people of different ages: (a) *juveniles*: broadly, persons between 13–17; (b) *early adolescents*: persons ages 10–13; (c) middle adolescents: persons ages 14–17; (d) *late adolescents:* persons ages 18–21; and (e) *young adults*: persons ages 22–25.
3 *Jones*, 141 S. Ct. at 1311.
4 *Id*.
5 *Roper v. Simmons*, 543 U.S. 551 (2005).
6 *Graham v. Florida*, 560 U.S. 48 (2010).
7 *Miller v. Alabama*, 567 U.S. 460 (2012); *Montgomery v. Louisiana*, 577 U.S. 190, 211 (2016) (extending *Miller* retroactively).
8 *Miller*, 567 U.S. at 479.

critical research developments.[9] This White Paper is intended to facilitate science-informed decision-making and application of updated research findings in law and public policy bearing upon adolescence and criminal proceedings.

In the landmark case *Miller v. Alabama* (2012), the United States Supreme Court eliminated mandatory life-without-parole sentences for murders committed by youth under age 18.[10] This decision was informed by an evolving understanding of adolescent brain development and behavioral research. Since then, scientific research has emerged which reinforces the reasoning of the *Miller* decision and, if its implications are accepted, extends much of the science that resonated with the *Miller* court to late adolescents (ages 18–21).

Maturation of brain structure, brain function, and brain connectivity continues throughout the early twenties.[11] This ongoing brain development has profound implications for decision-making, self-control and emotional processing. For example, new neuroscience research reveals that during emotionally charged situations, late adolescents (ages 18–21) respond more like younger adolescents (ages 13–17) than like young adults (ages 22–25) due to differences in brain maturation.[12]

Compared to young adults above age 21, late adolescents (ages 18–21) also take more risks and engage in more sensation-seeking behavior.[13] Due to differences in brain development, late adolescents are more likely than young adults to respond to immediate outcomes and are less likely to delay gratification.[14] The presence of peers can intensify these behaviors, and the brains of late adolescents are more responsive to peer involvement than those of young adults.[15] Late adolescents are also more easily swayed by adult influence and coercion than their adult counterparts.[16] These developmental differences in behavior have direct implications for legal decision-making, including waiving *Miranda* rights, susceptibility to false confessions, and making ill-advised trial decisions (e.g., plea decisions).

9 *See* Appendix A for a foundational review of the science. For an extensive review of brain and socio-behavioral research and its policy implications, *see also* National Academies of Sciences, Engineering, and Medicine, The Promise of Adolescence: Realizing Opportunity for All Youth. (2019), https://doi.org/10.17226/25388; Institute of Medicine and National Research Council, Investing in the Health and Well-Being of Young Adults (2015), https://doi.org/10.17226/18869.

10 *Miller,* 567 U.S. at 480.

11 Leah Somerville, *Searching for Signatures of Brain Maturity: What Are We Searching For?*, 92 Neuron 1164, 1164–67 (2016).

12 Alexandra O. Cohen et al., *When Is an Adolescent an Adult? Assessing Cognitive Control in Emotional and Nonemotional Context*s, 27 Psych. Sci. 549 (2016); Marc D. Rudolph et al., *At Risk of Being Risky: The Relationship Between "Brain Age" Under Emotional States and Risk Preference*, 24 Developmental Cognitive. Neurosci., 93, 93–106 (2017); B. J. Casey et al, *Development of the Emotional Brain*, 29 Neurosci. Letters 693 (2019).

13 Laurence Steinberg, *Adolescent Brain Science and Juvenile Justice Policymaking*, 23 Psych., Pub. Pol'y, & L. 410 (2017).

14 Michelle Achterberg et al, *Frontostriatal White Matter Integrity Predicts Development of Delay of Gratification: A Longitudinal Study*, 36 J. Neurosci. 1954 (2016); Samuel Hawes et al, *Modulation of Reward-Related Neural Activation on Sensation Seeking Across Development*, 147 Neuroimage 763 (2017).

15 Dustin Albert, Jason Chein & Laurence Steinberg, *The Teenage Brain: Peer Influences on Adolescent Decision-Making*, 22 Current Directions Psych. Sci. 114 (2013); Ashley Smith et al, *Age Differences in the Impact of Peers on Adolescents' and Adults' Neural Response to Reward*, 11 Developmental Cognitive Neurosci. 75 (2015).

16 Hayley Cleary, *Applying the Lessons of Developmental Psychology to the Study of Juvenile Interrogations: New Directions for Research, Policy, and Practice*, 23 Psych., Pub. Pol'y, & L., 118, 118–130 (2017).

Adversity, racism, and poverty also have a profound impact on health, quality of life, and criminal justice involvement.[17] As discussed below, adolescents who have experienced adversity, racism, and poverty are significantly overrepresented in juvenile and criminal justice systems. However, while these experiences pose developmental challenges, they do not dictate fate, as late adolescents are also remarkably resilient, and their developing brains are poised for positive learning through interventions and rehabilitation.[18]

For late adolescents engaged in criminal behavior, research consistently indicates that most will not continue to offend and become adult repeat offenders through their twenties, thirties, and beyond.[19] This has significant implications for both policy and the legal system. For example, this high rate of desistance from even serious or persistent adolescent offending as youth move into their early to mid-twenties renders it impossible to reliably predict, based on current science, which individual youth will continue to offend into adulthood and which will desist as they mature. There is certainly no basis in science to reliably determine that an individual youth at the time of sentencing in adolescence is incapable of rehabilitation (or even unlikely to achieve it) over the course of a lifetime.

While *Jones v. Mississippi* (2021) held that a sentencing court need not make a formal finding of "permanent incorrigibility" in considering a JLWOP sentence,[20] the *Miller* factors remain applicable and key to articulating the "transient" nature of adolescence generally and applying those factors in the individual case before the court. Science cannot divine which "rare" adolescent may be "permanently incorrigible," but it can identify the characteristically "transient characteristics" of adolescence.

One inherent challenge to incorporating science into litigation and decision-making lies in the application of research developed in studies on groups of subjects to the circumstances, conduct, and developmental trajectories of individual persons before the court. This is sometimes referred to as the "Group to Individual" conundrum. For example, developmental brain science can provide "on average" group-level descriptions of brain development and maturation which can be supplemented by consideration of the specific individual characteristics at issue in the legal context. This, of course, is a challenge that is familiar in the practice of medicine, where physicians must apply research based upon groups to diagnose and treat individuals.

In cases involving adolescents and late adolescents, research applied in individual cases must be derived from studies in multiple domains including neuroscience, social determinants of misconduct, peer affiliations and social networks, developmental trajectories, and individual characteristics (e.g., cognitive capacities, physical maturation, emotional charac-teristics, learning style, family dynamics).

17 Scott Lorch & Elizabeth Enlow, *The Role of Social Determinants in Explaining Racial/Ethnic Disparities in Perinatal Outcomes* 79 Pediatric Rsch. 141 (2016).

18 B.J Casey et al, *Making The Sentencing Case: Psychological and Neuroscientific Evidence for Expanding the Age of Youthful Offenders,* 5 Ann. Rev. Criminology (forthcoming 2022).

19 Off. Juv. Just. Delinq. Prot., *Law Enforcement & Juvenile Crime: Arrests by Offense, Age, and Gender,* U.S. Dept. Just. (Oct. 21, 2019), https://www.ojjdp.gov/ojstatbb/crime/ucr.asp?table_in=1 [https://perma.cc/T6H7–3LWX].

20 *Jones v. Mississippi*, 141 S. Ct. 1307, 1309 (2021).

This Guide is intended to support attorneys and judges in familiarizing themselves with the contours of the relevant science and how it can be applied to individual cases. A working knowledge of developmental and brain science allows attorneys and judges to make best use of what a juvenile defendant's life course, circumstances of an alleged offense, and expert evaluations and opinions can tell them to assist in understanding a defendant.[21] For attorneys, this facilitates preparing a case, educating the legal finder of fact, and making optimal use of expert testimony. For judges, this facilitates science-informed decision-making at all trial and appellate phases of a case involving a juvenile or young adult.[22]

The goal is to position each individual young defendant within a developmental trajectory comprised of biological, psychological, and social domains. A significant majority of cases will ultimately reflect "transitory immaturity," a feature of adolescence which will resolve as adolescents mature, resulting in desistance from criminal misconduct. Science-informed decision-making and evidence-based interventions can guide rehabilitation and reduce recidivism (thereby improving community safety) while avoiding or minimizing the negative impact of common responses (such as overuse of detention and incarceration) that can inadvertently compromise positive youth development and increase recidivism.

A better understanding of late adolescent brain and behavioral development can transform how the legal system and policy makers respond to late adolescents who offend. By educating decision-makers and advocates, this White Paper informs the criminal justice system and policy makers through providing an updated research perspective on late adolescence and supporting public safety by reducing recidivism through developmentally aligned accountability and empirically based processes and interventions.

21 Readers conducting forensic evaluations or using these evaluations in legal proceedings can find guidance in generating or relying upon them from sources including Antoinette Kavanaugh & Thomas Grisso, Evaluations for Sentencing of Juveniles in Criminal Court (2020).

22 For a review of aspects of "developmental evidence" and application of the *Miller* factors, see Thomas Grisso & Antoinette Kavanaugh, *Prospects for Developmental Evidence in Juvenile Sentencing Based on Miller v. Alabama,* 22 Psych. Pub. Pol'y & L. 235, 235–249 (2016); *See also* Thomas Grisso, *Three Opportunities for the Future of Juvenile Forensic Assessment,* 46 Crim. Just. & Behav. 1671 (2019), https://doi.org/10.1177/0093854819883671

Juveniles	Ages 13–17
Early Adolescence	Ages 10–13
Middle Adolescence	Ages 14–17
Late Adolescence	Ages 18–21
Young Adults	Ages 22–25

Age Ranges Defined for Purposes of this White Paper

Introduction

In a series of landmark decisions starting in 2005, the United States Supreme Court ruled that no one can be put to death,[23] receive a sentence of Life Without Parole for a non-homicide offense,[24] or receive a sentence of mandatory Life Without Parole for an offense committed prior to age 18.[25]

In drawing the line at age 18, the Supreme Court continued a tradition of raising the age at which Eighth Amendment protections against cruel and unusual punishment are applied. As Justice Stevens recognized in his concurring opinion in *Roper v. Simmons*, the holding reaffirmed the principle that "evolving standards of decency … have driven [the Court's] construction of this critically important part of the Bill of Rights," and recognized that "[i]f the meaning of that Amendment had been frozen when it was originally drafted, it would impose no impediment to the execution of 7-year-old children today."[26]

Jones v. Mississippi (2021) held that the requirements of *Miller v. Alabama* (2012) are satisfied if a juvenile's sentence of Life Without Parole (JWOP) is imposed after an individualized hearing. Notably, the *Jones* majority did not reinforce the *Miller* court's view that this sentence should be "uncommon" and reserved for the "rare" youth deemed "permanently incorrigible." Indeed, the *Jones* decision held that a sentencing judge need not make a specific finding that a juvenile is "permanently incorrigible" or even make formal findings of fact in support of a discretionary sentencing decision. However, SCOTUS did not explicitly strike down the *Miller* factor framework, acknowledged that states may set their own standards and protections more stringently than the *Jones* approach[27] (which many states have), and left undisturbed the concept of the "transient immaturity" of youth reflected in decisions from *Roper* (2005) through *Montgomery v. Louisiana* (2016).[28]

23 *Roper v. Simmons*, 543 U.S. 551 (2005).
24 *Graham v. Florida*, 560 U.S. 48 (2010).
25 *Miller v. Alabama,* 567 U.S. 460 (2012).
26 *Roper*, 543 U.S. at 1205.
27 *Jones v. Mississippi*, 141 S. Ct. 1307, 1322 (2021).
28 *Montgomery v. Louisiana,* 136 S. Ct. 718 (2016)

The *Jones* court abandoned any consideration of "evolving standards of decency" that might lead to the abolition of JLWOP outright, although case law and statutes in many states since *Miller* have taken that step. Other states have established minimum sentences[29] to be served before juvenile homicide offenders are afforded the requirement set by the *Miller* court for a "meaningful" opportunity to demonstrate that they have achieved rehabilitation.

The *Jones* court paid scant attention to the scientific foundations of the *Roper* through *Montgomery* line of cases. By contrast, prior to the dilution by *Jones* of protections afforded to juvenile offenders, SCOTUS Eighth Amendment rulings about sentencing youthful offenders had drawn heavily from advances in social sciences and neurodevelopmental research.[30] The Court cited scientific publications when it ruled that the Eighth Amendment prohibits the death penalty for those under age 18 at the time of their capital offense;[31] prohibits life without the possibility of parole (LWOP) for non-homicide offenders under age 18 at the time of their offense;[32] and prohibits *mandatory* life imprisonment without parole for those under age 18 at the time of the offense, even for homicide offenses.[33]

From those scientific studies it cited, the Court reached the conclusion that youth are less morally culpable, more susceptible to peer pressure, and more amenable to positive change. Indeed, SCOTUS had absolutely barred for juveniles as a class both execution and life without possibility of parole for non-homicide offenses, reflecting a strong "children are different" approach to Eighth Amendment constitutional doctrine.

The *Miller* majority stepped back from this categorical "children are different" approach when it barred mandatory LWOP but permitted it for a presumably very small number of "permanently incorrigible" youth based on a judge's discretion following an individualized sentencing hearing. In doing so, however, the *Miller* Court reaffirmed the law's recognition that "relevance of youth as a mitigating factor derives from the fact that the signature qualities of youth are transient; as individuals mature, the impetuousness and recklessness which may dominate in younger years can subside."[34]

Although the *Jones* majority did not focus upon the "transient immaturity" of youth, legislative and case law developments among the states implementing *Miller* suggest the concept of "transient immaturity" may be central to incorporating into litigation and policy advocacy the continuing developments in science. While there is no scientifically reliable basis to predict that a youthful offender is "permanently incorrigible," there is a robust scientific basis, as described

29 Litigation continues to clarify at what point a lengthy minimum mandatory sentence for a juvenile offender violates the *Miller* requirement there be afforded a "meaningful" opportunity to demonstrate achievement of rehabilitation. The disparity among states of minimum mandatory terms to be served range from less than two decades to four or more decades, resulting in a problematic "justice by geography" situation where sentenced youthful offenders may serve sentences for the same offenses that differ by decades before a putatively "meaningful" case review.

30 *See, e.g., Miller*, 567 U.S. at 471 (noting relevance of studies in Am. Psychologist and other journals for the reasoning in *Roper* and *Graham*).

31 *Roper v. Simmons*, 543 U.S. 551 (2005).

32 *Graham v. Florida*, 560 U.S. 48 (2010). *Graham* held that states must provide "meaningful opportunity to obtain release based on demonstrated maturity and rehabilitation." *Id.* at 75.

33 *Miller* 567 U.S. at 460.

34 *Id.* at 1195–96 (internal citations omitted).

in this Guide, to identify the "transient immaturity" of youth and emerging young adults and the normal process of self-desistence from criminal misconduct that occurs with maturation. The *Miller* factors still serve as a framework for organizing and explaining this research and as a means for accounting for the hallmarks of youthful immaturity, the circumstances of their offenses, and their greater prospects for self-desistence with maturation alone or with the support of empirically-based interventions.

This White Paper reviews recent scientific research establishing that these same "signature qualities of youth" extend into the period of *late adolescence* (ages 18–21). Since the Supreme Court decided *Miller v. Alabama* in 2012, more than one hundred new publications have explored the brain's development throughout late adolescence. Over 1,000 legal cases have referenced the same or similar neuroscience to that discussed in *Miller*, with many citing newer scientific articles as well.[35] Roughly half of these cases concerned individuals who were 18 years old or older at the time of the offenses for which they were charged.

In addition to their implications for legal challenges, the scientific findings reported in this White Paper are relevant for criminal justice policy. Late adolescents (ages 18–21) and young adults (ages 22–25) make up approximately 10–12% of the U.S. population,[36] yet this age group accounts for 23% of all arrests.[37] Late adolescents also make up 20% of incarcerated persons.[38] Youth of color are disproportionately represented,[39] as half of incarcerated 18–24

35 Francis X. Shen, et al., *Justice for Emerging Adults after* Jones: *The Rapidly Developing Use of Neuroscience to Extend Eighth Amendment Miller Protections to Defendants Ages 18 and Older*, 97 N.Y.U. L. Rev. Online (forthcoming 2022) (examining how the science proffered in *Miller* has been cited in subsequent cases).

36 Population estimates vary depending upon demographic data sources and years the samples were derived. *See* Just. Policy Inst., Improving Approaches to Serving Young Adults in the Justice System 3 (2016) (9.9% of U.S. population); *see also* Annie E. Casey foundation, *Kids Count Data Center https://datacenter.kidscount.org/* (last visited April, 17, 2021) (similar). Alternatively, one could calculate this percentage by combining population data sources: for example, the U.S. Census Bureau projected a total U.S. population of 326,971,407 on January 1, 2018. U.S. Census Bur., *Census Bureau Projects U.S. and World Populations* (Dec. 28, 2017), https://www.census.gov/newsroom/press-releases/2017/new-years-2018.html [https://perma.cc/8MKP-FUHU]. The Center for Education Statistics estimated a population of 30,600,000 18- to 24-year-olds for the same date. Nat'l Ctr. For Ed. Statistics, *Indicator 1: Population Distribution* (Feb. 2019), https://nces.ed.gov/programs/raceindicators/indicator_RAA.asp [https://perma.cc/9XZQ-YRY9] (last visited Dec. 12, 2020). 30,600,000 divided by 326,971,407 equals about 9.36%.

37 *See* Office of Juvenile Justice and Delinquency Prevention, *Estimated number of arrests by offense and age group*, U.S. Dep't of Justice (2019), https://www.ojjdp.gov/ojstatbb/crime/ucr.asp?table_in=1 [https://perma.cc/T6H7–3LWX] (last visited Apr. 18, 2021). To calculate the percentage of offenses committed by those between 18 and 24 for each year between 2015 to 2019, add total offenses for the 18 to 20 age group and the total offenses for the 21 to 24 age group, then divide that total by the total number of offenses for all ages. Results are (rounded to the hundredths place): 19.88% for 2019, 21.69% for 2018, 23.15% for 2017, 24.62% for 2016, and 25.67% for 2015. Averages for the past five years of data were derived by adding these five percentages together and then dividing by 5 to get 23.002%. A five-year annual average was used to reflect continuity. Worth noting, however, is the declining trend: Each year from 2015 to 2019, the percentage of crimes committed by those between 18 and 24 decreased. Alternatively put, in 2019, 19.88% of all arrests in the U.S. were for offenses committed by individuals from 18 to 24 years old, a percentage slightly less than in the previous four years. This arrest data was cross-checked with FBI data available for 2016 (last available year) which also resulted in an arrest rate calculation of 24.62%. *See* Crim. Just. Servs. Div., *2016 Crime in the United States*, Fed. Bur. Investigation (2016), https://ucr.fbi.gov/crime-in-the-u.s/2016/crime-in-the-u.s.-2016/tables/table-20 [https://perma.cc/NWQ2-HYGW] (last visited Dec. 12, 2020).

38 Just. Policy Inst., *Improving Approaches to Serving Young Adults in the Justice System* 1 (2016), http://www.justicepolicy.org/uploads/justicepolicy/documents/jpi_report_summary_improving_approaches_to_serving_young_adults_in_the_justice_system.pdf [https://perma.cc/NPU6-YUYR] (last visited Apr. 18, 2021).

39 *Id.* at 2 ("The data show … that young adults of color are disproportionately impacted by the justice system.").

year-olds are people of color.[40] Additionally, many of these incarcerated late adolescents and young adults face long sentences. Almost 40% of the individuals serving the longest prison sentences in the United States were incarcerated before age 25, and 56% of those serving the longest sentences are Black.[41]

Research in neuroscience, psychology, and law have contributed to an evolving understanding of both behavioral and brain development during adolescence. This contemporary research has direct implications for juvenile justice policy and practice.[42] This White Paper assembles and synthesizes both foundational and recent scientific developments to provide an updated overview of the science of late adolescence.

Foundational background information summarizing contemporary research on adolescent brain development is presented in Appendix A for readers who would benefit from a primer or refresher on the basic neuroscience.[43] This paper presents a synthesis of the brain and behavioral science most relevant for understanding legal and policy implications of these areas of research. The science is organized by the distinguishing characteristics of youth identified as critical factors by SCOTUS in *Miller* and is subsequently reflected, further developed, or limited.

Post-*Miller* activity involving juvenile defendants[44] and defendants ages 18 and older largely reflects actions taken by state courts and legislatures.[45] We anticipate that, particularly following the *Jones* decision in Spring 2021, most legal and legislative activity in this area will continue to occur at the state rather than federal level. The *Miller* factors have made their way into state case law and policy debates and so continue to be relevant. The *Miller* factors that serve as the organizing factors for the science presented in this paper are:

Immaturity, Impetuosity, and Risk-taking The "hallmark features" of adolescence include "immaturity, impetuosity, and a failure to appreciate risks and consequences."

40 *Id.* at 1.

41 Urban Inst., *A Matter of Time: The Causes and Consequences of Rising Time Served in America's Prisons* (2017), https://apps.urban.org/features/long-prison-terms/demographics.html [https://perma.cc/CQ6V-QP3L] (last visited Apr. 18, 2021).

42 B.J. Casey et al, *Healthy Development as a Human Right: Insights from Developmental Neuroscience for Youth Justice,* 16 Ann. Rev. L. & Soc. Sci. 9.1 (2020); B.J. Casey et al, *Making the Sentencing Case: Psychological and Neuroscientific Evidence for Expanding the Age of Youthful Offenders*, 5 Ann. Rev. Criminology (forthcoming 2022); Leark, R. A. (2021). *An Introduction to the Special Issue on the Death Penalty Among Teen-Aged Offenders.* 7 J. Pediatric Neuropsych. 1–2 (2021).

43 The authors acknowledge that contemporary neuroscience increasingly focuses upon neural circuit connections and extraordinarily complex interactions among brain regions rather than merely attribution of functions to "lobes" or other specific brain areas. However, the published research often references structure and function of specific brain areas and so the reporting of brain research will often make references to specific brain areas.

44 By 2020, courts or legislatures in at least 19 states had barred Life Without Parole for juvenile defendants. *See, e.g.*, *Diatchenko v. Dist. Att'y for Suffolk Dist.*, 1 N.E.3d 270 (Mass. 2013); *State v. Bassett*, 428 P.3d 343 (Wash. 2018). For a review of post-*Miller* actions by state courts and legislatures, see Gina Kim, *State-by-State Abolition of Juvenile Life without Parole Sentences in the United States since Miller v. Alabama (2012)*, (2019) (Ph.D. dissertation, Columbia University; available through Academic Commons, Columbia University Libraries).

45 For a review of post-*Miller* use of neuroscience in litigation involving late adolescents, see Francis Shen et al, *Justice for Emerging Adults after* Jones*: The Rapidly Developing Use of Neuroscience to Extend Eighth Amendment Miller Protections to Defendants Ages 18 and Older,* 97 N.Y.U. L.Rev. Online (forthcoming 2021).

Peer Involvement/Influence "[T]he family and home environment that surrounds him—and from which he cannot usually extricate himself—no matter how brutal or dysfunctional . . . the circumstances of the homicide offense, including the extent of his participation in the conduct and the way familial and peer pressures may have affected him."

Understanding Legal Proceedings Deficits in legal understandings were described as: "the incompetencies associated with youth" including an "inability to deal with police officers or prosecutors (including on a plea agreement)" and "incapacity to assist his own attorneys."

Greater Potential for Rehabilitation The greater potential of adolescents for rehabilitation was first recognized in *Roper.* This greater potential for positive change and the absence of a scientific basis to reliably identify that "rare" youth whose "permanent incorrigibility" warrants LWOP continue to present a challenge to sentencing courts.

Jones v. Mississippi (2021) held that a separate finding of "permanent incorrigibility" is not required in a discretionary sentencing to LWOP.[46] However, opportunities to inform sentencing procedures and decisions with the science presented in this White Paper remain due to: (a) the long-standing recognition of the "transient immaturity" of youth" resulting in diminished culpability; (b) the common self-desistance from misconduct as youth mature; and, (c) law requiring analysis using the so-called *Miller* factors in these cases. The science is also relevant to adolescents older than the current "bright line" of age 18 for criminal culpability.

Especially in state cases, there are opportunities to inform legislatures, sentencing procedures, and individual case sentencing decisions with the science presented in this White Paper, particularly in state proceedings. Each of these distinguishing characteristics are discussed below for middle to late adolescents in light of broadly accepted leading research.

Readers who want further description of foundational neuroscience are directed to Appendix A at page 47 for a summary.

46 *Jones v. Mississippi*, 141 S. Ct. 1307, 1311 (2021).

Section I: Miller Factor 1 Immaturity, Impetuosity, Risk-taking

First Miller factor: The "hallmark features" of adolescence include "immaturity, impetuosity, and a failure to appreciate risks and consequences."

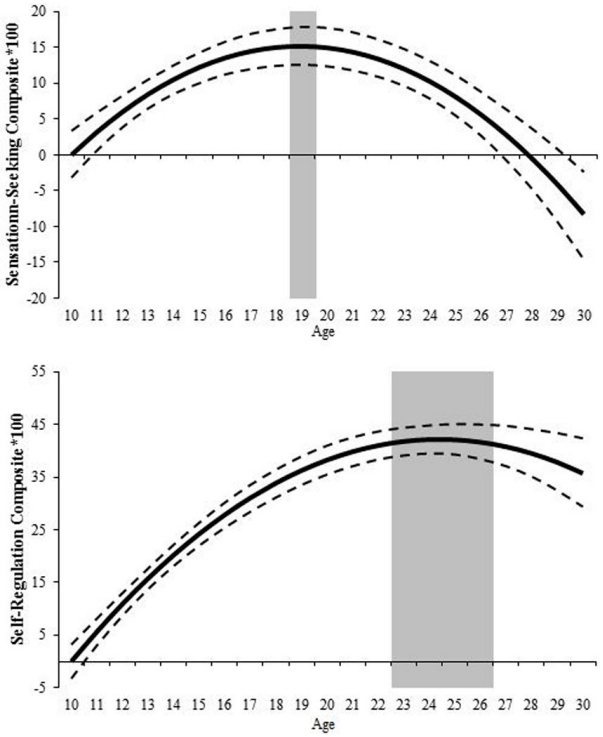

Figure 1: Steinberg et al. 2017. Age differences in sensation seeking (top) and self-regulation (bottom). Sensation seeking peaks in late adolescence. Self-regulation stabilizes in young adulthood.

Adolescence is a dynamic lifespan period characterized by changes in brain structure and brain function. In *Miller v. Alabama*, the United States Supreme Court explicitly referenced adolescents' tendency toward immaturity, impetuosity, and irresponsibility.[47] The predisposition for sensation seeking, hypersensitivity to immediate rewards, and present-focused decision-making peaks in middle to late adolescence and then declines in young adulthood. Further, capacities for self-regulation also improve with age and stabilize in young adulthood (Figure 1).[48] This is in part due to changes in brain function and connectivity and to improved executive functioning as the prefrontal cortex matures.

47 *Miller v. Alabama,* 567 U.S. 460, 472 (2012).

48 Laurence Steinberg et al, *Around The World, Adolescence Is a Time of Heightened Sensation Seeking and Immature Self-Regulation* 21 Developmental Sci. 10.1111 (2018).

The brain continues to be malleable throughout the lifespan, and this malleability may be enhanced during adolescence as compared to adulthood. This means that the adolescent brain can change in response to experiences and is developmentally primed to do so. When an adolescent is subjected to positive influences, this can have advantageous implications for brain development and for positive personal development as manifested by enhanced sensitivity to social and emotional information that promotes learning about oneself, one's peers, and societal norms.[49]

Adolescents exhibit increased impulsivity and risk-taking, as compared to adults. Elevations in risk-taking decisions and behaviors are found among adolescents across cultures. Enhanced risk-taking is developmentally normative and can be adaptive in certain contexts.[50] For example, risk-taking in academic or social contexts can promote positive outcomes such as exploring new intellectual pursuits, skills and interests, or forming new healthy friendships. However, enhanced risk-taking can also lead to negative outcomes such as health risk behaviors or legal risks.

Compared to adults, middle adolescents and late adolescents are more likely to engage in behaviors that risk their lives and wellbeing.[51] Many health risk behaviors peak in late adolescence and young adulthood. This includes risk-taking behaviors and risk-related outcomes such as reckless driving, unprotected sex, and unintentional injuries.[52] Further, overdose deaths and substance misuse peak in late adolescence and early adulthood.[53]

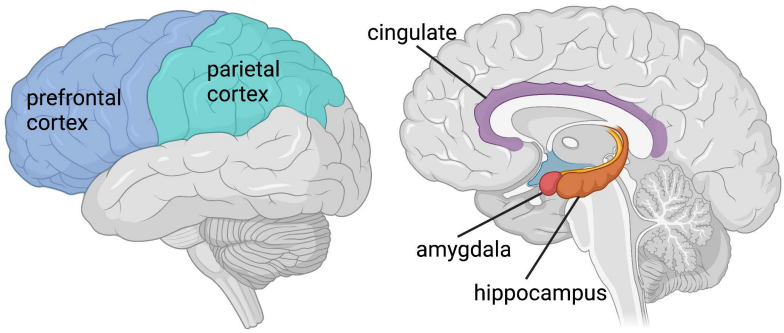

Figure 2: Brain Anatomy. Left image depicts a lateral view of the brain (side view from the outside). Right image depicts a medial view of the brain (side view from the middle inside).

49 Crone, E. A., & Dahl, R. E. *Understanding Adolescence as a Period of Social–Affective Engagement and Goal Flexibility*, 9 Nature Rev. Neurosci. 636, 636–650 (2012).

50 Natasha Duell & Laurence Steinberg, *Positive Risk-Taking in Adolescence,* 13 Child Development Perspectives 48, 48–52 (2019).

51 Laurence Steinberg, *A Social Neuroscience Perspective on Adolescent Risk-Taking*, 28 Development Rev. 78 (2008).

52 Teena Willoughby et al, *Examining the Link Between Adolescent Brain Development and Risk-Taking From a Social–Developmental Perspective (Reprinted)*, 89 Brain & Cognition 70 (2014).

53 Andrea Stone et al, *Review of Risk and Protective Factors of Substance Use and Problem Use in Emerging Adulthood,* 37 Addictive Behav. 747, 747–775 (2012).

Executive Functioning

The term "executive function" is used to describe the cognitive processes of controlling and regulating behavior and encompasses working memory, inhibitory control, and cognitive flexibility.[54] Connections within the prefrontal cortex and across more distributed brain networks (including the parietal cortex and subcortical regions) facilitate executive function, self-control, and emotion regulation. These connections continue to develop through early adulthood.[55] Therefore, behaviors associated with executive functions continue to develop throughout the transition from adolescence and into adulthood. This explains why late adolescents can be more impulsive in certain contexts and why their self-control abilities are vulnerable to disruption from emotional cues or heated contexts.[56]

"Working memory" is a type of executive function which continues to develop during adolescence. Working memory is a type of short-term memory that allows individuals to actively hold information in mind. It is important for remaining cognizant of present actions, past actions, and future actions. It is also important for processing conversations and social contexts, understanding instructions, creative thinking, charting a course of action, decision-making, and problem-solving.[57] Working memory allows us to take in new information and incorporate that information when devising a plan and considering alternatives to a plan. Parts of the prefrontal cortex (including the middle and inferior frontal regions) and regions within distributed brain networks (including subcortical regions), support working memory. The developmental fine-tuning of this circuitry facilitates improvements in working memory over time.[58]

Basic working memory abilities mature before adolescence, but more complex and challenging working memory capacities associated with continued brain development continue to mature through late adolescence[59] and into young adulthood. Compared to adults, working memory capacities are still developing through late adolescence, which can create vulnerabilities to interference and disruption. Specifically, emotional contexts can transiently disrupt working memory in late adolescence and young adulthood.[60] Research findings demonstrate that

54 In scientific and medical literatures, the terms "executive function" and "cognitive control" are both used to describe higher order behaviors that are important for self-control, decision-making, and complex thinking. We use the phrase "executive function" in this White Paper because the term is used regularly expert testimony and appears in hundreds of legal cases. *See* Akira Miyake et al, *Assessment of Executive Functions In Clinical Settings: Problems And Recommendations,* 21 Sem. Speech & Language 0169 (2000).

55 Jennifer Silvers et al, *vlPFC–vmPFC–amygdala Interactions Underlie Age-Related Differences in Cognitive Regulation of Emotion*, 27 Cerebral Cortex 3502 (2017).

56 B. J. Casey, *Beyond Simple Models of Self-Control to Circuit-Based Accounts of Adolescent Behavior*, 66 Ann. Rev. Psych. 295 (2015).

57 Working memory: The state of the science (Robert Logia, Valeria Camos, & Nelson Cowan eds., 2020).

58 Monica Rosenberg et al, *Behavioral and Neural Signatures of Working Memory in Childhood*, 40 J. Neurosci. 5090 (2020).

59 Theodore Satterthwaite et al, *Functional Maturation of the Executive System During Adolescence*. 33 J. Neurosci. 16249, 16249–16261 (2013).

60 Madeline Lee Pe et al, *Interference Resolution Moderates the Impact of Rumination and Reappraisal on Affective Experiences in Daily Life*, 27 Cog. & Emotion 492, 492–501 (2013); Lanciano Curci et al, *Negative Emotional Experiences Arouse Rumination and Affect Working Memory Capacity.* 13 Emotion 867, 867–880 (2013); Alan Anticevic et al, *Resisting Emotional Interference: Brain Regions Facilitating Working Memory Performance During Negative Distraction*, 10 Cog., Affective, & Behav. Neurosci. 159, 159–173 (2010)

individuals ages 20–30[61] have more disrupted working memory during periods of emotional stimulation, suggesting that emotional contexts can compromise their cognition, but the influence of emotional context is less disruptive for older adults.[62]

Hot/Cold Cognition and Reward Sensitivity

Decision-making Middle adolescents and late adolescents are more likely than adults to change how they make decisions when they are faced with emotional contexts as compared to more neutral conditions where they are given time to think through a problem. Adolescents are cognitively similar to adults in certain contexts, like how by age 16 they perform comparably to adults when they are given adequate time for reasoned and thoughtful deliberation to consider consequences and make decisions.[63] However, during adolescence, youth experience a hypersensitivity to emotional content while still developing the purposeful problem-solving that comes with adulthood. Because adolescents exhibit different responses in the brain during decision-making, while exerting self-control, and when engaging emotion regulation, adolescent behavior is highly sensitive to emotional contexts. This renders adolescents susceptible to emotionally driven decisions, impulsive behavior, and poor judgment.[64]

Self-Control Behavioral studies demonstrate that adolescents are hypersensitive to emotional contexts, and this sensitivity to emotional information can interfere with self-control. Researchers have tested the ability of adolescents and adults to engage in self-control in emotional contexts by utilizing the Emotional Go/NoGo test. The Emotional Go/NoGo test is a test of cognitive control in which participants are instructed to press a button in response to target images (e.g., calm faces) but withhold responses to other types of images (e.g., happy faces). Research shows that adolescents are worse than adults at inhibiting responses to emotional stimuli, but they perform similarly to adults when neutral stimuli are presented.[65] Adolescents, more so than children and adults, show impaired self-control when inhibiting responses to negative and positive emotional cues.[66] For example, adolescents are more likely to make a self-control error when seeing a happy smiling face, compared to a neutral calm face. Notably, emotional cues continue to influence self-control through the mid-twenties.[67]

61 The age ranges for the sample group were 20–30 years and 60–75 years.

62 Susanne Scheibe & Fredda Blanchard-Fields, *Effects of Regulating Emotions on Cognitive Performance: What Is Costly for Young Adults Is Not So Costly for Older Adults*, 24 Psych. & Aging 217 (2009).

63 Brend Figner et al, *Affective and Deliberative Processes in Risky Choice: Age Differences in Risk-Taking in the Columbia Card Task,* 35 J. Experimental Psych.: Learning, Memory & Cog. 709 (2009).

64 Steinberg, *supra* note 51 ("This account is consistent with a growing body of work on structural and functional changes in the prefrontal cortex, which plays a substantial role in self-regulation, and in the maturation of neural connections between the prefrontal cortex and the limbic system, which permits the better coordination of emotion and cognition. These changes permit the individual to put the brakes on impulsive sensation-seeking behavior and to resist the influence of peers, which, together, should diminish risk-taking.").

65 Leah Somerville et al, *Frontostriatal Maturation Predicts Cognitive Control Failure to Appetitive Cues in Adolescents*, 23 J. Cog. Neurosci. 2123, 2123–2134 (2011); Nim Tottenham et al, *Behavioral Assessment of Emotion Discrimination, Emotion Regulation, and Cognitive Control in Childhood, Adolescence, and Adulthood*, 2 Frontiers Psych. 39 (2011).

66 Casey, *supra* note 12.

67 Dienke Bos et al, *Distinct and Similar Patterns of Emotional Development in Adolescents and Young Adults,* 62 Development Psychobiology 591, 591–500 (2020).

Research also indicates that middle adolescents and late adolescents are more sensitive to sustained emotional arousal states than older adults. This vulnerability to emotional context has been found to persist through early adulthood.[68] In research studies, late adolescents had diminished cognitive abilities under sustained negative emotional arousal relative to adults age 22–25, but late adolescents performed similarly to 22–25 year-olds in neutral and positive emotional arousal conditions.[69] For example, during "threat states" in which individuals anticipated the possibility of hearing an aversive sound, late adolescents (ages 18–21) exhibited patterns of brain activity that were more similar to the adolescent group (ages 13–17) than the adult group (ages 22–25). This included reduced connectivity between distributed brain regions that are activated when exerting self-control, including the prefrontal cortex.[70]

Social and Emotional Regulation The impact of enhanced emotional influence on adolescent behavior is also observed within the context of peer interactions. As adolescents mature, they are better able to inhibit emotionally-driven impulses that arise in the presence of peers.[71] This means adolescents are more likely to react impulsively when faced with potential social rewards or friendly peers. This can be seen, for example, in middle and late adolescents' more frequent unprotected sex. [72]

The ability to use effective cognitive strategies to regulate emotion in social situations increases with age into the mid-twenties and helps to explain why the ability to regulate emotions for social cues develops over time.[73] Studies of explicit emotion regulation ask participants to use cognitive strategies to change their emotional responses, such as by reinterpreting a situation or imagining the situation to be farther away in time or space. These studies have reported developmental differences in the use of effortful self-regulatory strategies to manage strong feelings. Research indicates that the strategies individuals use to regulate their emotions change throughout development, and that adolescents use less beneficial or less helpful emotional regulation strategies than adults.[74]

Long-term Planning and Future Oriented Decision-making

Middle and late adolescents evaluate risks and benefits differently than those in their late twenties and thirties. While adults tend to integrate potential consequences of decisions, middle adolescents and late adolescents exhibit less future-oriented decision-making. These age-related differences in behavior are associated with ongoing development of structural and functional connectivity between the prefrontal cortex, a region important for self-control, and the striatum, a region important for reward processing.

68 *See, e.g.,* Cohen, *supra* note 12.

69 The three comparison groups included adolescents (age 13–17), late adolescents (age 18–21), and young adults (age 22–25). *Id.*

70 For a more complete discussion of functional connectivity, *see infra*, Section II on page 18.

71 For additional information on the effect of peer influence, *see infra*, Section IV page 38.

72 Willoughby, *supra* note 52.

73 Jennifer Silvers et al, *Age-Related Differences in Emotional Reactivity, Regulation, and Rejection Sensitivity in Adolescence*, 12 Emotion 1235 (2012).

74 Kalee De France & Tom Hollenstein, *Emotion Regulation and Relations to Well-Being Across the Lifespan*, 55 Development Psych. 1768 (2019).; Oliver John & James Gross, *Healthy and Unhealthy Emotion Regulation: Personality Processes, Individual Differences, and Life Span Development*, 72 J. Personality 1301 (2004).

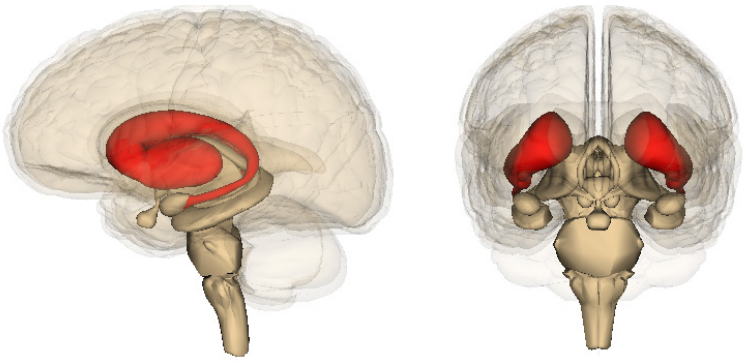

Figure 3: Striatum. The striatum is illustrated in red, showcasing a view from the side (left) and from the front (right) of the brain.

Relative to adults, late adolescents tend to plan for the short-term rather than the future. Future orientation increases with age. However, compared to adults both middle adolescents and late adolescents are more focused on immediate gains and rewards rather than potential long-term consequences.[75] These age groups are also less likely than adults to identify and consider potential future consequences of their actions.[76] Late adolescents are especially susceptible to making poor decisions due to privileging short-term rewards over future risks.

To explore the capacity to delay gratification, researchers ask individuals to decide between receiving a small reward sooner or a larger reward later. This measures how much a person devalues a reward based on how long they must wait to receive it. The tendency to delay gratification (choose larger but later rewards) increases with age.[77] Middle and late adolescents particularly often struggle with delaying gratification. A large-scale study of 900 individuals found that adolescents are more likely to prioritize immediate rewards over long-term outcomes, and delay of gratification improves continuously from age 14 to 22.[78]

Adolescents who are worse at delaying gratification are more prone to real world risk-taking, such as experimentation with drugs like tobacco, alcohol, and marijuana.[79] This may also account for why middle adolescents and late adolescents are more likely to engage in risky behaviors that lead to immediate rewards, such as reckless driving, unprotected sex, and dangerous behavior resulting in unintentional injuries.[80] [81]

This age-related preference for more immediate rewards is associated with developmental differences in brain function. In a research study conducted in individuals ages 11–31, delay of gratification increased with age and middle and late adolescents were more likely to choose

75 Laurence Steinberg et al, *Age Differences in Future Orientation and Delay Discounting*, 80 Child Development 28 (2009).
76 Daniel Read & Nicoleta Read, *Time Discounting Over the Lifespan*, 94 Org. Behavior. & Human Decision Proc. 22, 22–32 (2004).
77 Steinberg, *supra* note 75.
78 Daniel Romer et al, *Can Adolescents Learn Self-Control? Delay of Gratification in the Development of Control Over Risk-Taking*, 11 Prevention Sci. 319, 319–330 (2010).
79 *Id.*
80 Steinberg, *supra* note 51.
81 Willoughby, *supra* note 52.

immediate rewards than adults. Older individuals (ages 25–31) were more likely to simultaneously activate both the striatum and prefrontal cortex, which was associated with a decreased tendency to prefer immediate rewards.[82]

One interpretation of this effect is that the development of the prefrontal cortex is associated with reduced impulsivity, which, in turn, enhances the ability to make decisions that adequately weigh future outcomes. Developing connectivity between the striatum and prefrontal cortex may also influence future-oriented decision-making. For example, adults ages 25–30 exhibit enhanced brain connectivity between regions in the prefrontal cortex and striatum, and they are better at delaying gratification than both middle and late adolescents.[83] Longitudinal research testing of individuals ages 8–26 demonstrates that the strengthening of white matter connections between the prefrontal cortex and striatum may also account for why individuals are better able to delay gratification as they age.[84]

As a result of strengthening connections, adults may be more likely than adolescents or late adolescents to use the prefrontal cortex to regulate reward-related regions and decrease impulsive responses to reward. Ongoing development of functional and structural connectivity can also explain why future-oriented decision-making increases with age from ages 10 to 25.[85] The ability to delay gratification continues to develop during adulthood.

While adolescents typically privilege immediate rewards over long-term consequences, there are cases where adolescents can be more patient than adults. For example, when faced with a decision that requires an individual to integrate evidence over time, adolescents are more willing to wait for information before making a choice when a high-value reward is at stake.[86] This suggests that reward motivation may actually render adolescents less impulsive in certain situations.

82 Anastasia Christakou et al, *Maturation of Limbic Corticostriatal Activation and Connectivity Associated With Developmental Changes in Temporal Discounting*, 54 Neuroimage 1344 (2011); Wouter van den Bos et al, *Adolescent Impatience Decreases with Increased Frontostriatal Connectivity*, 112 Proc. Nat'l Acad. Sci. E3765 (2015).

83 Christakou, *supra* note 82.

84 Michelle Achterberg et al, *Frontostriatal White Matter Integrity Predicts Development of Delay of Gratification: A Longitudinal Study*, 36 J. Neurosci. 1954 (2016).

85 Bos, *supra* note 82.

86 Theresa Teslovich et al, *Adolescents Let Sufficient Evidence Accumulate Before Making a Decision When Large Incentives Are at Stake*, 17 Development Sci. 59, 59–70 (2014).

Section II: Miller Factors 2 and 3 Family and Home, Peer Influence

Second and third Miller factors: "the family and home environment that surrounds him—and from which he cannot usually extricate himself—no matter how brutal or dysfunctional . . . the circumstances of the homicide offense, including the extent of his participation in the conduct and the way familial and peer pressures may have affected him."

Impact of Adversity on Late Adolescent Brain Development

A growing body of research demonstrates that the early life environment significantly influences the developing brain. Middle and late adolescents involved in the criminal justice system have experienced childhood adversity and trauma at higher rates than the general population.[87] Some research estimates that up to 90% of justice-involved youth have experienced at least one adverse experience and that more than 20% meet criteria for post-traumatic stress disorder (PTSD).[88] This far exceeds the prevalence of PTSD in the general population in which approximately 5% of adolescents and 3.6% of adults meet criteria for post-traumatic stress disorder.[89]

These experiences influence behavioral development and have consequences for brain development.[90] Additionally, environmental social determinants, including racism and poverty, have a profound impact on health, quality of life, and criminal justice involvement.[91] For example, while nearly 4 out of every 10 children are poor for one year or more before they reach the age of 18, justice-involved youth are even worse off and are much more likely to be raised in poverty.[92] While many youth are resilient and childhood adversity does not set a determined destiny, exposure to stress and adversity during childhood and adolescence can produce long-term changes in both brain and behavior.[93]

87 Jessica Craig et al, *A Little Early Risk Goes a Long Bad Way: Adverse Childhood Experiences and Life-Course Offending in the Cambridge Study*, 53 J. Crim. Just. 34 (2017); Michael Baglivio et al, *The Prevalence of Adverse Childhood Experiences (ACE) in the Lives of Juvenile Offenders*, 3 J. Juv. Just. (2014).

88 Carly Dierkhising et al, *Trauma histories among justice-involved youth: Findings from the National Child Traumatic Stress Network*, 4 Eur. J. Psychotraumatology 20274 (2013).; Karen Abram, et al, *PTSD, Trauma, and Comorbid Psychiatric Disorders in Detained Youth*. OJDP Juv. Just. Bulletin (U.S. Dept. Just. Off. Juv. Justice & Delinquency Prev., Washington, D.C.), June 2013.

89 Nat'l Inst. Health, *Post-Traumatic Stress Disorder (PTSD)* (2019), https://www.nimh.nih.gov/health/statistics/post-traumatic-stress-disorder-ptsd [https://perma.cc/M53J-QDD7].

90 Jenifer Siegel et al, *Exposure to Violence Affects the Development of Moral Impressions and Trust Behavior in Incarcerated Males*, 10 Nature Comm. 1 (2019).

91 Lorch & Enlow, *supra* note 17.

92 Caroline Ratcliffe, *Child Poverty and Adult Success* (Urban Inst., Washington, D.C.) September, 2015 at 855–902.

93 Panagiota Pervanidou & George Chrousos, *Metabolic Consequences of Stress During Childhood and Adolescence*. *Metabolism,* 61 Clinical & Experimental 611, 611–619 (2012); Lisa Eiland & Russel Romeo, *Stress and the Developing Adolescent Brain*. 249 Neuroscience 162, 162–171 (2013); Lovallo, W. R. (2013). *Early Life Adversity Reduces Stress Reactivity and Enhances Impulsive Behavior: Implications for Health Behaviors.* 90 Int. J. Psychophysiology 8*,* 8–16.

Neurobiological changes during adolescence enhance vulnerability to the maladaptive effects of stress and adversity, and these effects can influence cognitive processes such as emotion regulation, impulsivity, and executive function.[94] Early life stress can impact the development of emotional regions, including the amygdala and striatum, and self-control regions, such as the prefrontal cortex. Exposure to early adversity is also associated with impaired reward processing, and youth who report early life adversity exhibit differences in the brain's structural connections that are important for learning from rewards.[95]

However, while adversity results in increased risk of poor outcomes, exposures to adversity do not dictate a fate.[96] Adolescence is a dynamic period of the lifespan that is shaped by interactions with both environmental and social factors.[97] Most adolescents' brain and behavioral responses can adapt to the many challenges that they face.[98] Moreover, the effects of psychosocial stress on the brain are not permanent, and these temporary changes in brain function can be reversed after reductions of stress occur.[99] As discussed further below, many young adults positively adapt despite adversity during childhood because they also have individual characteristics (e.g., intelligence, adaptability, ready engagement with others) or access to social circumstances (e.g., family stability and care, access to quality education, medical and behavioral health care, positive community activities) that buffer them from exposures to adversity and/or support a high degree of resilience.

Adversity comes in many forms and can result in psychological trauma, violence, poverty, neglect, and maltreatment.[100] These negative experiences during development increase the risk for psychopathology in late adolescence.[101] The extent of the impact on brain and behavioral development depends on the number and severity of adverse events that an individual encounters during early life.[102]

94 Nim Tottenham & Adriana Galván, *Stress and the Adolescent Brain: Amygdala-Prefrontal Cortex Circuitry and Ventral Striatum as Developmental Targets*, 70 Neuroscience & Biobehavioral Rev. 217 (2016).

95 Bryan Kennedy et al, *Accumbofrontal Tract Integrity is Related to Early Life Adversity And Feedback Learning.* 46 Neuropsychopharmacology 2288, 2288–2294 (2021).

96 *See generally* Emmy Werner, *What Can We Learn about Resilience from Large-Scale Longitudinal Studies?, in* Handbook of Resilience in Children 87–102 (S. Goldstein & R. B. Brooks ed., 2013).; Caitlin Cowan et al, *The Lasting Impact of Early-Life Adversity on Individuals and Their Descendants: Potential Mechanisms and Hope for Intervention*. 15 Genes, Brain, & Behavior 155, 155–168 (2015).

97 Courtney Simmons et al, *Responsible Use if Open-Access Developmental Data: The Adolescent Brain Cognitive Development (ABCD) Study*. 32 Psych. Sci. 866 (2021).

98 *Id.*

99 Conor Liston et al, *Psychosocial Stress Reversibly Disrupts Prefrontal Processing and Attentional Control.* 106 Proc. Nat. Acad. Sci. 912, 912–917 (2008).

100 Ronald Kessler et al, *Childhood Adversities and Adult Psychopathology in the WHO World Mental Health Surveys*, 197 Brit. J. Psychiatry 378 (2010); Lucy Fitton et al*, Childhood Maltreatment and Violent Outcomes: A Systematic Review and Meta-Analysis of Prospective Studies.* 21 Trauma, Violence, & Abuse 754, 754–768 (2020).

101 R. C. Kessler, K. A. McLaughlin, J. G. Green, M. J. Gruber, N. A. Sampson, A. M. Zaslavsky & C. Benjet, *Childhood adversities and adult psychopathology in the WHO World Mental Health Surveys*, 197 Brit. J. Psych. 378 (2010).

102 Joan Luby et al, *Association Between Early Life Adversity and Risk for Poor Emotional and Physical Health in Adolescence: A Putative Mechanistic Neurodevelopmental Pathway*, 171 JAMA Pediatrics 1168, 1168–1175 (2017).

Contemporary psychological models[103] have classified early life adversity along two dimensions: exposure to *threat* and exposure to *deprivation*. Exposure to threat includes exposure to violence or abuse. Exposure to deprivation encompasses exposure to poverty, lack of resources, lack of access to mental stimulation and/or diminished parental or social support.[104] These different types of adversity (threat and deprivation) are associated with distinct effects on brain development and behavior.

Exposure to threat has the greatest impact on the brain processes that are involved in detecting threats, learning from emotional information, and regulating emotions.[105] This includes subcortical regions (such as the amygdala and striatum) as well as connections between subcortical systems and the prefrontal cortex. A 2019 study assessed differences between adolescents who were and were not exposed to child abuse.[106] When viewing emotional images, children who had been abused exhibited enhanced co-activation between the amygdala and the ventromedial prefrontal cortex, regions important for emotional regulation. Differences in brain activity in abused children also predicted the presence and severity of psychiatric symptoms two years later.

Exposure to deprivation most often influences the development of brain systems important for language development and executive function, such as the prefrontal and parietal cortex. Deprivation can be a result of growing up in an impoverished environment. Researchers found that youth growing up in poverty tended to display differences in the development of brain structure. Youth living in low socioeconomic environments are more likely to have smaller volume in subcortical regions such as the hippocampus (a region important for memory formation).[107]

A large-scale study of individuals ages 3–20 found that cortical development is also influenced by parental education and family income.[108] Adolescents from disadvantaged backgrounds have less cortical surface area in regions important for language, memory, and executive function. These differences in the brain could account for why underprivileged youth as a group exhibit worse cognitive performance than peers from high-resource backgrounds. Socioeconomic status also relates to differences in functional recruitment of the prefrontal cortex during tasks testing executive function.[109]

103 Katie McLaughlin et al, *Childhood Adversity and Neural Development: A Systematic Review*, 1 Ann. rev. Developmental psych. 277 (2019). *But see* Karen Smith & Seth Pollak, *Rethinking Concepts and Categories for Understanding the Neurodevelopmental Effects of Childhood Adversity,* 16 Persp. psych. sci. 67, 67–93 (2021) (presenting an alternative neurodevelopmental model of early life adversity).

104 McLaughlin, *supra* note 103.

105 Katie McLaughlin et al, *Mechanisms Linking Childhood Trauma Exposure and Psychopathology: A Transdiagnostic Model of Risk and Resilience*, 18 BMC Med. 1 (2020).

106 Matthew Peverill et al, *Atypical Prefrontal–Amygdala Circuitry Following Childhood Exposure to Abuse: Links with Adolescent Psychopathology*, 24 Child Maltreatment 411 (2019).

107 Natalie Brito & Kimberly Noble, *Socioeconomic Status and Structural Brain Development*, 8 Frontiers in Neuroscience 276 (2014).

108 Kimberly Noble et al, *Family Income, Parental Education and Brain Structure in Children and Adolescents*, 18 Nat. Neurosci. 773 (2015).

109 Emily Merz et al, *Socioeconomic Inequality and the Developing Brain: Spotlight on Language and Executive Function*, 13 Child Development Persp. 15 (2019).

It is critical to note that these changes in the brain may actually serve *adaptive* purposes which help adolescents function in their current environment.[110] Therefore, certain changes may be beneficial for adapting to a low-resource environment, but these same changes may pose challenges when individuals are placed in different contexts or are faced with new circumstances.[111] It is also important to appreciate there are many complexities surrounding the relationships between brain development and socioeconomic status. For example, external factors such as nutrition, exposure to toxins, safety, and even the frequency of verbal conversations in the home may contribute to these effects.[112] This means that many of the conditions affecting brain development that arise from poverty may be transient or remediable.

When early life adversity leads to psychological trauma, it has profound effects on brain and behavioral development. However, there is considerable individual variability.[113] A new frontier of research is investigating what factors foster childhood resilience in the face of adversity. For example, there is evidence that capacities for emotion regulation can buffer the effects of adversity. Individuals with a history of maltreatment who exhibit better emotion regulation skills, and who exhibit enhanced activity in the frontoparietal regions of the brain, are less likely to report symptoms of depression.[114]

The social environment can also confer resilience in youth. The presence of supportive caretakers/mentors and an emotionally warm and supportive family context can buffer the effects of stress and adversity in youth.[115] The research on resilience, while in its infancy, offers potential targets for intervention to support the healthy development of children and adolescents exposed to adversity.

Impact of Adversity on Late Adolescent Behavioral and Health Outcomes

Trauma is a potential consequence of adversity,[116] and there are many definitions of trauma. For example, one definition of trauma includes events that pose a "significant threat (physical, emotional, or psychological) to the safety of the victim or loved ones/friends and are overwhelming and shocking."[117] The Diagnostic and Statistical Manual of Mental Disorders provides the following threshold definition of trauma as Criteria A of post-traumatic stress disorder: "The person was exposed to: death, threatened death, actual or threatened serious injury, or actual

110 *Roper v. Simmons*, *supra* note 97.
111 *Id*.
112 Brito, *supra* note 107.
113 Emily Cohodes et al, *Influences of Early-Life Stress on Frontolimbic Circuitry: Harnessing a Dimensional Approach to Elucidate the Effects of Heterogeneity in Stress Exposure*, 63 Developmental Psychobiology 153 (2020).
114 Alexandra Rodman et al, *Neurobiological Markers of Resilience to Depression Following Childhood Maltreatment: The Role of Neural Circuits Supporting the Cognitive Control of Emotion*, 86 Biological Psych. 464 (2019).
115 Adriana Leak & Jennifer Silvers, *Neurobiological Markers of Resilience to Early Life Adversity During Adolescence*, 6 Biological Psych. Cog. Neurosci. & Neuroimaging 238, 238–247 (2020).
116 Valery Krupnik, *Trauma or adversity?* 25 Traumatology 256, 256–261 (2019).
117 Am. Psychl. Ass'n, *Clinical Practice Guideline for Treatment of Posttraumatic Stress Disorder (PTSD) in Adults,* February 24, 2017 https://www.apa.org/ptsd-guideline/ptsd.pdf (last visited December 20, 2021).

or threatened sexual violence, in the following way(s): direct exposure; witnessing the trauma; learning that a relative or close friend was exposed to trauma; indirect exposure to aversive details of the trauma, usually in the course of professional duties (e.g., first responders such as police or medics)."[118] As we've learned over the past several decades, adverse events that can overwhelm the individual and become psychologically traumatic events are not confined to clearly catastrophic contexts like war or natural disaster but can and do occur in everyday settings including schools, families, and communities.[119]

The Adverse Childhood Experiences Study (ACES) was a landmark study of over 17,000 individuals with health insurance through their employers and showed how adverse (e.g., potentially traumatic) events early in life have profound long-term deleterious effects on the physical and mental health of adults. The ACES study was limited to ten categories of trauma. These included caretaker maltreatment as a child, parental substance abuse or serious psychiatric illness, family violence, and parental incarceration.

However, other difficult childhood adversities such as exposure to community violence are associated with increased risk of emotional and behavioral dysregulation, learning difficulties, conduct problems, court involvement (child protection, status offender, delinquency, early criminal justice involvement), and future violence.[120] Even among this relatively well educated and employed population, exposure to childhood adversity was linked to increased risk of poor life outcomes including earlier onset of risk-taking behaviors, substance misuse, psychiatric diagnoses, smoking, earlier onset of medical conditions and earlier death, and sexual practices resulting in early or unintended pregnancy.[121] This study clearly demonstrated that the greater the number of childhood exposures, the greater the risks of negative life outcomes.

118 American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders 5 (2013); Trent et al, *The Impact of Racism on Child and Adolescent Health*. 144 Pediatrics 2144 e20191765 (2019).

119 Jeong-Kyun Choi et al, *Neighborhood Disadvantage, Childhood Adversity, Bullying Victimization, and Adolescent Depression: A Multiple Mediational Analysis*, 279 J. Affective Disorders 554, 554–562 (2021).

120 Kristen McCabe et al, *The Relation Between Violence Exposure and Conduct Problems Among Adolescents: A Prospective Study.* 75 Am. J. Orthopsychiatry 575, 575–584 (2005); Suzanne Estrada et al, *Individual And Environmental Correlates of Childhood Maltreatment and Exposure to Community Violence: Utilizing a Latent Profile and a Multilevel Meta-Analytic Approach.* 51 Psychol. Med. 1 (2021).

121 *See, e.g.*, Robert Anda et al*, The Enduring Effects of Abuse and Related Adverse Experiences in Childhood: A Convergence of Evidence from Neurobiology and Epidemiology*. 256 Eur. Archives Psych. & Clinical Neurosci 174 (2011); Centers for Disease Control and Prevention, *About the CDC-Kaiser ACE study: Homepage.* https://www.cdc.gov/violenceprevention/aces/about.html (last visited December 20, 2021).

Social Determinants of Late Adolescent Wellbeing

Compared to earlier generations, late adolescents today face more challenges when removing themselves from difficult home environments.[122] While late adolescents who come from resource-rich families are often able to remove themselves from the family environment by pursuing a college education and living away from home, disadvantaged late adolescents (ages 18–21) are more likely to have fewer options when deciding where and with whom to reside. This can be disadvantageous when the home environment is high conflict or inattentive, criminogenic, dangerous, or otherwise toxic.

Like nearly all children in mid-adolescence who have limited choice about where and with whom they live, disadvantaged late adolescents may have no other option but to remain in a dysfunctional family environment[123] or in a turbulent neighborhood. Multilayered environmental stressors, including poverty, lack of access to resources and education, and unstable housing all contribute to a lack of agency. These factors work to substantially diminish or preclude an adolescent's ability to "extricate" oneself from a negative home or community situation. Each of the factors identified above has significant consequences for behavior, brain development, and future life outcomes.[124]

Racism, a social determinant[125] of poverty and health/educational inequality, also influences how youth of color are treated by the criminal justice system and society at large. For example, research indicates that beginning at age 10, youth who are Black are more likely to be mistakenly viewed as being older.[126] This can have significant implications for interactions with law enforcement and subsequent treatment by the court. Studies indicate that discrimination and racism also contribute to negative mental health for late adolescents,[127] including increased symptoms of anxiety and depression[128] and increased alcohol use.[129]

122 Jeffrey Arnett, *Emerging Adulthood: A Theory of Development from the Late Teens Through Early Twenties.* 55 Am. Psych. 69, 69–480 (2000); Jeffrey Arnett, *Does Emerging Adulthood Theory Apply Across Social Classes? National Data on a Persistent Question.*" 4 Emerging Adulthood 227, 227–35 (2020); Seth Schwartz, *Turning Point for a Turning Point: Advancing Emerging Adulthood Theory and Research,* 4 Emerging Adulthood 307, 307–17 (2016); James Côté, *The Dangerous Myth of Emerging Adulthood: An Evidence-Based Critique of a Flawed Developmental Theory*, 18 Applied Developmental Sci. 177, 177–88 (2014); Sara Sandberg-Thoma et al, *Exiting and Returning to the Parental Home for Boomerang Kids,* 77 J. Marriage & Family 806 (2015); Lei, Lei & Scott J. South, *Racial and Ethnic Differences in Leaving and Returning to the Parental Home: The Role of Life Course Transitions, Socioeconomic Resources, and Family Connectivity*, 34 Demographic Rsch. 109, 109–42 (2016).

123 Alison De Marco & Stephanie Berzin, *The Influence of Family Economic Status on Home-Leaving Patterns During Emerging Adulthood.* 89 Families in Society 208, 208–218 (2008).

124 Despite the challenges faced by disadvantaged adolescents, most young people are resilient and largely overcome adversity as they mature into early young adulthood, particularly if they are in environments or relationships that buffer them from long-term impact of adversities and foster resilience.

125 Social determinants may be highly contextual such as whether or not a youth resides in an area heavily surveyed by law enforcement or in a school system where school resource officers more commonly respond to students in crisis with arrest as opposed to de-escalation.

126 Phillip Goff et al, *The Essence of Innocence: Consequences of Dehumanizing Black Children.* 106 J. Personality & Soc. Psych. 526 (2014).

127 Donte Bernard et al, *Making The "C-ACE" for a Culturally-Informed Adverse Childhood Experiences Framework to Understand the Pervasive Mental Health Impact of Racism on Black Youth*. 14 J. Child & Adolescent Trauma 233, 233–247 (2020).

128 Regina Miranda et al, *Perceived Discrimination, Ruminative Subtypes, and Risk for Depressive Symptoms in Emerging Adulthood*. 19 Cultural Diversity & Ethnic Minority Psych. 395 (2013).

129 Noelle Hurd et al, *Does Perceived Racial Discrimination Predict Changes in Psychological Distress and Substance Use Over Time? An Examination Among Black Emerging Adults.* 50 Developmental Pscyh. 1910 (2014).

Further, discrimination has implications for physical health outcomes. A study of Black adolescents found that individuals who experienced higher levels of discrimination between the ages of 16–18, had higher levels of stress hormones[130] (e.g. cortisol, epinephrine, and norepinephrine), higher blood pressure, more inflammation, and higher body mass index by the age of 20.[131] Structural racism compounds difficulties for Black and Latino adolescents who are more likely to lack equal access to high quality education, employment (especially higher income jobs), safe housing, credit, and good health care.[132]

Specifically, Black children are less likely to be given the benefit of the doubt with regards to perceptions or judgments about their innocence and are more likely to be viewed as adults while White children are more often granted the presumption or privilege of innocence and are viewed as less culpable. In one study, perceptions of innocence for Black children ages 10–13 were equal to those for non-Black children ages 14–17 while perceptions of innocence for Black children ages 14–17 equaled those for non-Black subjects ages 18–21. In another study, Black felony suspects were perceived as being 4.5 or more years older than their actual age.[133] A similar disparity was also found in a study of police officers, where officers tended to overestimate the ages of Black and Latino children but not overestimate the ages of White children.[134]

Racial bias also influences the perception of threat.[135] In a study examining threat detection, researchers found that study participants were worse at correctly perceiving threat and neutral cues in Black faces as compared to White faces.[136] In a study of prospective teachers, Black children were incorrectly perceived as angry more often than White children.[137] This is consistent with other research which found that, while young age in general may moderate general threat associations, race-based threat associations persist throughout the lifespan, even when the individual is a young Black child.[138] Overall, these disparities together with research consistently finding disproportionate rates of arrest and incarceration of Black and Latino youth indicate that these youth do not receive the same community responses or protections as White children from the severity of juvenile and young adult consequences for misconduct.

130 Cortisol is a "stress hormone" that regulates the body's metabolic and immune responses, and high levels enhance alertness during stress. Epinephrine is a hormone that cues up the sympathetic nervous system by increasing heart rate and respiration rate during stress. Norepinephrine is released during times of stress, and its release stimulates action, arousal, and alertness.

131 Gene Brody et al, *Perceived Discrimination Among African American Adolescents and Allostatic Load: A Longitudinal Analysis With Buffering Effects*. 85 Child Development 989, 989–1002 (2014).

132 David Williams et al, *Racism and Health: Evidence and Needed Research.* 40 Ann. Rev. Pub. Health 105, 105–125 (2019).

133 Goff, *supra* note 126.

134 *Id.*

135 Jason Okonofua et al, *A Vicious Cycle: A Social-Psychological Account of Extreme Racial Disparities in School Discipline.* 11 Persp. Pscyh, Sci. 381, 381–398 (2016); Jason Okonofua & Jennifer Eberhardt, *Two Strikes: Race and the Disciplining of Young Students*. 26 Psych. Sci*.* 617, 617–624 (2015); Jennifer Eberhardt, Biased: Uncovering the Hidden Prejudice That Shapes What We See, Think, and Do (2020). Jennifer Eberhardt et al, *Seeing Black: Race, Crime, and Visual Processing*. 87 J. Personality & Soc. Pscyh 876, 876–893 (2004).

136 Glasgow, S., Imbriano, G., Jin, J., & Mohanty, A, *Is Threat Detection Black and White? Race Effects in Threat-Related Perceptual Decision-Making*. 20 Emotion 1495 (2020).

137 Amy Halberstadt et al, *Racialized Emotion Recognition Accuracy and Anger Bias of Children's Faces.* 8 Emotion (2020).

138 Andrew Todd et al, *Does Seeing Faces of Young Black Boys Facilitate the Identification of Threatening Stimuli?* 27 Psych. Sci. 384, 384–393 (2016).

Late Adolescent Sensitivity to Peer Influence

In addition to environmental influences, social influences in general and specifically peer involvements are more powerful for adolescents than adults. This has significant implications for adolescent decision-making, impulse control, and risk-taking behavior. In general, late adolescents are more likely to take risks in the presence of peers than when they are alone or when an adult is watching.[139] This is why many crimes committed by adolescents involve peers.

Why are adolescents more likely to engage in criminal behavior in the presence of peers?[140] Peer involvement results in greater risk-taking behavior and is associated with changes in brain responses during adolescence.[141] For example, middle and late adolescents elicit more brain activity in reward centers when receiving monetary incentives if a peer is present, compared to when they are alone. Specifically, peer presence enhances responses in a brain region that is important for motivation and reward processing (striatum). However, peer presence does not modulate neural responses to reward in adults ages 25–35.[142] This effect of peer presence on reward-related activity in the brain relates to enhanced risk-taking behavior. During a risk-taking task, adolescents ages 14–19 showed more activity in the striatum while peers were present than when they were alone, and this boost in brain activity was related to increased risk-taking behavior.[143]

Sensitivity to peer influence has direct consequences for real world behavior. Peer presence and social influence can contribute to risk of substance misuse during late adolescence. For example, when in a bar-like setting, late adolescents are more likely to imitate the drinking habits of their peers even without direct pressure to do so.[144] Similar effects have been reported for cigarette smoking—merely observing a peer smoke increased the chances that an individual would also smoke more than if they were explicitly asked to smoke.[145] This demonstrates that mere peer presence can result in imitative behavior which can be adaptive when modeling positive behavior or decision-making or maladaptive when involving health risks or poor decision-making.

139 Karol Silva et al, *Adolescents in Peer Groups Make More Prudent Decisions When a Slightly Older Adult is Present*, 27 Psych. Sci. 322 (2016); Raymond Bingham et al, *Peer Passenger Norms and Pressure: Experimental Effects on Simulated Driving Among Teenage Males.* 41 Transportation Rch. Part F, Traffic Psych & Behaviour 124, 124–137 (2016).

140 F. E. Zimring, American youth violence. (Oxford University Press on Demand 2020).

141 Albert, *supra* note 15.

142 Ashley Smith et al, *Age Differences in the Impact of Peers on Adolescents' and Adults' Neural Response to Reward*, 11 Developmental Cognitive Neurosci. 75 (2015).

143 Jason Chien et al, *Peers Increase Adolescent Risk-Taking by Enhancing Activity in the Brain's Reward Circuitry*, 14 Developmental Sci. F1 (2011).

144 Sander Bot et al, *Sociometric Status and Social Drinking: Observations of Modelling and Persuasion in Young Adult Peer Groups*. 35 J. Abnormal Child Psych. 929, 929–941 (2007).

145 Zeena Harakeh & Wilma Vollebergh, *The Impact of Active and Passive Peer Influence on Young Adult Smoking: An Experimental Study.* 121 J. Drug & Alcohol Dependence 220, 220–223 (2012).

Studies of decisions made during simulated driving exercises demonstrate that late adolescents and young adults take more risks when driving with peers.[146] The presence of peers at one point while driving persists in increasing risk-taking even when a participant later drives alone.[147] This sensitivity to peer influence is more pronounced in late adolescents than in adults. In a study of individuals ages 18–22, research participants were significantly more likely to engage in risk-taking when a peer was present, even if the participant was told the peer was unknown to them and observing from another room.[148] In another study, 18-year-olds were more likely to increase speeding behavior based on peer influence and peer pressure than individuals in their late twenties.[149] Digital communication can also influence risk-taking among late adolescents. Late adolescents were more likely to make risky decisions when exchanging brief, text-like communications with a peer than when alone or when a peer was passively observing them.[150]

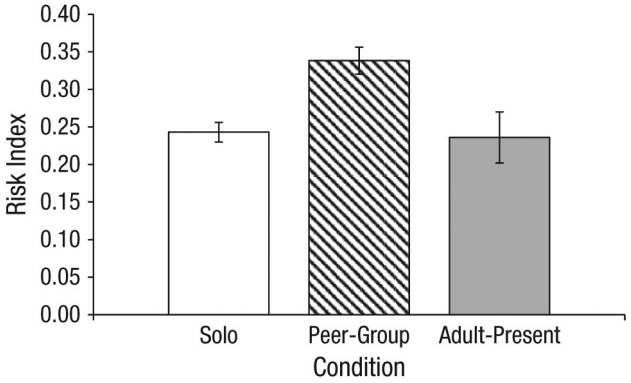

Figure 4: Silva et al. 2016. Risk-taking behavior when the late adolescent was alone (Solo), with four age 18-22 peers (Peer-Group), or with 3 18-22 peers and one young adult age 25-30 (adult present).

The specific composition of peer groups also influences risk-taking behavior. Notably, the presence of adults can reduce risky decision-making for late adolescents.[151] In a study testing late adolescent males ages 18–22, participants completed a set of risk-taking tasks either alone, in the presence of four 18–22 year old peers, or in the presence of three 18–22 year old peers and

146 Bruce Simons-Mortion et al, *The Observed Effects Of Teenage Passengers on the Risky Driving Behavior of Teenage Drivers*, 37 Accident Analysis & Prevention 973 (2005); Rui Pei et al, *Neural processes during adolescent risky decision-making are associated with conformity to peer influence*. 44 Developmental Cognitive Neuroscience 100794 (2020); Bingham, *supra* note 139; Christopher Cascio et al, *Buffering Social Influence: Neural Correlates of Response Inhibition Predict Driving Safety in the Presence of a Peer*. 27 J. Cognitive Neurosci, 83, 83–95 (2015). Marie Claude Ouiment et al, *The Effect of Male Teenage Passengers on Male Teenage Drivers: Findings From a Driving Simulator Study.* 58 Accident Analysis & Prevention 132, 132–139 (2013).

147 J. L. Shepherd et al, *Susceptible to Social Influence: Risky "Driving" in Response to Peer Pressure 1*, 41 J. Applied Soc. Psych.773 (2011).

148 Alexander Weigard et al, *Effects of Anonymous Peer Observation on Adolescents' Preference for Immediate Rewards*, 17 Developmental Sci. 71 (2014).

149 Mette Møller & Sonja Haustein, *Peer Influence on Speeding Behaviour Among Male Drivers Aged 18 and 28*, 64 Accident Analysis & Prevention 92 (2014).

150 R. Ross MacLean et al, *Digital Peer Interactions Affect Risk-Taking in Young Adults.* 24 J. Rsch. Adolescence 772, 772–780 (2014).

151 Silva, *supra* note 139.

one adult between ages 25–30. When only similarly aged peers were present, late adolescents exhibited more risk-taking behavior than when they were alone or when an older adult was present (Figure 4)[151]. Specifically, when peers were present, individuals made riskier decisions on a delay discounting task, meaning they were less likely to delay gratification.

While peer influence can promote maladaptive risk-taking behaviors, the presence and influence of peers can also reduce risk-taking or serve a prosocial function. For example, when presented with risky economic decisions, adolescents are just as likely to conform to peers whether they make risky or safe decisions.[152] Moreover, late adolescents as compared to early adolescents are more prosocial (sharing, giving) towards their friends than with less familiar peers.[153]

Notably, both health-risk behaviors (such as substance misuse) and prosocial behaviors (such as giving to or helping a peer) peak in late adolescence.[154] Together these findings demonstrate that peer influence can have both positive and negative impacts on decision-making.

Summary

Late adolescents are more influenced by their environment and by peers than are adults. Adolescents facing difficult circumstances in their home and community face challenges to their emotional and physical wellbeing, which can influence behaviors such as decision-making and self-control. These factors can lead to involvement with the criminal justice system. Despite these challenges, the vast majority of individuals over time will be successful and demonstrate resilience as they grow and mature (please see Section II at page 18 for additional discussion on resilience). This is most likely to be the case for late adolescents who are given positive social supports and have access to adequate resources (social, community, housing, health, educational, leisure, vocational).

152 Barbara Braams et al, *Developmental Patterns of Change in the Influence of Safe and Risky Peer Choices on Risky Decision-Making*, Developmental Sci. e12717 (2018).

153 Berna Güroğlu et al, *Sharing and Giving Across Adolescence: An Experimental Study Examining the Development of Prosocial Behavior,* 5 Frontiers Psych. 291 (2014).

154 Neeltje Blankenstein et al, *Behavioral and Neural Pathways Supporting the Development of Prosocial and Risk-Taking Behavior Across Adolescence*, 91 Child Development e665-e681 (2020).

Section III: Miller Factor 4 Understanding Legal Proceedings

Fourth Miller factor: "the incompetencies associated with youth" including an "inability to deal with police officers or prosecutors (including on a plea agreement)" and "incapacity to assist his own attorneys."

The decision of whether to invoke *Miranda* rights is often critical to the trajectory of a criminal case.[155] In 2019, law enforcement conducted more than 10 million arrests.[156] Many of these arrested individuals were subject to police interrogation. Decades of research suggests that many children and adolescents do not fully comprehend their *Miranda* rights or the implications of waiving *Miranda* rights.[157] For those in the age range of 18–21, the "temporal discounting" discussed in the previous sections may lead late adolescents to waive their rights in the heat of the moment, without fully appreciating the resulting consequences.[158] For example, despite future ramifications, a late adolescent may elect to waive their right to counsel and then provide or agree with information or statements consistent with an officer's expectations during interrogation in an attempt to end the interrogation.

Research indicates that like early/middle adolescents, late adolescents are more easily swayed by adult influence and coercion than their adult counterparts.[159] This vulnerability has unique implications for late adolescents' ability to effectively navigate interactions with law enforcement, including decisions about whether to assert *Miranda* rights and whether to disclose information or make a statement during police interrogation. Both susceptibility to adult influence and developmentally-based future discounting has implications for how late adolescents interface with the legal system, including judgments during plea bargaining and the extent to which they are able to meaningfully assist their defense attorneys. Additionally, due to racial profiling and cultural stereotypes that promote inaccurate perceptions of Black criminality, late adolescents who are Black are more likely to have had negative experiences with law enforcement and expect to be treated unfairly during interrogation, which can alter the decisions they make during interrogation.[160]

155 *Miranda* rights are 5th Amendment rights that attach when a person is taken into police custody and during custodial interrogation, including the right to remain silent and the right to an attorney.

156 Federal Bureau of Investigation, *FBI Releases: 2019 Crime Statistics* (2020) https://www.fbi.gov/news/pressrel/press-releases/fbi-releases-2019-crime-statistics., FBI (last visited Sep. 28, 2020) [https://perma.cc/V76M-QNZ6].

157 *See* Thomas Grisso, *Juveniles' Capacities to Waive* Miranda *Rights: An Empirical Analysis*, 68 Calif. L. Rev. 1134, 1166 (1980).

158 Late adolescents with cognitive or learning impairments are at heightened risk of misunderstanding *Miranda* rights. A review of over 350 juvenile *Miranda* warnings across the United States found over half of *Miranda* warnings required an eighth grade reading level or above. Richard Rodgers et al, *Juvenile Miranda Warnings: Perfunctory Rituals or Procedural Safeguards?* 39 Crim. Just. & Behavior 229, 229–249 (2012).

159 Cleary, *supra* note 16.

160 Cynthia Najdowski et al, *Stereotype Threat and Racial Differences in Citizens' Experiences of Police Encounters*, 39 L. & Human Behavior 463 (2015).

Neurocognitive Processes Underlying Late Adolescent Decision-making

Future Oriented Decision-Making

Compared to adults, late adolescents are more likely to prioritize immediate outcomes over long-term consequences.[161] Overvaluing immediate consequences has direct implications for waiving *Miranda* rights, making plea decisions, and susceptibility to falsely confessing.[162] As discussed in Section I (page 10), neuroscientists and psychologists have studied how future-oriented decision-making changes with age. Researchers measured a form of future-oriented decision-making, referred to as temporal discounting, by asking individuals to decide between accepting a smaller reward sooner or waiting longer to receive a larger reward (e.g., $5 today or $25 in four weeks). The ability to delay gratification and prioritize later outcomes continues to develop during adolescence and through young adulthood.[163]

Age-related changes in temporal discounting have been linked to the development of the prefrontal cortex,[164] a brain region that is important for thinking abstractly and making decisions about future outcomes. Future-oriented decision-making is associated with enhanced communication between the prefrontal cortex and subcortical regions that are responsive to rewards. Importantly, these connections continue to strengthen during late adolescence,[165] which can account for why late adolescents prioritize immediate outcomes and make more impulsive decisions.[166]

Because of this preference for immediate reward, adolescents may be more likely to comply with an authority figure with the goal of escaping an uncomfortable situation as quickly as possible. These differences in adolescent future orientation have implications for police interrogations.[167] For example, because adolescents may perceive the ability to go home as an immediate reward, adolescents may face increased pressure to make both true and false confessions,[168] including situations in which officers assure the youth or young adult that they will be permitted to go home if they will "just tell the truth" or "help us understand your involvement" in an alleged offense.

161 Grace Icenogle et al, *Adolescents' Cognitive Capacity Reaches Adult Levels Prior to Their Psychosocial Maturity: Evidence for a "Maturity Gap" in a Multinational, Cross-Sectional Sample,* 43 L. & Human Behavior 69 (2019).

162 Scientist Action and Advocacy Network, *Scientific Support for a Developmentally Informed Approach to Miranda Rights* (May 2, 2018) https://scaan.net/docs/20180607-MirandaReport.pdf (last visited December 20, 2021).

163 Eveline Crone & Nikolaus Steinbeis, *Neural perspectives on cognitive control development during childhood and adolescence.* 21 Trends in Cognitive Sci. 205*,* 205–215 (2017); Christopher Holmes et al, *Peer Influence, Frontostriatal Connectivity, and Delay Discounting in African American Emerging Adults,* 14 Brain Imaging & Behavior 155, 155–163 (2020).

164 Laurence Steinberg & Jason Chein, *Multiple Accounts of Adolescent Impulsivity*. 112 Proc. Nat. Acad. Sci. 8807, 8807–8808 (2015).

165 Michelle Achterberg et al, *Frontostriatal White Matter Integrity Predicts Development of Delay of Gratification: A Longitudinal Study.* 36 J. Neurosci. 1954, 1954–1961 (2016).

166 Bos, *supra* note 82.

167 Cleary, *supra* note 16.

168 Lindsay Malloy et al, *Interrogations, Confessions, and Guilty Pleas Among Serious Adolescent Offenders,* 38 L. & Human Behavior 181 (2014).

Decision-making Under Stress

A large body of research has demonstrated that acute stress impairs decision-making.[169] For example, evidence across multiple studies has shown that future-oriented decision-making is significantly impaired during highly stressful situations, and this effect is heightened in late adolescents and young adults.[170] The effect of stress on decision-making is especially pronounced when individuals are faced with social stressors, and when they are required to make decisions about uncertain outcomes.[171] For example, an adolescent or young adult defendant's capacities for considering likely future outcomes may be compromised in situations where police insist "that you talk with us right now and we'll put in a good word for you with the prosecutor" or they are informed that "the plea deal needs to be done right now" or the offer will be withdrawn and harsh sentencing recommendations will be offered to the court if the defendant is later convicted after a trial.

Interactions with law enforcement and authorities induce heightened stress and arousal in youth.[172] Research has demonstrated that adolescents experience heightened physiological stress responses when speaking in front of authorities or when being evaluated by adults.[173] When feeling stressed, both middle and late adolescents are more likely to make risky decisions.[174] A study evaluated risky decision-making and self-control performance when adolescents ages 14–21 were experiencing low and high stress life events. Results indicated that when adolescents were highly stressed, they made more risky decisions when they were presented with choices about uncertain financial outcomes. This suggests that when stressed, adolescents are more likely to pursue immediately rewarding outcomes without factoring in the potential costs of their actions and less likely to weigh the consequences of their decisions. This research again demonstrates the vulnerability of adolescents when making substantive decisions during arrest, interrogation, or high-stress moments throughout subsequent legal proceedings.

Stress influences activity in the prefrontal cortex,[175] and stress can alter communication between the prefrontal cortex and subcortical regions that are responsive to emotional and salient information.[176] A recent study testing adolescents and young adults found that the extent of structural connectivity between the prefrontal cortex and the striatum, a region

169 Anthony Porcelli & Mauricio Delgado, *Stress and Decision-Making: Effects on Valuation, Learning, and Risk-Taking,* 14 Current Opinion Behavioral Sci .33, 33–39 (2017).

170 Sherecce Fields et al, *The Relationship Between Stress and Delay Discounting: A Meta-Analytic Review*. 25 Behavioural Pharmacology 434, 434–444 (2014).

171 Oriel FeldmanHall et al, *The Effects of Social Context and Acute Stress on Decision-Making Under Uncertainty,* 26 Psych. Sci 1918, 1918–1926 (2015).

172 Cleary, *supra* note 16.

173 Jessica Seddon et al, *Meta-Analysis of the Effectiveness of the Trier Social Stress Test in Eliciting Physiological Stress Responses in Children and Adolescents*. 116 Psychoneuroendocrinology 104582 (2020).

174 Adriana Galván & Kristine McGlennen, *Daily Stress Increases Risky Decision-Making in Adolescents: A Preliminary Study*, 54 Developmental Psychobiology 433, 433–440 (2012).

175 Reinoud Kaldeqaij et al, *Frontal Control Over Automatic Emotional Action Tendencies Predicts Acute Stress Responsivity,* 4 Biological Psych.: Cognitive Neurosci. & Neuroimaging 975, 975–983 (2019).

176 J. Van Oort et al, *How the Brain Connects in Response to Acute Stress: A Review at the Human Brain Systems Level.* 83 Neurosci. & Biobehavioral Rev. *281,* 281–297 (2017).

responsive to rewards, was associated with risky decision-making during stressful conditions.[177] Individuals with weaker connectivity were more likely to make risky decisions during highly stressful situations. Because these connections continue to develop during adolescence and into young adulthood, the late adolescent brain may be especially vulnerable to the effects of acute stress.[178]

Development of the prefrontal cortex can also influence how late adolescents respond in vigilant states when they are anticipating potential threats.[179] When faced with acute threats, late adolescents (ages 18–21) respond more impulsively than young adults (ages 22–25). This enhanced impulsivity is associated with decreased recruitment of the prefrontal cortex. Notably, late adolescents' brain responses look more like those of middle adolescents (ages 13–17) than those of young adults (ages 22–25). Together, these findings demonstrate that adolescent decision-making and impulsivity may be more vulnerable to psychosocial stress than young adults, which can have implications for how late adolescents proceed when faced with interrogation. This includes impulsively confessing during an interrogation or providing information in the heat of the moment that an adult would be less likely to disclose.

Interrogation also uniquely impacts the physiological and biological arousal of late adolescents when confronted with coercive interrogation techniques. For example, the condition of *actual* innocence produced "immediate and fundamental" differences in suspects when examining systolic and diastolic blood pressure and various respiratory measures.[180] This translated to a significantly lower level of physiological arousal. Researchers hypothesized that this lower level of arousal contributed to the failure of innocent suspects to perceive the potential dangers of continuing to participate in an interrogation.

This, in turn, increased the likelihood that innocent participants would waive their *Miranda* rights because they naively believed that they would be able to convince police of their innocence. This physiological under-arousal and failure to assert their *Miranda* rights contributed to prolonged interrogation and increased the risk of false confession. For late adolescents, interrogation of both suspects who are innocent and who are guilty prompt different but powerful physiological responses which increase likelihood of false confession. Innocent subjects often fail to appreciate the jeopardy they are in and continue interrogation in the misguided belief that they can convince the interrogators of their innocence. Guilty subjects may fail to assert *Miranda* rights due to a stress-driven desire to promptly get out of an acutely anxiety-provoking encounter by appearing cooperative and perhaps acknowledging aspects of the allegations in an effort to mollify the interrogators.

177 Jessica Uy & Adriana Galván, *Individual Differences in Accumbofrontal Tract Integrity Relate to Risky Decisions Under Stress in Adolescents and Adults,* 45 Developmental Cognitive Neuroscience 100859 (2020).

178 Tottenham, *supra* note 94.

179 Cohen, *supra* note 12.

180 Max Guyll et al, *Innocence and Resisting Confession During Interrogation: Effects on Physiologic Arousal*. 37 L. & Human Behavior 366–75 (2013).

181 *J.D.B. v. North Carolina*, 564 U.S. 261 (2011).

Decision-making in Legal Contexts

The United States Supreme Court acknowledged age-related susceptibility to adult influence within the context of *Miranda* rights and in the landmark case *J.D.B. v. North Carolina*.[181] At the time of the interrogation, 13-year-old special education student J.D.B. was suspected of two break-ins. Without being provided with his *Miranda* warnings, J.D.B. was questioned by a uniformed police officer at school behind closed doors. While J.D.B. initially denied involvement in the burglaries, J.D.B. confessed after the officer encouraged him to tell the truth and threatened him with the possibility of juvenile detention. It was only then that the officer informed the student that he could refuse to answer questions or leave. Over the course of 30 to 45-minutes, J.D.B. verbally and in writing provided details of the crimes.

In remanding the case to state court, Justice Sotomayor observed:

"It is beyond dispute that children will often feel bound to submit to police questioning when an adult in the same circumstances would feel free to leave. Seeing no reason for police officers or courts to blind themselves to that commonsense reality, we hold that a child's age properly informs the *Miranda* custody analysis."[182]

In broadening the "in custody" test to include a consideration of the suspect's age, the majority reasoned that children and adults experience their surroundings differently and that certain settings are inherently more coercive to youth. This was a significant shift in the *Miranda* custody analysis. Post-*J.D.B.*, a child's age can be an important factor in determining whether a juvenile suspect was "in custody" and thus entitled to *Miranda* protections. However, despite the developmental similarities between late adolescents and middle adolescents, thus far, state appellate courts and the United States Supreme Court have declined to extend *J.D.B.*'s consideration of age to late adolescents.[183, 184]

182 *Id*. at 264–65.

183 *See, e.g., United States v. Eaton*, No. CR1801795TUCJGZBGM, 2019 WL 2135878, at *7 (D. Ariz. May 16, 2019) ("Defendant points to his age as a factor noting that 'a reasonable child subjected to police questioning will sometimes feel pressured to submit when a reasonable adult would feel free to go.' Mr. Eaton was twenty-one (21) at the time of the incident, and although a young adult he was not a child. In fact, Mr. Eaton is a father. The Court finds that Mr. Eaton's age is not a factor invalidating his consent.") (citations omitted); *People v. McCullough*, No. 311083, 2013 WL 195607, at *5 (Mich. Ct. App. 2013); *United States v. Hunter*, 912 F. Supp. 2d 388, 399 (E.D. Va. 2012); *State v. Wentzel*, No. A15–1495, 2016 WL 3884417, at *2 (Minn. Ct. App 2016).

184 Some courts have determined that both youth and race must be taken into account in determining reasonableness under the 4th Amendment seizure principles. *See, e.g., Commonwealth v. Tykorie Evelyn*, 485 Mass. 691, 152 N.W.3d 108 (Mass. 2020). ("Going forward, however, the age of a juvenile suspect, if known to the officer or if objectively apparent to a reasonable officer, will be part of the totality of the circumstances relevant to whether the juvenile was seized under art. 14 of the Massachusetts Declaration of Rights....With respect to the defendant's arguments on race, we have examined the continued relevance of our reasoning in *Commonwealth v. Warren*, 475 Mass. 530, 540 (2016), on the question of reasonable suspicion. In that case, we concluded that an innocent African-American man in an urban area might flee from police for fear of racial profiling, and therefore the weight of the inference properly given to flight should be less when the individual is African-American. *See id.* We conclude that this reasoning remains pertinent to the reasonable suspicion analysis and should be extended to other types of nervous or evasive behavior in addition to flight.")

False Confessions

As indicated previously, late adolescents are less equipped to appreciate long-term consequences and make complicated decisions when in emotionally-driven contexts where they are given very limited time to decide on a course of action.[185] These deficits are exacerbated in high stress situations. Arguably, few experiences are more stressful than interrogation by armed uniformed police officers. Research has established a connection between coercive techniques, such as feigned eyewitnesses and promises of leniency, and false confessions.[186] According to the National Registry of Exonerations, the false confession rates for adolescents are three times higher than the rates for adults.[187]

Many of the developmental factors discussed in earlier sections also contribute to increased risk of false confessions in late adolescents. Due to the impact of peer influence and heightened allegiance to peers, as discussed in Section II (page 18), late adolescents may be more likely to be hesitant to expose a peer's behavior even if the disclosure mitigates the extent of their own involvement in the crime or exonerates them. They may even take responsibility for acts they did not commit out of misplaced loyalty to a peer.

There are two main causes of false confessions. The first category emanates from coercive interrogation techniques including coercive questions, comments, and conduct. The second category includes mental states where the defendant's mental status creates vulnerabilities to suggestibility or disruptions of deliberative decision-making due to mental illness, cognitive impairment, or substance use.[188]

False Self-Incrimination

In 1996, the first experimental study on false confessions was conducted using late adolescent college students who were instructed not to hit the ALT key on a computer keyboard.[189] In this study, after being accused of having hit the ALT key, nearly 70% agreed to sign a confession falsely admitting they had hit the ALT key while typing. Approximately 39% were led to believe they had actually pressed the key and nearly 10% offered corroborating facts and details. Notably, in a test condition where participants were instructed to type at a more rapid speed and where confederate witnesses were present to support the accusation, 100% of

185 Casey, *supra* note 12; Willoughby, *supra* note 52; Bernd Figner et al, *Affective and Deliberative Processes in Risky Choice: Age Differences in Risk-Taking in the Columbia Card Task*. 35 J. Exp. Psych: Learning, Memory & Cognition 709 (2009); Erik de Water, et al, *Distinct age-related differences in temporal discounting and risk-taking in adolescents and young adults*, 85 Child Development 1881, 1881–1897 (2014).

186 *See, e.g.,* Melissa Russano et al., *Investigating True and False Confessions Within a Novel Experimental Paradigm*, 16 Psychol. Sci. 481, 482 (2005).

187 Samuel Gross & Rob Warden, *Exonerations in the United States, 1989 through 2012,* Rep. from Nat.l Reg. Exonerations (U. Mich./Nw U. L. Center on Wrongful Convictions), 2012; *see generally* Barry Field, Kids, Cops, and Confessions: Inside the Interrogation Room (2012).

188 There are significant ethical barriers to conducting comparison research studies of coerced false confessions, as inducing harm to research subjects is prohibited and inhibits the research replication of strong-arm tactics. As researchers over the years have attempted to move away from theoretical study and replicate the psychological pressure of the interrogation room while avoiding harm to research subjects, they have developed alternative ways to study coercion.

189 Saul Kassin & Katherine Keichel, *The Social Psychology of False Confessions: Compliance, Internalization, and Confabulation*, 7 Psychol. Sci. 125, 125 (1996).

participants gave a false confession. This experiment, and subsequent studies, demonstrated that when late adolescent populations are confronted with false incriminating evidence, a common technique used by police, individuals may falsely confess to actions and may even come to believe they had acted in ways they did not.

This pattern of false confessions was observed again when researchers conducted a study of late adolescents that created an environment more analogous to police interrogation. Social scientists orchestrated a "cheating" experiment where 330 undergraduate students were assigned to complete individual and joint problem-solving activities with a confederate who posed as a participant.[190] Each undergraduate student was then told they had identical wrong answers on a problem and that a professor had been made aware of the situation and was upset about the sharing of answers and so was weighing appropriate consequences. Research subjects were then interrogated and given a statement to sign that indicated they had cheated. They were also told that if they did not sign the statement, the professor would be called into the laboratory to address the situation with the implication being this would make things worse for the student.

Without interrogation, confession rates were 46% for guilty participants and 6% for innocent participants. The use of two interrogation techniques—promises of leniency ("Things could probably be settled pretty quickly") and minimization ("I'm sure you didn't realize what a big deal it was")—elevated the confession rate to 87% for guilty participants and 43% for innocent participants. The high rate of confessions by innocent participants offered leniency demonstrated that people without mental illness or cognitive impairment, and particularly those in the late adolescent age range, can be led to confess when they believe that asserting their innocence could lead to a potentially worse outcome.

False Memory and Peer Influence

Late adolescents are also more vulnerable to false memory formation than adults. Researchers compared youth ages 16–23 with adults ages 29–58 using a classic false memory task.[191] Compared to adults ages 29–58, youth ages 16–23 were more likely to report recalling that they saw a word that had just been implied but never actually shown to them previously. This study suggests that late adolescents and young adults are more likely to form false memories than adults. Similar research showed that the tendency to report false memories increases during adolescence from ages 11 to 21.[192] This body of research indicates that late adolescents are more prone to false memory formation. This also has implications for statements made by late adolescents during interrogation, particularly when inaccurate information is intentionally or inadvertently introduced or implied during interrogation.

190 Melissa Russano et al., *Investigating True and False Confessions Within a Novel Experimental Paradigm*, 16 Psychol. Sci. 481, 482 (2005).

191 L. Meusel et al, *Youth Are More Vulnerable to False Memories Than Middle-Aged Adults Due to Liberal Response Bias.* 21 J. Can. Acad. Child & Adolescent Psych. 289 (2012).

192 Katherine McGuire, Kamala London & Daniel Wright, *Developmental Trends in False Memory Across Adolescence and Young Adulthood: A Comparison of DRM and Memory Conformity Paradigms*, 29 Applied Cognitive Psych. 334, 334–344 (2015).

Adolescent memory is also susceptible to peer influence. When late adolescents are given information attributed to a friend, they are more likely to be influenced by the friend's statement.[193] In one research study, the impact of social influence was consistent from ages 11 to 21. This demonstrates that late adolescents are just as susceptible to peer influence as early to middle adolescents.

During interrogation, adolescents are also more likely to selectively share information to protect their friends. This tendency is especially strong in late adolescence and can have implications for false confessions. Middle and late adolescents are more prone to prosocial risk-taking than young adults, but they are also more likely to take a risk to benefit a peer because they underweight the personal risks at stake.[194] For example, middle and late adolescents (ages 16–21) are more likely to engage in high-cost prosocial behaviors to defend friends and family members compared to strangers.[195] Further, research on late adolescence has demonstrated that friendship closeness can predict the willingness of an individual to take the blame for a friend's offense.[196] This means that late adolescents are willing to compromise their own reputations and perhaps even their liberty to benefit their close friends despite negative personal consequences.

Contextual Influences and Individual Differences

Lastly, an additional consideration is that late adolescents held in jail pending trial are more likely to face a difficult environmental context, which could lead them to be at increased risk of falsely confessing to a crime as a means of being released from jail. Incarceration challenges for this population include increased exposure to potentially traumatizing adversities including rape and physical assault.[197] This population is also more likely to be held in solitary confinement, which is uniquely emotionally stressful for late adolescents due to this population's heightened need for social interaction.[198] This may lead to individuals within this age group (more so than adults) confessing to crimes or accepting plea bargains when they otherwise would maintain their innocence.

193 Katherine McGuire, Kamala London & Daniel B. Wright, *Peer Influence on Event Reports Among Adolescents and Young Adults,* 19 Memory 674, 674–683 (2011).

194 Kathy Do et al, *But Is Helping You Worth The Risk? Defining Prosocial Risk-Taking in Adolescence.* 25 Developmental Cognitive Neurosci. 260, 260–271 (2017).

195 Laura Padilla-Walker et al, *Longitudinal Change in High-Cost Prosocial Behaviors of Defending and Including During the Transition to Adulthood,* 47 J. Youth & Adolescence 1853, 1853–1865 (2018).

196 Willard, J., & Burger, C. (2018). *Willingness to Falsely Take Blame Among Friends: Closeness, Reporting Wrongdoing, and Identity,* 39 Deviant Behavior 981 (2018).

197 Listwan, S. J., Daigle, L. E., Hartman, J. L., & Guastaferro, W. P. (2014). *Poly-victimization Risk in Prison: The Influence of Individual And Institutional Factors.* 29 J. Interpersonal Violence 2458 (2014).

198 *See, e.g.,* J. Lee, *Lonely Too Long: Redefining and Reforming Juvenile Solitary Confinement*. 85 Fordham L. Rev. 845 (2016).

Overall, developmental neuroscience, social science, and behavioral health research over recent decades has established that late adolescents as a group can make sound decisions when in circumstances supporting calm reflection with opportunities to communicate with others about the decisions to be made. However, when they are exposed to certain coercive and/or emotionally charged circumstances where they feel pressured to make specific statements or acknowledgements, feel as though they have limited options, and are under time pressures to decide or take action, late adolescents are vulnerable to making decisions that undermine their exercise of fundamental Constitutional protections.[199]

199 *See, e.g.,* Field, *supra* note 188.

Section IV: Miller Factor 5
Greater Potential for Rehabilitation

Fifth Miller factor: The greater potential for rehabilitation of youth, the limits of risk assessment, and the high likelihood of desistance from misconduct with maturation

Adolescent Brains Are Poised for Learning

Late adolescents exhibit enhanced neural sensitivity to rewards, as compared to children and adults,[200] which enhances the vulnerabilities for risk-taking described above, but also creates a window of opportunity for prosocial learning and adaptation.[201] A longitudinal learning study tested individuals ages 8–25 and found that increased activity in a key reward region in the brain (striatum) that receives inputs from dopamine centers supports learning improvements during late adolescence.[202] Developmental changes in the dopamine system increase plasticity in the brain. "Plasticity" is the term describing the brain's ability to change and adapt in response to experience. The prolonged period of plasticity during adolescence through young adulthood is also a time during which youth are neurologically primed to learn from experience.[203,204]

During late adolescence, connections between the striatum and prefrontal cortex strengthen. These developing connections support goal-directed behavior,[205] and stronger connections between the prefrontal cortex and the striatum are associated with adaptive learning strategies. Relative to children and early-middle adolescents, late adolescents ages 18–21 are more likely to update and refine their decision-making strategies after receiving rewards for "successful" decisions. This change in learning strategy is associated with enhanced connectivity between

200 Barbara Braams et al, *Longitudinal Changes in Adolescent Risk-Taking: A Comprehensive Study of Neural Responses to Rewards, Pubertal Development, and Risk-Taking Behavior.* 35 J. Neurosci 7226*,* 7226–7238 (2015).

201 Samantha DePasque & Adriana Galván, *Frontostriatal Development and Probabilistic Reinforcement Learning During Adolescence*, 143 Neurobiology Learning & Memory 1 (2017); Juliet Davidow et al, *An Upside to Reward Sensitivity: The Hippocampus Supports Enhanced Reinforcement Learning in Adolescence,* 92 Neuron 93 (2016).

202 Sander Peters & Eveline Crone, *Increased Striatal Activity in Adolescence Bene its Learning*, 8 Nature Communications 1 (2017).

203 Surjeet Mastwal et al, *Phasic Dopamine Neuron Activity Elicits Unique Mesofrontal Plasticity in Adolescence*, 34 J. Neuroscience 9484 (2014).

204 Vishnu Murty, Finnegan Calabro & Beatriz Luna, *The Role of Experience in Adolescent Cognitive Development: Integration of Executive, Memory, and Mesolimbic Systems*, 70 Neurosci. & Biobehavioral Rev. 46 (2016).

205 Catherine Insel et al, *Development of Corticostriatal Connectivity Constrains Goal-Directed Behavior During Adolescence,* 8 Nature Comm*.* 1 (2017); Juliet Davidow, Catherine Insel & Leah Somerville, *Adolescent Development of Value-Guided Goal Pursuit,* 22 Trends Cognitive Sci. 725 (2018).

the striatum and prefrontal cortex.[206] When learning from feedback, research indicates that late adolescents are more responsive to positive feedback (including both material rewards and social rewards such as praise and recognition) than to punishments.[207]

The neuroscience and behavioral research indicate that late adolescents are particularly well suited to learning from experience given the right circumstances and contexts. Further, positive reinforcement may be especially beneficial for adolescent learning, as late adolescents are more responsive to learning from reward than punishment. This has direct consequences for intervention and rehabilitation, as the research demonstrates that late adolescents are more likely to learn from the outcomes of their experiences to change their behavior[208] unless their capacities for social and other learning are compromised by psychiatric, developmental, or cognitive challenges. This, of course, has direct bearing for how to best promote positive behavioral change in youths.

Middle and Late Adolescent Behavior Patterns and Emerging Personality Features Are More Malleable Than Those of Adults

As noted by the United States Supreme Court in *Roper, Graham,* and *Miller,* the frequency of criminal offending increases in late adolescence and then tapers off in early adulthood.[209] Most late adolescents who are chronically involved in the criminal justice system and/or commit violent acts are likely to self-desist from or "age out" of crime as they enter into adulthood, with or without punitive intervention.[210] As discussed in Section I (page 10), middle and late adolescence is a time where individuals are predisposed to impulsive decision-making, preferring immediate over delayed rewards (future discounting), and peer influence.

In 2019, there were more than 10 million crimes committed in the United States. Individuals ages 18–20 accounted for 8% of all offenses and 8.76% of all violent offenses.[211] In a criminal trajectory study, which included individuals who were classified as persistent and serious

206 Wouter can den Bos et al, *Striatum–Medial Prefrontal Cortex Connectivity Predicts Developmental Changes In Reinforcement Learning*, 22 Cerebral Cortex 1247 (2012).

207 Dorothea Hämmerer et al, *Life Span Differences In Electrophysiological Correlates Of Monitoring Gains And Losses During Probabilistic Reinforcement Learning*, 23 J. Cognitive Neuroscience 579 (2011); Katherine Luking et al, *Do Losses Loom Larger for Children than Adults?* 16 Emotion 338 (2016).; Catherine Insel & Leah Somerville, *Asymmetric Neural Tracking of Gain and Loss Magnitude During Adolescence*, 13 Soc Cognitive & Affective Neurosci. 785 (2018).

208 Arielle Baskin-Sommers et al, *Towards Targeted Interventions: Examining the Science Behind Interventions for Youth Who Offend.* 5 Ann. Rev. Criminology (forthcoming 2022).

209 Natsuaki Misaki, Xioajia Ge & Ernst Wenk, *Continuity and Changes in the Developmental Trajectories of Criminal Career: Examining the Roles of Timing of First Arrest and High School Graduation*, 37 J. Youth & Adolescence 431, (2008).

210 Terrie Moffit, *Male Antisocial Behaviour in Adolescence and Beyond*, 2 Nature Human Behaviour 177 (2018); Georg Kessler, *Delinquency in Emerging Adulthood: Insights into Trajectories of Young Adults in a German Sample and Implications for Measuring Continuity of Offending*. 6 J. Developmental & Life-Course Criminology 424, 424–447 (2020); Maryann Davis et al, *Reducing Recidivism and Symptoms in Emerging Adults with Serious Mental Health Conditions and Justice System Involvement*. 42 J. Behavioral Health Services & Rsch. 172, 172–190 (2015).

211 *See* Off. of Juvenile Justice and Delinquency Prevention, *Estimated number of arrests by offense and age group*, U.S. Dep't Just. (2019), https://www.ojjdp.gov/ojstatbb/crime/ucr.asp?table_in=1 [https://perma.cc/T6H7–3LWX].

delinquents, most individuals who committed serious crimes at 17 and 18 (including armed robbery and felony assault) did not continue to engage in antisocial behavior into adulthood, following court involvement.[212]

Violent crime peaks at ages 17–19 and decreases in the early twenties.[213] While counterintuitive, a robust body of research indicates that committing a violent crime before age 20 is not a strong predictor of a persistent criminal trajectory.[214] While there are no research studies involving solely late adolescents, research indicates that early and middle adolescents who commit homicides have similar rates of desistance from misconduct to youth who commit other kinds of less serious offenses, and committing a homicide in adolescence is not itself a predictor of either future violent or non-violent recidivism .[215]

This is in part, because—as discussed in Section I (page 10)—characteristics such as impulsivity, poor decision-making in "hot cognition" contexts and susceptibility to peer influence diminish as the brain continues to develop. However, while *most* late adolescents who commit crimes do not significantly penetrate the adult criminal justice system, pre-adolescent onset of criminal behavior is associated with a higher likelihood of persistent criminal offending behavior [216] and greater exposure to childhood adversities.[217] Versatility of criminal offending is also more likely among those who continue to commit more serious crimes into adulthood.[218] However, as previously noted, *most* chronic and repeat offenders in youth do not persist into adulthood.

Adolescence Gives Rise to Developmentally Expectable Changes in Behavior

Adolescence is characterized by evolving identity, fluctuating family and social relationships, changing motivations and goals, and maturing physical characteristics and cognitive abilities.[219] Adolescent brains continue to develop as they amass life experience. Brain development also responds to the characteristics of the specific physical and social environment within which the adolescent is maturing. Their decision-making, relationships, their ways of understanding the world they navigate, emotional regulation, and behaviors will necessarily change with age as

212 Edward Mulvey et al, *Trajectories of Desistance and Continuity in Antisocial Behavior Following Court Adjudication Among Serious Adolescent Offenders*, 22 Development & Psychopathology 453 (2010).

213 *See, e.g.*, Off. Juv. Just. Delinq. Prot., *Law Enforcement & Juvenile Crime: Arrests by Offense, Age, and Gender,* U.S. Dep't of Justice (Oct. 21, 2019), https://www.ojjdp.gov/ojstatbb/crime/ucr.asp?table_in=1 [https://perma.cc/T6H7–3LWX]; Alex Piquero, et al, *Criminal Career Patterns*, *in* From Juvenile Delinquency to Adult Crime: Criminal Careers, Justice Policy, and Prevention 14 (Rolf Loeber & David P. Farrington eds., 2012).

214 *See* Piquero, *supra* note 215.

215 Elizebth Cauffman & Laurence Steinberg, *(Im)Maturity of Judgment in Adolescence: Why Adolescents May Be Less Culpable Than Adults*, 18 Behav. sci. & l. 741 (2000); M. DeLisi, A.R. Piquero & S. M. Cardwell, *The unpredictability of murder: Juvenile homicide in the pathways to desistance study*, 14 Youth Violence & Juv. Just. 26 (2000).

216 Terrie Moffitt, *Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy*, 100 Psychol. Rev. 674 (1993).

217 Michael Baglivio et al, *The Relationship Between Adverse Childhood Experiences (ACE) and Juvenile Offending Trajectories in a Juvenile Offender Sample*, 43 J. Crim. Just. 229, 229–241 (2015).

218 Moffit, *supra* note 218.

219 Casey, *supra* note 18.

each person transitions across adolescence and young adulthood. For example, development of the prefrontal cortex is accompanied by improvements in self-control and decision-making[220] that are reflected in desistance of misconduct, diminished impulsivity and risk-taking, and long-term planning towards goals.

This is developmentally to be expected. It is currently not possible to reliably predict an individual adolescent's future developmental trajectory based upon current presentation and past history. This is partly because of the high rates of desistance from antisocial conduct as youth mature into young adulthood and partly because behavioral, emotional, and attitudinal changes are expected components of adolescent development.[221] It is also currently scientifically impossible to reliably predict how much or how quickly an individual will change with age based on their presumed brain development, history, or current behavioral profiles.[222]

While adolescents, as compared to adults, may exhibit increased impulsivity and riskier decision-making, these behaviors are ordinarily temporary and developmentally expected.[223] In certain situations, enhanced risk-taking tendencies can be adaptive to promote learning and exploration.[224] These changing behaviors help adolescents navigate the world as they seek to establish autonomy and self-efficacy in society, including risk-taking to achieve positive goals. However, this developmental brain-based behavioral profile also increases risk for problematic behaviors during adolescence.[225] Risk-taking and impulsivity peak during childhood and adolescence and then decrease with age.[226] This developmental trajectory is reflected in age-related changes in delinquent and criminal misconduct (primarily property, substance possession, and other non-violent misconduct), which surges from early through late adolescence and then declines during young adulthood.[227]

220 Catherine Insel et al, *Development of Corticostriatal Connectivity Constrains Goal-Directed Behavior During Adolescence,* 8 Nature Comm. 1 (2018); Davidow, *supra* note 207.

221 Brief of Amici Curiae Professional Organizations, Practitioners, and Academics in the Fields of Neuroscience, Neuropsychology, and Other Related Fields in Support of Petitioner, *Wardlow v. State of Texas*, 141 S. Ct. 190 (2020) (No. 19–8712), https://www.supremecourt.gov/DocketPDF/19/19–8712/145983/20200619160740671_19–8712%20-%20Wardlow%20v.%20Texas%20-%20Professional%20Organizations%20et%20al.%20cert.%20amicus.pdf; Monahan et al., *Trajectories of Antisocial Behavior and Psychosocial Maturity from Adolescence to Young Adulthood*, 45 Developmental Psychol. 1654, 1655 (2009).

222 Violence and Serious Theft: Development and Prediction from Childhood to Adulthood 333 (Rolf Loeber, David Farrington, Magda Stouthamer-Loeber & Helene Raskin White, eds., 2008).

223 Gail Rosenbaum & Catherine Hartley, *Developmental Perspectives on Risky and Impulsive Choice*, 374 Phil. Transactions Royal Soc'y 1766 (2019).

224 Duell, *supra* note 50.

225 Whitney Fosco et al, *The Development of Inhibitory Control in Adolescence and Prospective Relations with Delinquency*, 76 J. Adolescence 37 (2019).

226 Natasha Duell et al, *Age Patterns in Risk-Taking Across The World*. 47 J. Youth & Adolescence 1052 (2018).

227 David Farrington, Rolf Loeber & James Howell, *Young Adult Offenders: The Need for More Effective Legislative Options and Justice Processing*, 11 Crim. & Pub. Pol'y 729 (2012).

Personality Continues to Change Across the Lifespan

Research has long demonstrated that personality is not firmly established in adolescence. Indeed, the 20s are a time of significant evolution of many personality traits, including growth in conscientiousness, self-discipline, and emotional stability.[228] Similarly, adolescence is characterized by continuous changes in personality as adolescents work to form a sense of identity.[229] Personality traits are influenced by environmental and contextual factors such as changing social roles and relationships. [230] Adolescents are uniquely attuned to their social world, and they are highly influenced by the perceptions and behaviors of their peers.[231]

On average, as adolescents age, they exhibit decreases in neuroticism[232] and increases in agreeableness, conscientiousness, openness, and extraversion.[233] Self-control and emotional stability also increase with age, with continued changes in the third and fourth decades of life.[234] As with most developmental research, studies of personality rely upon group averages so research cannot reliably predict whether or how a particular individual's personality will change with age.

Converging research from psychological science simply does not support a view that most youth offenders are incorrigible.[235] In fact, as described above, the science supports a view that (a) the significant majority of adolescent offenders will self-desist from misconduct with maturation, (b) that misconduct typically reflects the "transient immaturity" of youth, and (c) that it is not currently possible to reliably identify the "rare" juvenile who will fail at rehabilitation efforts over the course of a lifetime.

Research on personality and identity formation in late adolescents indicates that behavioral or temperamental traits change significantly through maturation. In other words, personality traits that once were believed to be fixed are actually subject to change over time. This is the case even for adolescents who display callous-unemotional traits and psychopathic traits, which

228 Cohen, *supra* note 12; Brent Roberts & Daniel Mroczek, *Personality Trait Change in Adulthood*, 17 Current Directions Psych. Sci 31 (2008); Brent Roberts, Kate Walton, Wolfgang Viechtbauer, *Patterns of Mean-Level Change in Personality Traits Across the Life Course: A Meta-Analysis of Longitudinal Studies.* 132 Psych. Bulletin 1 (2006); Brent Roberts & Dustin Wood, *Personality Development in the Context of the Neo-Socioanalytic Model of Personality, in* Handbook of Personality Development 11–39 (2006).

229 Theo Klimstra, *Adolescent Personality Development and Identity Formation*, 7 Child Development Perspectives 80, 80–84 (2012).

230 Brent Roberts, Dustin Wood & Jennifer Smith, *Evaluating Five Factor Theory and Social Investment Perspectives on Personality Development*, 39 J. Rsch. Personality 166, 166–184 (2005).

231 Sarah Blakemore & Jathryn Mills*, Is Adolescence a Sensitive Period for Sociocultural Processing?* 65 Ann. Rev. Psych, 187, 187–207 (2014); Leah Somerville*, Special Issue on the Teenage Brain: Sensitivity to Social Evaluation.* 22 Current Directions Psych. Sci 121, 121–127; Braams, *supra* note 152; Lisa Knoll et al, *Social Influence on Risk Perception During Adolescence*, 26 Psych. Sci. 583, 583–592 (2015).

232 Neuroticism is a trait characterized by a tendency to experience intense negative emotions and emotional instability in response to various forms of stress.

233 Theo Klimstra et al, *Maturation of Personality in Adolescence*, 96 J. Personality & Soc. Psych. 898, 898–912 (2009).

234 Casey, *supra* note 12; Roberts BW, Mroczek D. 2008. Personality Trait Change in Adulthood. *Curr Dir Psychol Sci* 17: 31–35

235 Casey, *supra* note 12.

turn out not to be confidently predictive of life-course-persistent offending into adulthood.[236] For example, in a longitudinal study of middle and late adolescents, ages 17–24, researchers found that previously identified psychopathic personality traits[237] decreased over time in late adolescents until age 24.[238]

For late adolescents who engage in criminal behavior, relying upon approaches that build on buttressing individual strengths and resiliencies, at a time when the brain's plasticity facilitates new learning from experience, can promote positive growth and prevent further penetration into the criminal justice system.[239] These approaches must be able to take into account the contributions to rehabilitation or continued criminality of the typically large number of social systems: family, peers, schools, their neighborhood and community, and public agencies.

Consistent interpersonal relationships with young and older adults and social engagement that supports positive prosocial relationships and activities are important for:

- fostering resilience and self-efficacy
- bolstering coping strategies and emotional self-regulation
- building on strengths
- improving prosocial competencies
- increasing a sense of personal responsibility
- establishing goals for the future
- providing opportunities for prosocial engagement and a sense of meaning, and
- establishing healthy and adaptive attitudes, values, and beliefs (norms)[240] that are inconsistent with continuing criminal misconduct.

236 Jennifer Skeem et al, *Psychopathic Personality: Bridging the Gap Between Scientific Evidence and Public Policy*, 12 Psych. Sci Pub. Interest, 95, 95–162 (2011); Matthew Harris et al, *Personality Stability from Age 14 to Age 77 Years*, 31 Psych. & Aging, 862 (2016).

237 Psychopathic personality traits include, for example, a lack of empathy, immoral behavior, and limited emotional responses.

238 Samuel Hawes et al, *Structural Coherence and Temporal Stability of Psychopathic Personality Features During Emerging Adulthood*, 123 J. Abnormal Psych. 623 (2014).

239 Anderson Moore, *Why Positive Youth Development Works*, Child Trends (2016) https://www.childtrends.org/why-positive-youthdevelopment-works [https://perma.cc/9CVX-JVSA]; Family & Youth Services Bureau, *Positive Youth Development,* Admin. For Children & Families, https://www.acf.hhs.gov/fysb/positive-youth-development; [https://perma.cc/NS47-DTVQ] (last visited Dec 20, 2021); Arielle Baskin-Sommers, *Towards Targeted Interventions: Examining the Science Behind Interventions for Youth Who Offend*. 5 Ann. Rev. Crim. (forthcoming 2022).

240 Moore, *supra* note 241.

Conclusion and Recommendations

The United States Supreme Court cases of *Roper* (2005), *Graham* (2010), and *Miller* (2012) drew attention to adolescent and young adult brain and social development by clearly articulating a "children are different" Eighth Amendment jurisprudence. In *Montgomery* (2016), SCOTUS maintained this line of jurisprudence and clarified that *Miller* was to be applied by states retroactively as mandatory Life Without Parole juvenile sentences (JLWOP) are substantive violations of the Eighth Amendment.

The *Jones* (2021) decision held that sentencing courts are not required to articulate findings that a juvenile is "irreparably corrupt" or even required to make findings on the specific "*Miller* factors" previously outlined. However, the *Jones* opinion left undisturbed the position of the prior cases that even serious crimes committed by persons under age 18 reflect the "transient immaturity" of youth" but for "rare" cases. The challenges of reliably identifying these "rare" youth required barring execution for crimes committed as a minor (*Roper)* and presumably would render discretionary JLWOP sentencing "uncommon" (*Miller).* Even then, a sentenced youth must be provided at least one "meaningful opportunity" to demonstrate rehabilitation as an adult.

Between 2005–2021, states have responded through case law and legislative action to craft frameworks consistent with the SCOTUS line of cases. The variability of the state responses has resulted in a patchwork of "justice by geography" with disparate outcomes for similarly situated cases. However, it also affords an opportunity by clarifying that the focus has shifted from whether a sentencing court must make findings of "irreparable corruption" to a focus on the undisturbed acknowledgement of the "transient immaturity" of youth—even for those who have committed heinous crimes as minors. While *Jones* does not impose a federal Constitutional requirement on sentencing judges to make findings regarding "irreparable corruption" or the *Miller* factors, some states have already incorporated these steps in their state statutes and/or case law. Even where states have not incorporated these steps in their legal framework, there is nothing in *Jones* or state law that bars submitting evidence relevant to the "transient immaturity" of a youthful defendant or the *Miller* factors.

Moreover, the focus in this line of cases upon the dispositive "bright line" drawn at age 18 for imposing accountability through the adult criminal legal system has raised the question: Is there a reasonable basis found in brain science and developmental research (social, behavioral, criminology) for drawing this line at age 18? Put another way, is there a basis in science for drawing this life-altering line between mid-adolescence (ages 16–17) and late adolescence (ages 18–21)? The neuroscience and social-behavioral science summarized in this document indicates there is no solid basis in science for a line drawn at age 18 for criminal jurisdiction.

Indeed, drawing this line at age 18 will lead most late adolescents who offend (and most will *not* offend with serious crimes against persons) to penetrate the criminal justice system just before the time when the significant majority of middle and late adolescent youth will self-desist (the "age-crime curve" occurring at ages 19–20) even if they have been violent and persistent offenders when younger.

From a public policy perspective, this means that young offenders highly likely to desist with maturation—especially if provided with meaningful non-criminal opportunities—will instead accrue the collateral consequences of criminal justice involvement (e.g., criminal records, social labeling, forced affiliation with adult criminals if in prolonged detention or incarcerated). These collateral consequences over time actually *increase* risk of criminal recidivism among young offenders who with maturation are otherwise highly likely desist from continuing criminal misconduct.

From a criminal justice perspective, research indicates that continuing traditional supervision and sentencing practices inadvertently tend to increase recidivism, fail to foster diversion from unwarranted penetration into the criminal justice system, and continue the pattern of disproportionate entanglement of young persons of color. Parole practices focused primarily on "supervision"—rather than "engagement" and individualized case planning—will persist. Younger offenders will continue to be processed at least as harshly (and arguably more harshly) than adult offenders.

This is not to suggest that younger offenders (ages 18–21) should not be accountable for criminal conduct. Indeed, accountability for decisions and conduct is essential for positive development and maturation. Rather, it is to observe that the science exists to guide policy and individual case practice (for judges and probation officers, prosecutors and defense counsel, and others) towards *proportional* and *developmentally aligned* accountability for middle and late adolescent offenders. Our currently worrisome rates of recidivism among younger offenders can be lowered—thereby contributing to community safety—by adopting a developmentally-informed approach to young offenders.

At a policy level, our currently dismal criminal justice outcomes could be improved for this age cohort by designing and implementing evidence-based processes for diversion, preventing unwarranted penetration (including pre-trial detention and avoiding harsh sentencing), and resourcing developmentally specialized intervention for late adolescent offenders which supports prosocial activities (including non-criminal social networks, education, and jobs). Corrections policy may look to evidence-based models in the United States and elsewhere which improve recidivism outcomes by separating younger offenders from older adult offenders, placing them into their own units with developmentally aligned programming, and using

developmentally-trained correctional, educational, pre-vocational, and behavioral health staff to utilize less punitive approaches and support positive community re-entry, thus increasing the likelihood of avoiding future criminal involvement.[241]

Judges can support local implementation of these kinds of policy measures while also informing themselves about the relevant brain and developmental science, considering science offered in briefs and expert testimony, encouraging processes (including plea agreements) which take the developmental status of younger offenders into account, and taking into account the inadvertent consequences of harsh sentencing or more punitive supervision practices. Judges may also look to emerging court-based models of deferred sentencing or innovative sentencing that may be adaptable to the local circumstances and resources of their jurisdiction.

Prosecutors can measure their success by metrics other than convictions and lengths of sentences imposed. For example, metrics can include cases successfully diverted from arraignment without subsequent recidivism, or cases where incarceration was precluded because of successful community-based and developmentally aligned services (e.g., education, vocation, prosocial interpersonal engagement, and behavioral health treatment) as part of initial diversion or subsequent plea bargaining.

Defense counsel can take a broader developmental view (taking into account biological, psychological, and social domains) of who the defendant is and what criminogenic needs must be addressed to lower recidivism risk. They can also learn how to create a complete trial record that includes successful and unsuccessful efforts to bring scientific and/or developmental information before the court in briefs, expert testimony, and oral argument. Appellate counsels are often disadvantaged by incomplete or unartful trial records and efforts are increasingly underway to train trial counsel on how to develop the best records possible.

241 Group-level research that yields "on average" data is a ready fit for guiding broad policy and program development and implementation. For example, policy and law can result in increased community safety if aligned with research finding that "on average" adolescents or youth adults diverted from unnecessary penetration into juvenile or criminal justice systems have lower recidivism rates than those who become entangled in these systems for relatively minor misconduct or misconduct that is likely to remit with maturation. The policy impact can be achieved without specifically assessing the likelihood that a given young person will desist, as the policy anticipates that a significant majority of young persons will desist from delinquent or criminal misconduct with maturation. This is similar to medical practice where decisions and practices are made for identified patient populations because they ordinarily work—such as prescribing antibiotics for certain kinds of infections although there may be some patients for whom the standard practice will not be as effective and alternatives may be considered.

Pre-trial and post-conviction probation staff can take a developmentally and trauma-informed approach to intake, recommendations made to the court, and supervision practices. These can include: (a) avoiding conditions of release/probation likely to result in violation but unlikely to contribute to public safety threat even if not fully complied with by the person under supervision; (b) advocating for conditions of release/probation that are likely to contribute to the person's stabilization and avoiding new arrests; (c) creating highly individualized supervision plans that are informed by the science of normal mid-late adolescent development, adversity/trauma, addictions, and mental health disorders; and (d) case planning that directly addresses each person's most significant criminogenic needs while building upon strengths and protective factors.

Behavioral health professionals likely to conduct forensic evaluations, provide forensic expert testimony, or provide clinical testimony about behavioral health needs/interventions for defendants can strive to be currently informed of relevant research domains. These include brain and developmental research about mid-late adolescents, the "age-crime curve," evidence-based assessment methods (clinical and forensic, including violence and recidivism risk), and evidence-based treatment and intervention approaches for younger offenders. Standard clinical training is ordinarily insufficient to provide proficiency in working with younger offenders, and, in any event, the continuing development of research in this area requires an ongoing process of professional development and learning.

Appendix: Introduction to Middle and Late Adolescent Brain Development

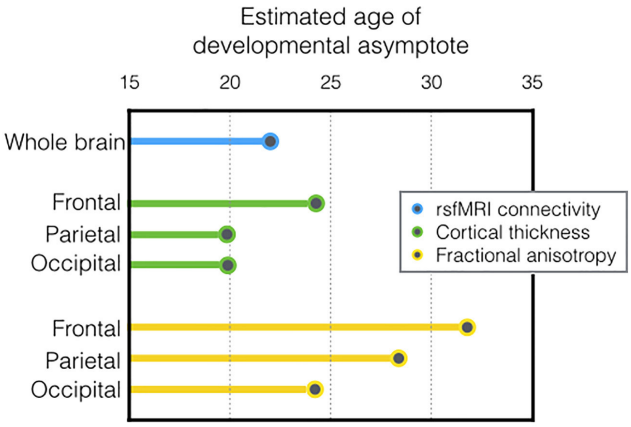

Figure 5: Somerville 2016. Age of developmental asymptote (plateau) for different brain measures. rsfMRI is a measure of whole brain connectivity; cortical thickness is a measure of grey matter development; fractional anisotropy is a measure of white matter development.

Brain development is a dynamic process that continues throughout the life course. Throughout early, middle, and late adolescence,[242] brain systems and the connections between them undergo a period of prolonged refinement.

Since *Miller* (2012), there have been a wealth of new research studies on adolescent brain development that have enhanced our understanding of how the brain matures and how this maturation impacts behavior. Scientists have begun using new approaches to measure brain development. Many newer studies include more individuals (large sample size), and some studies follow the same individuals over time (longitudinal research).[243] With this type of data, researchers can model a "growth curve"[244] of how the brain changes across development by averaging the brain changes of many individuals across different ages and time points. Researchers can measure the age at which the changes of different brain systems level off or plateau. Researchers can also estimate when a brain system reaches a point of stable

242 Because brain development does not rigidly conform to chronological boundaries, there is some disagreement in the field as to how to precisely define the stages of adolescence and adulthood. For clarity, in this document, we define early adolescence as 10–13, middle adolescence as 14–17, late adolescence as 18–21, and young adulthood as 22–25. For discussion of changing age definitions, *see* Susan Sawyer et al, *The Age of Adolescence*. 2 Lancet Child & Adolescent Health 223, 223–228 (2018).

243 A longitudinal study is a study that tracks individuals over time.

244 A "growth curve" is a graphical depiction of change over time. A "growth curve" of brain development depicts changes in brain processes as a function of age.

development.[245] It is important to note that different systems develop at different rates, and the brain never "stops developing," as brain development continues throughout the lifespan. Additionally, development does not occur at the same rate in all areas of the brain. Rather, different brain systems follow different developmental trajectories and time windows.

Dynamic changes in brain development continue well beyond the age of 18 (Figure 5).[245] This extended window of brain maturation is paralleled by prolonged social, emotional, and cognitive development during late adolescence.[246] As a result, late adolescents (ages 18–21) as a group, exhibit unique brain and behavioral profiles that are distinct from both younger adolescents and young adults (ages 22–25).

Fundamentals of Late Adolescent Brain Development

Structural Development

Late adolescence is accompanied by continued development of brain structure. Multiple brain regions and the connections between them continue to mature during this period. The last region to structurally mature is the prefrontal cortex, which guides "executive functions" such as complex decision-making, self-control, and higher-order cognitions.[247]

245 Somerville, *supra* note 11.

246 Laurence Steinberg & Grace Icenogle, *Using Developmental Science to Distinguish Adolescents and Adults Under the Law*, 1 Ann. Rev. Developmental Psych. 21 (2019).

247 "Higher order cognitions" include abilities to consider situations from the perspective of another person, identify and assess the likelihood of future alternate outcomes of decisions made now, and systematic and evaluative problem-solving that is also sufficiently flexible to effectively apply past experiences to novel situations (creativity).

Grey Matter Development

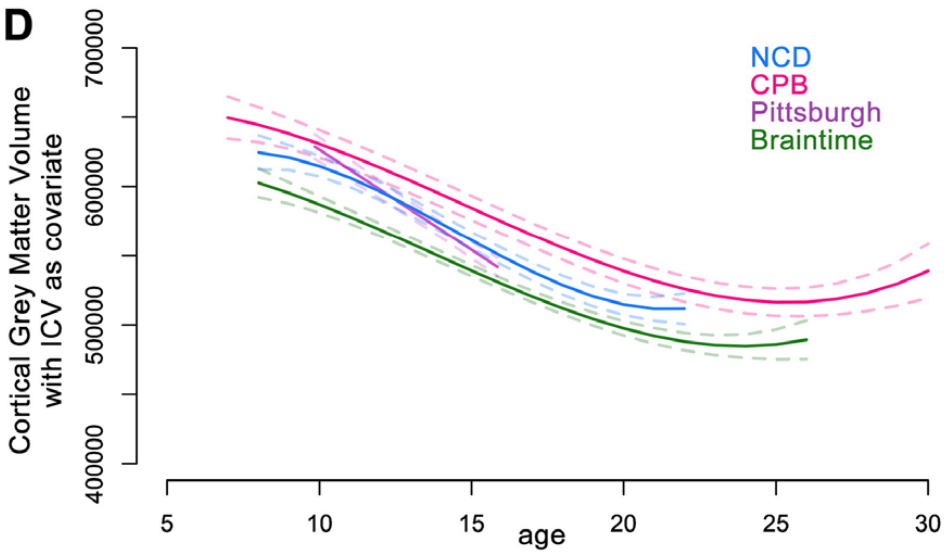

Figure 6: Mills et al. 2016. Age models for cortical grey matter across four research sites. Each line represents a different research site. This study included 852 scans for 391 individuals age 8 to 30. Note that the upturn from age 25 to 30 is not statistically significant.

Grey matter is tissue in the brain that is responsible for information processing. Grey matter volume normatively thins during adolescence, and thinning persists through young adulthood.[248] This decrease in grey matter results from a brain refinement process called synaptic pruning. Synaptic pruning is an experience-dependent process that weeds out underused synapses (connections between neurons). This developmental process sculpts a more efficient

248 Rhoshel Lenroot et al, *Sexual Dimorphism of Brain Developmental Trajectories During Childhood and Adolescence*, 36 Neuroimage 1065 (2007).

and specialized brain.[249] [250] Pruning during late adolescence is more pronounced in regions that support higher-level cognition, including the prefrontal cortex, which is among the last regions to mature. Prefrontal synaptic pruning persists well beyond adolescence and continues into young adulthood.[251]

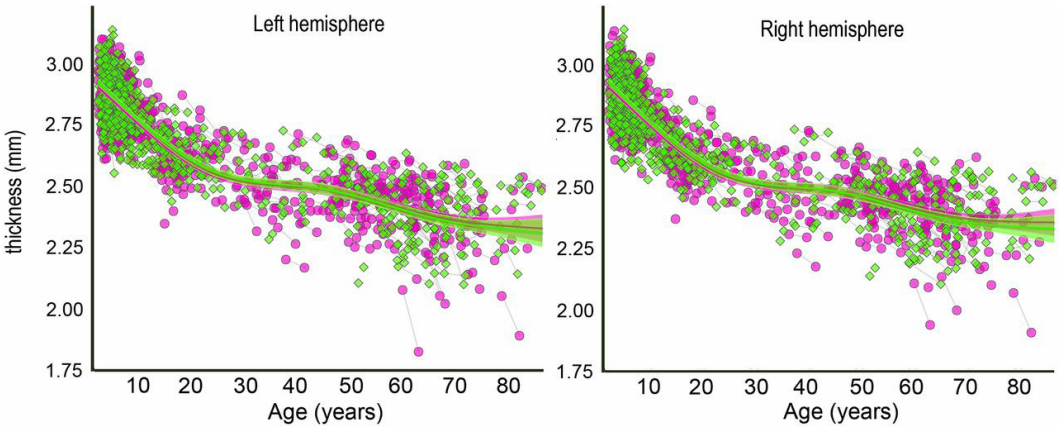

Figure 7: Fjell et al. 2015. Global changes in cortical thickness. Longitudinal study testing 974 participants ages 4–89. Green is female, pink is male.

Converging evidence across multiple studies and institutions demonstrates that grey matter thinning continues throughout the twenties (Figure 6).[252] Research examining structural development across the lifespan found that cortical thinning begins to plateau between ages 25 and 30 (Figure 7).[253] The prefrontal cortex in particular shows dramatic thinning, with a 17% reduction in prefrontal grey matter volume between the ages of 6 and 26.[254]

249 Zdravko Petanjek et al, *Extraordinary Neoteny of Synaptic Spines in the Human Prefrontal Cortex*, 108 Proc. Nat'l Acad. Sci. Acad. Sci. 13281 (2011).

250 Budhachandra Khundrakpam et al, *Brain Connectivity in Normally Developing Children and Adolescents*. 134 Neuroimage 192 (2016).

251 Zdravko Petaniek et al, *Extraordinary Neoteny of Synaptic Spines in the Human Prefrontal Cortex*, 108 Proc. Nat'l Acad. Sci. 13281 (2011).

252 Kathryn Mills et al, *Structural Brain Development Between Childhood and Adulthood: Convergence Across Four Longitudinal Samples*, 141 Neuroimage 273 (2016); Christian Tamnes et al, *Development of the Cerebral Cortex Across Adolescence: A Multisample Study of Inter-Related Longitudinal Changes in Cortical Volume, Surface Area, and Thickness*, 37 J. Neuroscience 3402 (2017).

253 Hugo Schnack et al, *Changes in Thickness and Surface Area of The Human Cortex and Their Relationship with Intelligence*, 25 Cerebral Cortex 1608 (2015); Anders Fjell et al, *Development and Aging of Cortical Thickness Correspond to Genetic Organization Patterns*, 112 Proc. Nat'l Acad. Sci. 15462 (2015).

254 Kathryn Mills et al, *The Developmental Mismatch in Structural Brain Maturation During Adolescence*, 36 Developmental neuroscience 147 (2014).

White Matter Development

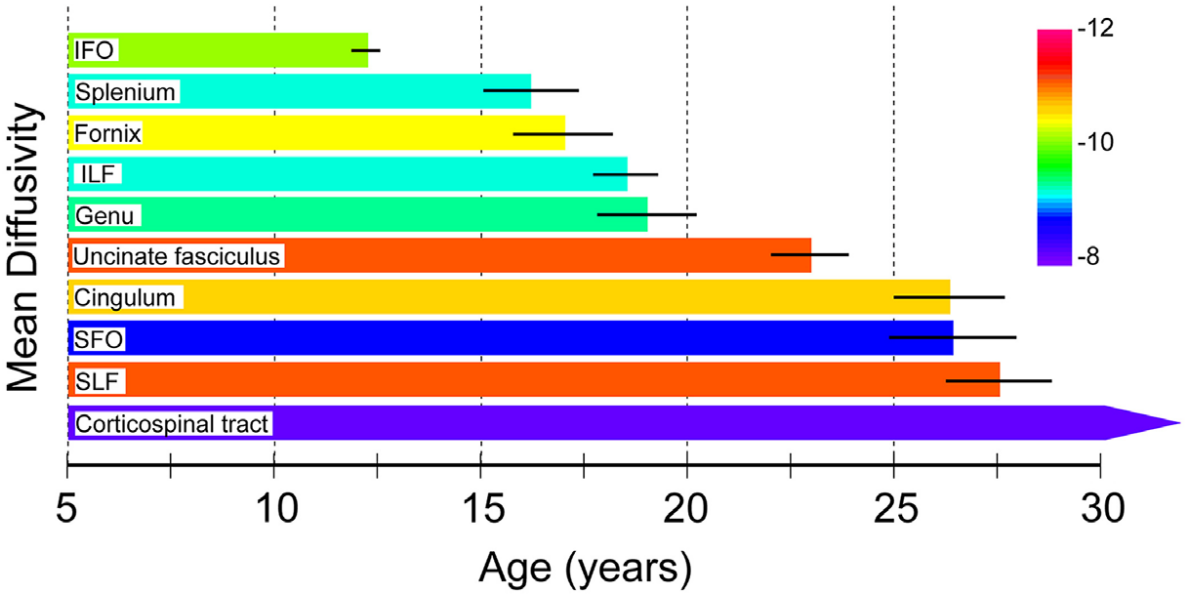

Figure 8: Lebel et al. 2019. Plot showing white matter development from age 5 to 30 in different white matter tracts of the brain (colored bars). Decreases in mean diffusivity provide an approximation of strengthening white matter connections. The end of each bar represents the age at which the measure reaches 90% of its developmental plateau. IFO: inferior fronto-occipital fasciculus; ILF: inferior longitudinal fasciculus; SFO: superior fronto-occipital fasciculus; SLF: superior longitudinal fasciculus.

White matter is tissue that is composed of tracts, which are bundles of myelinated axons in the brain that can relay information between brain regions. White matter connections facilitate efficient communication across the brain. Developmental changes in white matter are thought to reflect myelination. Myelin is a substance that surrounds neuron axons and serves an insulating function for the brain's wiring, which facilitates more rapid communication between brain regions. The process of myelination increases the amount of myelin in the brain, which speeds up communication between different brain regions. During late adolescence, myelination strengthens communication between brain regions that are far apart from one another in the brain. During this period, myelination progresses in the prefrontal cortex, which strengthens connections that are important for reasoning, decision-making, and self-control.[255]

Longitudinal studies have demonstrated that the development of white matter continues throughout the twenties and into the thirties (Figure 8).[256] Notably, connections between the prefrontal cortex and subcortical regions[257] continue to develop past age 18. Maturation of

255 Daniel Miller et al, *Prolonged Myelination in Human Neocortical Evolution*, 109 Proc. Nat'l Acad. Sci. 16480 (2012).

256 Catherine Lebel, Sarah Treit & Christian Beaulieu, *A Review of Diffusion MRI of Typical White Matter Development from Early Childhood to Young Adulthood*, 32 NMR Biomedicine E3778 (2019).

257 Subcortical regions include the hippocampus, amygdala, and striatum. These regions are important for reward processing, processing of emotionally arousing and salient information, and learning and memory.

these white matter connections is associated with improved self-control.[258] Connections between the prefrontal cortex and subcortical regions continue to develop through the twenties.[259] This means that communication and integration within brain networks continue to refine through late adolescence and young adulthood to support higher-order cognition.

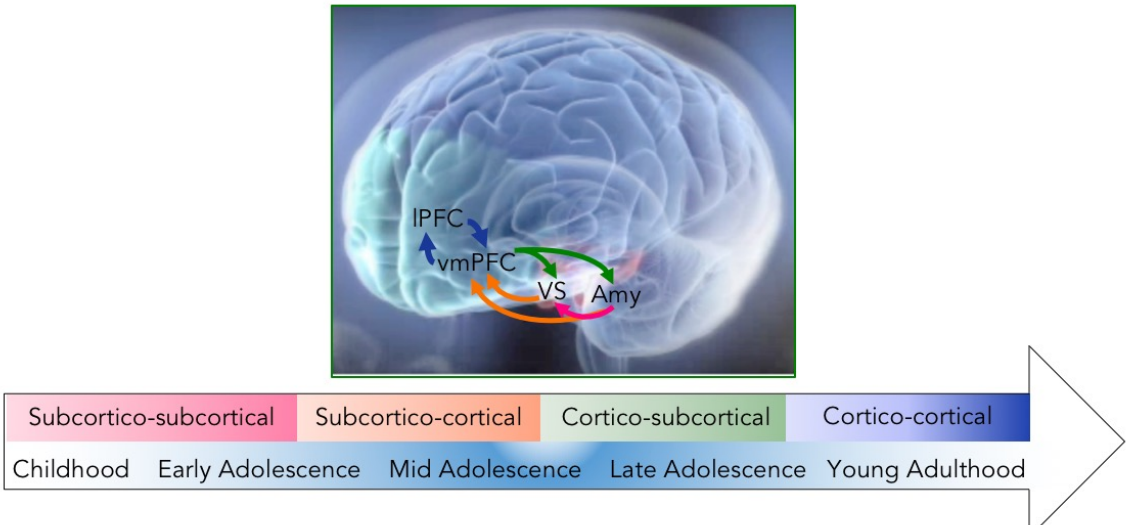

Figure 9: Casey 2020. Illustration of hierarchical development of brain circuitry. Amy is amygdala; VS is ventral striatum; vmPFC is ventromedial prefrontal cortex; lPFC is lateral prefrontal cortex.

Functional Development

While structural development reflects changes in the physical architecture of the brain, functional development reflects changes in the activity in brain regions and the communication between them in response to stimuli in the environment. In other words, functional development describes changes in how the brain's elements communicate with one another to produce cognitions and emotion. During adolescence, functional activity in brain regions and the functional connections between brain networks exhibit changes with age, which suggests that some regions and connections develop at different rates. This means that the development of distinct brain processes stabilizes at different ages (Figure 9).[260] Therefore, the development of some regions and connections stabilizes earlier in adolescence, whereas others continue to mature well into the twenties and early thirties.[261] [262]

258 Daniel Simmonds et al, *Developmental Stages and Sex Differences of White Matter and Behavioral Development Through Adolescence: A Longitudinal Diffusion Tensor Imaging (DTI Study*, 92 Neuroimage 356 (2014).

259 *Id.*

260 Casey, *supra* note 42.

261 B. J. Casey, Rebecca Jones & Leah Somerville, *Braking and Accelerating of the Adolescent Brain,* 21 J. Rsch. on Adolescence 21 (2011).

262 Leah Somerville & B.J. Casey, *Developmental Neurobiology of Cognitive Control and Motivational Systems*, 20 Current Op. Neurobiology 236 (2010).

Subcortical regions have earlier structural development in adolescence than cortical regions.[263] Subcortical regions include the striatum and amygdala, which are important for emotional and motivational processes like responding to rewards, emotionally salient information, and faces. In contrast, the prefrontal cortex, which guides self-control and complex decision-making, continues to mature throughout late adolescence. This extended window of prefrontal maturation supports the development of executive functioning, a set of mental processes that help with concentration, attention, cognitive flexibility, and self-control.[264]

The development of the prefrontal cortex, which guides self-control, exhibits a more protracted trajectory than the development of subcortical regions which are responsive to rewards and salient cues. As a result, late adolescents exhibit unique behavioral responses in reward-driven or emotionally heated situations. On the one hand, because the prefrontal cortex is more developed than it was during earlier periods in their lives, late adolescents have better cognitive control and decision-making skills than they did when they were younger. On the other hand, because the motivational and emotional systems in the brain are hyper-responsive during adolescence, middle and late adolescents as a group are more vulnerable than adults to lapses in self-control or impulsive decision-making—especially when in emotionally heated situations.[265]

Functional connectivity reveals which regions show synchronous activation. In other words, two regions are functionally connected if they show similar patterns of activity over time during a task or when at rest. Functional connectivity measures characteristics of the pathways the brain uses to communicate. The functional connections between brain regions continue to refine through late adolescence as connectivity patterns shift with age. Younger individuals exhibit more connections between regions that are closer together. However, during adolescence, connections strengthen among regions that are farther apart.[266] This enhanced integration supports the development of executive functions[267] which support complex reasoning and emotional regulation.

Emotional Influences on Cognition in the Late Adolescent Brain

Adolescents' cognitive abilities continue to strengthen as they age. However, adolescent self-control is more vulnerable to disruption than the self-control of adults. Specifically, adolescents are vulnerable to temporarily dampened self-control when in emotionally charged or high-stress situations. This occurs because the prefrontal cortex is still developing during adolescence, but subcortical systems in the brain are hyperresponsive to emotional information during this developmental period.

263 Kathryn Mills et al, *The Developmental Mismatch in Structural Brain Maturation During Adolescence*, 36 Developmental Neurosci. 147, 147–160 (2014).

264 Eveline Crone & Nikolaus Steinbeis, *Neural Perspectives on Cognitive Control Development During Childhood and Adolescence*, 21 Trends Cognitive Sci. 205 (2017); Adele Diamond, *Executive Functions*, 64 Ann. Rev. Psych. 135 (2013).

265 Casey, *supra* note 56. For a more detailed summary, see Section B (infra).

266 Damien Fair et al, *Functional Brain Networks Develop from a "Local to Distributed" Organization*, 5 PLoS Computational Biology e1000381 (2009); Nico Dosenbach et al, *Prediction of individual brain maturity using fMRI*, 329 Science 1358, 1358–1361 (2010).

267 Scott Marek et al, *The Contribution of Network Organization and Integration to the Development of Cognitive Control,* 13 PLoS Biology e1002328 (2015).

The prefrontal cortex and subcortical regions are connected to one another, and these connections strengthen during adolescence. The stronger connectivity between cortical and subcortical systems can account for the developmental differences in how people behave in emotional situations. Maturing connectivity between the prefrontal cortex and subcortical regions has been linked to improved cognitive performance in emotional scenarios.[268] Due to the refinement of communication between cortical and subcortical brain systems, emotion regulation abilities improve with age.[269] [270] Connections within the prefrontal cortex also facilitate self-control and emotion regulation. These connections continue to develop through late adolescence and into young adulthood.[271]

At the time of the *Miller* (2012) decision, most developmental research examining how emotionally heated situations influence behavioral and brain responses did so by comparing groups of individuals under age 18 to groups of individuals older than 18. However, research since 2012 has examined continuous changes in brain development throughout adolescence and beyond age 18 into late adolescence and young adulthood. This approach has revealed new insights about how the late adolescent brain responds to emotionally charged situations. Notably, this research shows that, when faced with certain emotional contexts, late adolescents exhibit situational disruptions in self-control. These suboptimal changes in behavior are related to differences in patterns of brain activity and connectivity. For example, these differences are reflected in the relative vulnerability of late adolescents to transient dampening of self-control when anticipating potential threats.[272] [273]

Relative to young adults (ages 22–25), late adolescents (ages 18–21) exhibit poorer self-control when anticipating a potential threat. Research found that during threat vigilance states, late adolescents exhibited patterns of brain activity more like the middle adolescent group (ages 13–17) than the young adult group (ages 22–25). Specifically, middle and late adolescents exhibited reduced connectivity between prefrontal regions and reduced activity in regions that guide successful self-control (lateral prefrontal cortex, the parietal cortex, and the dorsal anterior cingulate).

268 Somerville, *supra* note 65.

269 Dylan Gee et al, *A Developmental Shift from Positive to Negative Connectivity in Human Amygdala–Prefrontal Circuitry*, 33 J. Neuroscience 4584 (2013).

270 Aaron Heller et al, *Changes in Cortico-Subcortical and Subcortico-Subcortical Connectivity Impact Cognitive Control to Emotional Cues Across Development*, 11 Soc. Cognitive & Affective Neuroscience 1910 (2016).

271 Silvers, *supra* note 55.

272 Cohen, *supra* note 12.

273 One brain imaging study tested whether vulnerability to emotional scenarios persists through late adolescence by comparing brain activity and connectivity between adolescents (age 13–17), late adolescents (age 18–21), and young adults (age 22–25). Participants performed a self-control task with emotional cues during a neutral state, positive state, or a threat state. When in a positive or threat state, the participants were anticipating that something good (possibility of winning money) or bad (possibility of hearing an aversive sound) could happen at any point. Thus, the task compared behavioral and brain responses during reward and threat states to neutral states.

Related research has shown that the brain responses of late adolescents more closely resemble those of younger individuals rather than those of young adults for *both* negative and positive emotional states. When encountering both positive and negative vigilance states (such as anticipating potential rewards or threats), the brain responses of late adolescents (ages 18–21) look more similar to the brain responses of adolescents (ages 13–17) than those of young adults (ages 22–25).[274]

Researchers used brain measures to predict the age of an individual and examined how emotional states impacted these age predictions. The predicted "brain age" reveals how old someone's brain behaves given their connectivity pattern, independent of the actual chronological age of the individual. When in neutral states, the predicted "brain age" of adolescents was comparable to their chronological age.

However, when faced with positive (potential to win a high reward) and negative (threat of a loud noise) vigilance states, adolescents' brain connectivity patterns looked younger than their chronological age. This suggests that emotional states elicit temporary changes in patterns of activity and communication in the middle and late adolescent brain. Within the late adolescent group (ages 18–21), individuals who had "younger" patterns of brain connectivity during emotional states were more likely to self-report increased preferences for risk-taking. Therefore, late adolescents classified as having "younger" brain responses during emotional situations were deemed to be more at risk for engaging in real-world risky behavior.

Development of the Brain's Learning and Reward Systems

Developmental changes in the dopamine system increase plasticity in the brain. Dopamine is a neurotransmitter that coordinates movement and is also involved in motivational learning and reward-driven behavior.[275] Plasticity is the brain's ability to change and adapt in response to experiences. The prolonged period of plasticity during adolescence can facilitate learning from experience.[276] [277]

274 M. D. Rudolph, et al., *At Risk Of Being Risky: The Relationship Between "Brain Age" Under Emotional States and Risk Preference*, 24 Developmental Cognitive Neurosci (2017). This brain imaging study examined the effects of emotional states on brain response patterns in a sample of participants ages 10 to 25. Using a self-control task with emotional cues, the researchers compared brain responses of middle adolescents, late adolescents, and young adults. During this study, participants were exposed to different vigilance states that varied in terms of whether something good or bad could happen at any moment. Participants encountered either a sustained neutral state where they anticipated nothing would happen, a positive state where they anticipated the possibility of winning a high reward, or a threat state where they anticipated the possibility of hearing an aversive sound. This research used a neuroimaging technique that measures whole brain connectivity patterns, which reveals how brain regions simultaneously activate and communicate with each other. This approach can measure how connectivity in the brain changes when individuals experience different emotional contexts.

275 Adriana Galvan, *Adolescent Development of the Reward System*, 4 Frontiers Human Neuroscience 6 (2010).

276 Surjeet Mastwal et al, *Phasic Dopamine Neuron Activity Elicits Unique Mesofrontal Plasticity in Adolescence*, 34 J. Neuroscience 9484 (2014).

277 Vishnu Murty, Finnegan Calabro & Breatiz Luna, *The Role of Experience in Adolescent Cognitive Development: Integration of Executive, Memory, and Mesolimbic Systems*, 70 Neuroscience & Biobehavioral Rev. 46 (2016).

During late adolescence, connections are strengthened between the striatum (a region within the dopamine system that is responsive to reward) and prefrontal cortex. Stronger connections between these regions promote the emergence of more adaptive learning strategies. Relative to children and younger adolescents, late adolescents (ages 18–21) are more likely to use positive feedback and less likely to use negative feedback to update and refine their decisions.[278] In other words, adolescents are primed to learn from rewards. This change in learning strategy emerges because of enhanced connectivity between the striatum and prefrontal cortex.[279] The changes in the learning system that occur during adolescence suggest that individuals in this developmental window may be more amenable to intervention and rehabilitation.[280]

During adolescence, the brain's reward system is hyper-responsive, which means that adolescents exhibit exaggerated responses in the brain's reward centers compared to both younger and older persons in response to the same rewarding stimulus. Studies in humans and animals have shown that enhanced reward sensitivity during adolescence is related in large part to changes in the dopamine system.

Researchers use brain imaging techniques to measure how the dopamine system changes during development.[281] This research reveals that dopamine concentration increases during adolescence and stabilizes during adulthood. Yet, the density of dopamine receptors continues to decrease from ages 18 to 30.[282] Therefore, refinement of the dopamine system persists beyond adolescence and continues throughout young adulthood and beyond.

This remodeling of the dopamine system has consequences for reward sensitivity and risk-seeking behavior.[283] Adolescents, relative to children and adults, show exaggerated responses to reward in a key brain region in the dopamine system (striatum).[284] The striatum is important for anticipating and responding to rewards, learning from feedback, and coordinating motivated actions. Longitudinal studies have demonstrated that reward-related activity in the striatum peaks between ages 15 and 17 and remains elevated in late adolescence.[285] [286]

278 Wouter van den Bos et al, *Striatum–Medial Prefrontal Cortex Connectivity Predicts Developmental Changes in Reinforcement Learning*, 22 Cerebral Cortex 1247 (2012).

279 *Id.*

280 *See, e.g.*, David Yeager & Carol Dweck, *Mindsets that Promote Resilience: When Students Believe that Personal Characteristics Can Be Developed*, 47 Educ. Psych. 302 (2012).

281 Bart Larsen et al, *Maturation of the Human Striatal Dopamine System Revealed by PET and Quantitative MRI,* 11 Nature Comm. 1 (2020).

282 *Id.*

283 Tamara Fitzwater et al, *Motivational Systems in Adolescence: Possible Implications for Age Differences in Substance Abuse and Other Risk-Taking Behaviors*, 72 Brain & Cognition 114 (2010).

284 Merav Silverman, Kelly Jedd & Monica Luciana, *Neural Networks Involved in Adolescent Reward Processing: An Activation Likelihood Estimation Meta-Analysis of Functional Neuroimaging Studies*, 122 Neuroimage 427 (2015).

285 Braams, *supra* note 202.

286 Elisabeth Schreuders et al, *Contributions of Reward Sensitivity to Ventral Striatum Activity Across Adolescence and Early Adulthood*, 89 Child Development 797 (2018).

Adolescents show hyper-sensitivity in the striatum to a broad range of reward information. For example, adolescents, relative to adults, show more activity in the striatum when receiving positive feedback during learning,[287] when tasting sweet liquid,[288] when viewing smiling faces,[289] and when receiving "likes" on social media.[290]

This enhanced sensitivity to reward can promote adaptive behaviors during adolescence, such as healthy exploration, novelty seeking, and feedback processing.[291] During adolescence, enhanced brain sensitivity to rewards creates a window of opportunity for learning.[292] For example, a longitudinal learning study tested individuals ages 8–25 and found that increased activity in the striatum supports learning improvements during middle and late adolescence.[293] However, enhanced responses to reward in the brain have also been linked to increased sensation seeking and risk-taking behavior.[294] [295] Taken together, this research suggests that the adolescent brain is remarkably—and perhaps uniquely—attuned to what it identifies as rewarding cues in the environment. Enhanced brain responses to reward support the emergence of adaptive behaviors that promote learning and independence. Yet, this brain responsivity is also reflected in the adolescent propensity for maladaptive behaviors, impulsivity, and risky decision-making.

Social Influence Impacts Late Adolescent Brain Responses

Adolescents are hyper-attuned to their social worlds. In particular, the influence of peers is more powerful during this period than any other point in the lifespan.[296] Adolescents are more likely to conform to the expectations and behaviors of peers, especially when seeking peer approval. This can be adaptive as it promotes social exploration and novelty-seeking.[297] However, peer influence can also result in suboptimal self-control and decision-making. For example, adolescents typically make more cautious decisions when they are alone but riskier decisions when peers are present.[298]

287 Jessica Cohen et al, *A Unique Adolescent Response to Reward Prediction Errors*, 13 Nature Neuroscience 669 (2010).

288 Adriana Galván & Kristina McGlennen, *Enhanced Striatal Sensitivity to Aversive Reinforcement in Adolescents Versus Adults*, 25 J. Cognitive Neuroscience 284 (2013).

289 Somerville, *supra* note 65.

290 Lauren Sherman et al, *Peer Influence Via Instagram: Effects on Brain and Behavior in Adolescence and Young Adulthood*, 89 Child Development 37 (2018).

291 Juliet Davidow et al, *An Upside to Reward Sensitivity: The Hippocampus Supports Enhanced Reinforcement Learning in Adolescence.* 92 Neuron 93 (2016). (Citation: Davidow, *supra* note 203); Juliet Davidow, Catherine Insel & Leah Somerville, *Adolescent Development of Value-Guided Goal Pursuit,* 22 Trends Cognitive Sci. 725 (2018). (Citation: Davidow, *supra* note 207); Sabine Peters & Eveline Crone, Increased Striatal Activity in Adolescence Benefits Learning, 8 Nature Communications 1 (2017). (Citation: Sanders, *supra* note 204); Kate Nussenbaum & C. Hartley, *Reinforcement learning across development: What insights can we draw from a decade of research?* 40 Developmental Cognitive Neurosci. (2019).

292 Samantha DePasque & Adriana Galván, *Frontostriatal Development and Probabilistic Reinforcement Learning During Adolescence*, 143 Neurobiology Learning & Memory 1 (2017).

293 Peters, *supra* note 204.

294 Adriana Galvan et al, *Risk-Taking and the Adolescent Brain: Who Is at Risk?*, 10 Developmental Sci. F8 (2007).

295 Samuel Hawes et al, *Modulation of Reward-Related Neural Activation on Sensation Seeking Across Development*, 147 Neuro Image 763 (2017).

296 Eric Nelson et al, *The Social Re-Orientation of Adolescence: A Neuroscience Perspective on the Process and Its Relation to Psychopathology*. 35 Psych. Med. 163, 163–174 (2005).

Sensitivity to social influence uniquely impacts brain responses in adolescents, and the late adolescent brain is particularly sensitive to the presence of peers. This sensitivity is related to differences in brain responses in regions that are important for social and emotional processing.[299] Social influence can modulate brain responses in reward regions like the striatum, and in regions in the prefrontal cortex that support social cognitive functions such as thinking about self and others. Research shows that the mere presence of a peer can elicit exaggerated activity in the brains of middle and late adolescents, although this effect is tempered in younger children.

For example, a study examined brain activity when individuals thought a peer was observing them.[300] When a peer was watching, middle and late adolescents exhibited increased activity in a region within the prefrontal cortex that is important for social cognition and self-conscious awareness (medial prefrontal cortex). Middle and late adolescents also displayed increased connectivity between reward processing regions like the striatum and the medial prefrontal cortex. This suggests that the brains of middle and late adolescents are especially sensitive to social evaluation.

The presence of peers also modulates reward-related responses in the brain during middle and late adolescence, and this heightened reward response has direct implications for risk-taking behavior.[301] Neuroscience researchers found that when receiving rewarding outcomes, individuals ages 14–19 exhibited enhanced activity in reward-processing regions (including the striatum) when peers were present relative to when they were alone. However, peer presence did not modulate neural responses to reward in adults ages 25–35.[302] Peer modulation of reward-related activity in the brain has also been linked to enhanced risk-taking. For example, while completing a driving simulation task, adolescents ages 14–19 showed more activity in the striatum while in the presence of peers than when performing the task alone, and this difference was attributed to increased risk-taking behavior.[303]

297 Albert, *supra* note 15.
298 *Id.*
299 Laurence Steinberg, *A Social Neuroscience Perspective on Adolescent Risk-Taking*, 28 Developmental Rev. 78 (2008).
300 Leah Somerville et al, *The Medial Prefrontal Cortex and the Emergence of Self-Conscious Emotion in Adolescence*, 24 Psych. Sci. 1554 (2013).
301 Albert, *supra* note 15.
302 Ashley Smith, Laurence Steinberg, & Nicole Strang, *Age Differences in the Impact of Peers on Adolescents' and Adults' Neural Response to Reward*, 11 Developmental Cognitive Neuroscience 75 (2015).
303 Jason Chein et al, *Peers Increase Adolescent Risk-Taking by Enhancing Activity in the Brain's Reward Circuitry*, 14 Developmental Sc. F1 (2011).

Summary

Advances in contemporary psychology and neuroscience research provide converging evidence that adolescence is a period of dynamic brain development that persists beyond the age of 18. The vast majority of research has charted brain and behavioral development by averaging across groups of individuals and charting changes with age. However, moving forward, newer approaches in the field will allow scientists to quantify, and thus better understand, individual differences in brain and behavioral developmental trajectories.[304] New innovations in research methods have allowed scientists to take new approaches to measure brain development, and ongoing initiatives with large-scale sample sizes and longitudinal data collection will reveal a more nuanced and complex picture of brain development.

304 Simmons, *supra* note 97; B.J. Casey et al, *The Adolescent Brain Cognitive Development (ABCD) Study: Imaging Acquisition Across 21 Sites,* 32 Developmental Cog. Neurosci. 43. 43–54 (2018), Leah Somerville et al, *The Lifespan Human Connectome Project In Development: A Large-Scale Study of Brain Connectivity Development in 5–21 Year Olds,* 183 Neuroimage 456, 456–468 (2018).