IN THE SUPREME COURT OF TENNESSEE
AT KNOXVILLE

STATE OF TENNESSEE,	)	
	)	
Appellee,	)	Knox County Criminal 108568
	)	
v.	)	C.C.A. No. E2018-01439-CCA-R3-CD
	)	
TYSHON BOOKER,	)	S. Ct. No. E2018-01439-SC-R11-CD
	)	
Appellant.	)	

BRIEF OF *AMICUS CURIAE* JULIE A. GALLAGHER, PSY.D ABPP IN SUPPORT OF APPELLANT TYSHON BOOKER

Gibeault C. Creson (#32049)
Alexandra Ortiz Hadley (#36892)
Robert R. McLeod (#36120)
Butler Snow LLP
The Pinnacle at Symphony Place
150 Third Avenue, South, Suite 1600
Nashville, Tennessee 37201
Phone: (615) 651-6700
Beau.Creson@butlersnow.com
Alexa.Hadley@butlersnow.com
Robert.McLeod@butlersnow.com

Counsel for Julie A. Gallagher

TABLE OF CONTENTS

TABLE OF CONTENTS 2
TABLE OF AUTHORITIES 3
I. STATEMENT OF THE ISSUE 10
II. INTERESTS OF AMICUS 10
III. STATEMENT OF THE CASE 11
IV. ARGUMENT 15
A. Adolescence Is a Distinct Period of Development 15
B. The Phases of Adolescent Brain Development 17
C. The Behavioral Science of Adolescence 29
D. The Impact of Adolescence on Antisocial Behavior 38
E. Juveniles Should Be Treated Differently Than Adults For the Purposes of Sentencing 41
V. CONCLUSION 43
CERTIFICATE OF ELECTRONIC FILING COMPLIANCE 44
CERTIFICATE OF SERVICE 45
APPENDIX A 46

TABLE OF AUTHORITIES

Page(s)

Cases

Graham v. Florida,
560 U.S. 48 (2010) 11, 13, 14

Miller v. Alabama,
567 U. S. 460 (2012) 11, 13, 14

Montgomery v. Louisiana,
136 S. Ct. 718 (2016) 11, 13

Roper v. Simmons,
543 U. S. 551 (2005) 11, 12

Rules

Tennessee Supreme Court Rule 46 44

Other Authorities

Aaron Alexander-Bloch et al., *The convergence of maturational change and structural covariance in human cortical networks*. 33 JOURNAL OF NEUROSCIENCE 2889– 2899 (2013) 16

Adolescent brain science and juvenile justice policymaking,
23 PSYCHOLOGY, PUBLIC POLICY, AND LAW 410– (2017) 19

*Adolescents' cognitive capacity reaches adult levels prior to their psychosocial maturity: Evidence for a "maturity gap" in a multinational, cross-secti*onal sample,
43 LAW & HUMAN BEHAVIOR 69- (2019) 16

Adriana Galván et al., *Earlier Development of the Accumbens Relative to Orbitofrontal Cortex Might Underlie Risk-Taking Behavior in Adolescents*, 26 JOURNAL OF NEUROSCIENCE 6885–6892 (2006) 27

Adriana Galván, THE NEUROSCIENCE OF ADOLESCENCE, 2017 15

Adriana Galván, *The Teenage Brain*, 22 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 88–93 (2013) 22

Anita Cservenka et al., *High and low sensation seeking adolescents show distinct patterns of brain activity during reward processing*. 66 NEUROIMAGE 184–193 (2013) 21

Anna C. K. Van Duijvenvoorde et al., *Affective and Cognitive Decision-Making in Adolescents*, 35 DEVELOPMENTAL NEUROPSYCHOLOGY 539–554 (2010) 25

Ashley R. Smith, Jason Chein & Laurence Steinberg, *Peers increase adolescent risk taking even when the probabilities of negative outcomes are known.*, 50 DEVELOPMENTAL PSYCHOLOGY 1564–1568 (2014) 24

B. J. Casey, *Beyond Simple Models of Self-Control to Circuit-Based Accounts of Adolescent Behavior*, 66 ANNUAL REVIEW OF PSYCHOLOGY 295–319 (2015)..... 23

B. R. Braams et al., *Longitudinal Changes in Adolescent Risk-Taking: A Comprehensive Study of Neural Responses to Rewards, Pubertal Development, and Risk-Taking Behavior*, 35 JOURNAL OF NEUROSCIENCE 7226–7238 (2015) 22

B.J. Casey et al., *Beyond simple models of adolescence to an integrated circuit-based account: A commentary*, 17 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 128-130 (2016); National Academies 2019)..... 19

Beatriz Luna and Catherine Wright, *Adolescent brain development: implications for the juvenile criminal justice system*, in APA HANDBOOK OF PSYCHOLOGY AND JUVENILE JUSTICE..... 19

Beatriz Luna, Aarthi Padmanabhan & Kirsten O'Hearn, *What has fMRI told us about the Development of Cognitive Control through Adolescence?* 72 BRAIN AND COGNITION 101–113 (2010)..... 27

Bernd Figner & Elke U. Weber, *Who Takes Risks When and Why?* 20 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 211–216 (2011) 24

Bernd Figner et al., *Risky choice in children, adolescents, and adults: Affective versus deliberative processes and the role of executive functions*. 35 JOURNAL OF EXPERIMENTAL PSYCHOLOGY: LEARNING, MEMORY, AND COGNITION 709-730 (2009)..... 31

Budhachandra S. Khundrakpam et al., *Brain connectivity in normally developing children and adolescents*, 134 NEUROIMAGE 192-203 (2016) 28

D. B. Dwyer et al., *Large-Scale Brain Network Dynamics Supporting Adolescent Cognitive Control*, 34 JOURNAL OF NEUROSCIENCE 14096–14107 (2014) 24

Delia Fuhrmann, Lisa J. Knoll, & Sarah-Jayne Blakemore, *Adolescence as a Sensitive Period of Brain Development*, 19 TRENDS IN COGNITIVE SCIENCE 558-566 (2015) 20

Edward P. Mulvey, *Highlights from Pathways to Desistance: A Longitudinal Study of Serious Adolescent Offenders,* Office of Juvenile Justice and Delinquency Prevention (2011) 40

Erika E. Forbes & Ronald E. Dahl, *Pubertal development and behavior: hormonal activation of social and motivational tendencies*, 72 BRAIN AND COGNITION 66-72 (2010) 21

Eveline A. Crone & Elly A. Konijn, *Media use and brain development during adolescence*, 9 NATURE COMMUNICATION 588–598 (2018) 31

Eveline A. Crone & Ronald E. Dahl, *Understanding adolescence as a period of social– affective engagement and goal flexibility*, 13 NATURE REVIEWS NEUROSCIENCE, 636-650 (2012) 20

Heidi Ledford, *The shifting boundaries of adolescence,* 554 NATURE 429-431 (2018) 28

James M. Bjork et al., *Brain Maturation and Risky Behavior: The Promise and the Challenges of Neuroimaging-Based Accounts*, CHILD DEVELOPMENT PERSPECTIVES (2012) 22

Jason Chein et al., *Peers increase adolescent risk taking by enhancing activity in the brain's reward circuitry*, 14 DEVELOPMENTAL SCIENCE (2011) 31

Justin L. Vincent et al., *Evidence for a Frontoparietal Control System Revealed by Intrinsic Functional Connectivity*, 100 JOURNAL OF NEUROPHYSIOLOGY 3328– 3342 (2008) 26

Kathryn C. Monahan et al., *Trajectories of antisocial behavior and psychosocial maturity from adolescence to young adulthood.*, 45 DEVELOPMENTAL PSYCHOLOGY 1654– 1668 (2009) 39

Lauren E. Sherman et al., *Development of the Default Mode and Central Executive Networks across early adolescence: A longitudinal study*, 10 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 148–159 (2014) 25

Laurence Steinberg & Grace Icenogle, *Using Developmental Science to Distinguish Adolescents and Adults Under the Law*, 1 ANNUAL REVIEW OF DEVELOPMENTAL PSYCHOLOGY 21-40 (2019)..... 21

Laurence Steinberg & Kathryn C. Monahan, *Age differences in resistance to peer influence.*, 43 DEVELOPMENTAL PSYCHOLOGY1531–1543 (2007) 31

Laurence Steinberg et al., *Age Differences in Future Orientation and Delay Discounting*, 80 CHILD DEVELOPMENT 28–44 (2009)..... 32

Laurence Steinberg et al., *Around the world, adolescence is a time of heightened sensation seeking and immature self-regulation*, DEVELOPMENTAL SCIENCE (2018) 36

Laurence Steinberg, AGE OF OPPORTUNITY: LESSONS FROM THE NEW SCIENCE OF ADOLESCENCE (2014)..... 17

Laurence Steinberg, *Commentary on Special Issue on the Adolescent Brain: Redefining Adolescence*, 70 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS 343–346, 344 (2016) 16

Leah H. Somerville, Negar Fani & Erin B. McClure-Tone, *Behavioral and Neural Representation of Emotional Facial Expressions Across the Lifespan*, 36 DEVELOPMENTAL NEUROPSYCHOLOGY 408–428 (2011) 30

Linda Patia Spear *The adolescent brain and age-related behavioral manifestations*, 24 NEUROSCIENCE AND BIOBEHAVIORAL REVIEWS 417–463 (2000)..... 17

Linda Patia Spear, *Consequences of adolescent use of alcohol and other drugs- Studies using rodent models*, 70 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS 228-243 (2016)..... 17

Linn B. Norbom et al., *Probing brain developmental patterns of myelination and associations with psychopathology in youths using gray/white matter contrast*, 85 BIOLOGICAL PSYCHIATRY 389-398 (2019) 23

M.A.J. van Tetering et al. *Sex differences in self-regulation in early, middle and late adolescence: A large-scale cross-sectional study*, 15 PLoS ONE 1-17 (2020)..... 27

Margo Gardner & Laurence Steinberg, *Peer Influence on Risk Taking, Risk Preference, and Risky Decision Making in Adolescence and Adulthood: An Experimental Study.*, 41 DEVELOPMENTAL PSYCHOLOGY 625–635 (2005)..... 31

Matthew B. Johnson & Beth Stevens, *Pruning hypothesis comes of age*, 554 NATURE 438-439 (2018) 23

Matthew Peverill et al., *Working memory filtering continues to develop into late adolescence*, 18 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 78–88 (2016) 28

Megan M. Herting & Elizabeth R. Sowell, *Puberty and structural brain development in humans*, 44 FRONTIERS OF NEUROENDOCRINOLOGY 122–137 (2017)..... 20

Michael Dreyfuss et al., *Teens impulsively react rather than retreat from threat*, 36 DEVELOPMENTAL NEUROSCIENCE 220–227 (2014) 23

Models for Change, RESEARCH ON PATHWAYS TO DESISTANCE (2012) 40

Monica Luciana & Paul F. Collins, *Incentive Motivation, Cognitive Control, and the Adolescent Brain: Is It Time for a Paradigm Shift?* CHILD DEVELOPMENT PERSPECTIVES (2012)..... 27

Monique Ernst et al., *fMRI Functional Connectivity Applied to Adolescent Neurodevelopment*, 11 ANNUAL REVIEW OF CLINICAL PSYCHOLOGY 361–377 (2015) 26

Nandita Vijayakumar et al. *Puberty and the human brain: Insights into adolescent development,* 92 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS 417–436 (2018)..... 20

Natasha Duell et. al., *Age Patterns in Risk Taking Across the World*, 47 J. YOUTH ADOLESCENCE, 1052-1072 (2018) 36

Natasha Duell et. al., *Correction to: Age Patterns in Risk Taking Across the World*, 48 J. YOUTH ADOLESCENCE, 835-836 (2019) .. 35

National Academies of Sciences, Engineering and Medicine, THE PROMISE OF ADOLESCENCE: REALIZING OPPORTUNITY FOR ALL YOUTH, Richard J. Bonnie and Emily P. Backes eds. 2019 15

National Research Council, REFORMING JUVENILE JUSTICE: A DEVELOPMENTAL APPROACH (Committee on Assessing Juvenile Justice Reform, Richard J. Bonnie, Robert L. Johnson, Betty M. Chemers and Julie A. Schuck eds. 2013) 29

National Research Council, THE SCIENCE OF ADOLESCENT RISK-TAKING: WORKSHOP REPORT (Committee on the Science of Adolescence, Laurence Steinberg, Chair 2011) 33

Nico U. F. Dosenbach et al., *Prediction of Individual Brain Maturity Using fMRI*, 329 SCIENCE 1358–1361 (2010) 28

Nico U. F. Dosenbach, Steven E. Petersen & Bradley L. Schlaggar, *The Teenage Brain*, 22 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 101–107 (2013) 25

Ronald Dahl et al. *Importance of investing in adolescence from a developmental science perspective*, 554 NATURE 441–450 (2018) ... 16

Tarika Daftary-Kapur & Tina M. Zottoli, *A first look at the plea deal experiences of juveniles tried in adult court*, 12 INTERNATIONAL JOURNAL OF FORENSIC MENTAL HEALTH 323–336 (2014) 33

Terrie E. Moffitt, *Male antisocial behaviour in adolescence and beyond,* 2 Nature Human Behaviour 177-186 (2018) 39

To plead or not to plead: a comparison of juvenile and adult true and false plea decisions, 40 LAW AND HUMAN BEHAVIOR 611– (2016) 33

Todd A. Hare et al., *Biological Substrates of Emotional Reactivity and Regulation in Adolescence During an Emotional Go-Nogo Task*, 63 BIOLOGICAL PSYCHIATRY 927–934 (2008) 27

Todd F. Heatherton, Neuroscience of Self and Self-Regulation, 62 ANNUAL REVIEW OF PSYCHOLOGY, 363-390 (2011) 30

Tomas Paus, *Brain Development, in* HANDBOOK OF ADOLESCENT PSYCHOLOGY (R. Lerner and L. Steinberg eds. 2009)..... 28

Vincent J. Schmithorst & Weihong Yuan, *White matter development during adolescence as shown by diffusion MRI*, 72 BRAIN AND COGNITION 16–25 (2010)..... 26

Amicus Curiae Julie A. Gallagher, Psy.D ABPP, submit this brief in support of Appellant Tyshon Booker's appeal.

I. STATEMENT OF THE ISSUE

Whether a minimum 51-year term of prison confinement mandatorily imposed on a juvenile, without consideration of the juvenile's youth, immaturity, or other mitigating circumstances, violates the United States and Tennessee Constitutions, in that it deprives the juvenile of a meaningful opportunity to obtain release based on demonstrated maturity and rehabilitation.

II. INTERESTS OF AMICUS

The interests of Dr. Gallagher are more fully described in her Motion of Amicus Curiae Julie Gallagher, Psy.D ABPP in Support of Filing an Amicus Brief, which is being filed contemporaneously herewith. Her interests can be briefly summarized as follows:

Dr. Gallagher is a clinical and forensic psychologist, board certified in forensic psychology by the American Board of Professional Psychology. Her expertise is primarily in criminal forensic psychology, with specialization in juvenile justice work. She is the current president of the American Academy of Forensic Psychology.

Dr. Gallagher's expertise brings a crucial, scientific perspective to the legal questions at issue in this case and enables her to assist the Court by providing information on the developmental and behavioral factors involved in the sentencing of juvenile offenders.

III. STATEMENT OF THE CASE

In a series of decisions beginning with *Roper v. Simmons*, 543 U. S. 551 (2005), the United States Supreme Court considered and relied upon research regarding adolescent psychology and brain development to conclude that juveniles are constitutionally different from adults for purposes of sentencing, and, thus, that a juvenile cannot be sentenced to a mandatory life sentence without the chance of parole because such a sentence deprives him or her of the opportunity to obtain release based on demonstrated maturity and rehabilitation as they grow older. *See also Montgomery v. Louisiana*, 136 S. Ct. 718 (2016); *Miller v. Alabama*, 567 U. S. 460 (2012); *Graham v. Florida*, 560 U.S. 48 (2010).

In making these rulings, the Supreme Court focused on three primary differences between juveniles and adults that bear on criminal sentencing.

First, "[a] lack of maturity and an underdeveloped sense of

responsibility are found in youth more often than in adults and are more understandable among the young. These qualities often result in impetuous and ill-considered actions and decisions. ... In recognition of the comparative immaturity and irresponsibility of juveniles, almost every State prohibits those under 18 years of age from voting, serving on juries, or marrying without parental consent." *Roper*, 543 U. S. at 569 (citations and internal quotations omitted).

Next, "juveniles are more vulnerable or susceptible to negative influences and outside pressures, including peer pressure….This is explained in part by the prevailing circumstance that juveniles have less control, or less experience with control, over their own environment….'[A]s legal minors, [juveniles] lack the freedom that adults have to extricate themselves from a criminogenic setting.'" *Id.* (internal citations omitted).

And finally, "the character of a juvenile is not as well formed as that of an adult. The personality traits of juveniles are more transitory, less fixed." *Id.* at 570. Accordingly, "[f]rom a moral standpoint it would be misguided to equate the failings of a minor with those of an adult, for a greater possibility exists that a minor's character deficiencies will be

reformed." *Id.* Indeed, "[t]he 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 that may dominate in younger years can subside." *Id.* (citation and internal quotations omitted).

Based on these key differences, the Supreme Court has held that with regard to juvenile offenders the State "must impose a sentence that provides some meaningful opportunity to obtain release based on demonstrated maturity and rehabilitation." *Graham*, 560 U.S. at 75 (2010). Indeed, it has concluded that this is a substantive constitutional rule, found to have been violated by life without parole sentences against juvenile offenders who committed both non-homicide and homicide offenses. *See Montgomery*, 136 S. Ct. at 723; *Miller*, 567 U. S. at 471-74; 560 U.S. at 68-70, 78.

As a clinical and forensic psychologist who is board certified in forensic psychology by the American Board of Professional Psychology, and who has specialized in criminal forensic psychology for almost two decades, it is my expert opinion that the Supreme Court's recognition of these key differences between adolescents and adults, both with regard

to their psychology and brain development, was absolutely correct. Indeed, the research in this area since those decisions were made has further substantiated those differences and reinforced the importance of treating juveniles different for the purposes of sentences.

The purpose of this Amicus Brief is to summarize the research from those Supreme Court opinions, expand upon the state of the research since the opinions were written, and express my opinion that the scientific consensus on the nature of adolescent brain development continues to support providing juveniles offenders with "a meaningful opportunity to obtain release based on demonstrated maturity and rehabilitation." *Miller*, 567 U.S. at 479. (quoting *Graham*, 560 U.S. at 75).

My analysis and opinions in this regard are based on recent publications, including authoritative treatises and texts, reports of the National Academies of Sciences, review articles, and original peer reviewed research reports, focusing on those published since 2012, when the amicus briefs in *Miller* were completed. A complete list of the academic and scientific sources relied upon in forming my opinions can be found in Appendix A.

IV. ARGUMENT

A. Adolescence Is a Distinct Period of Development

Adolescence is a distinct period of development that begins with the onset of puberty (which typically occurs between the ages of 10 and 12) and ends in the mid-20s. (National Academies of Sciences, Engineering and Medicine, THE PROMISE OF ADOLESCENCE: REALIZING OPPORTUNITY FOR ALL YOUTH, Richard J. Bonnie and Emily P. Backes eds. 2019, pg. 37). Indeed, the adolescent brain can be reliably distinguished from the brains of children and adults. Researchers have consistently identified changes in the structural and functional development of the brain during adolescence. (Adriana Galván, THE NEUROSCIENCE OF ADOLESCENCE, 2017). One of the leading researchers in the field of adolescent development, Professor Laurence Steinberg, Ph.D. noted in a 2016 commentary on the adolescent brain that, "There are just as many, if not more, differences between adolescents and adults as there are between adolescents and children, and the differences between adolescents and adults are often more striking than the differences between adolescents and children." (Laurence Steinberg, *Commentary on Special Issue on the Adolescent Brain: Redefining Adolescence*, 70 NEUROSCIENCE &

BIOBEHAVIORAL REVIEWS 343–346, 344 (2016)). As will be described further below, compared to adults, the adolescent brain is significantly less mature, both in its structure and in its ability to utilize that structure efficiently. (Aaron Alexander-Bloch et al., *The convergence of maturational change and structural covariance in human cortical networks*. 33 JOURNAL OF NEUROSCIENCE 2889– 2899 (2013). This has a profound impact on learning and behavior during adolescence.

The brain systems in which these structural and functional changes take place during adolescence are involved in important cognitive, emotional, social and motivational processes. (Ronald Dahl et al. *Importance of investing in adolescence from a developmental science perspective*, 554 NATURE 441–450 (2018). These changes result in significant deficits in important skills affecting legally relevant constructs such as planning, decision-making and impulse control. (National Academies 2019). This results in vulnerabilities that are thought to explain the increased rate of criminal behavior seen in adolescents. (Casey et al. 2020 *adapted from* 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 LAW & HUMAN BEHAVIOR 69-85 (2019)).

A substantial body of literature has shown that even across mammalian species similar patterns of structural and functional changes in the brain are seen during adolescence. (Linda Patia Spear *The adolescent brain and age-related behavioral manifestations*, 24 NEUROSCIENCE AND BIOBEHAVIORAL REVIEWS 417–463 (2000)). Adolescent rodents have been found to demonstrate many of the same behavioral changes during adolescence that adolescent humans do. (*See, e.g.* Linda Patia Spear, *Consequences of adolescent use of alcohol and other drugs- Studies using rodent models*, 70 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS 228-243 (2016)). This speaks to the biological underpinnings of this distinct developmental phase, rather than any form of cultural explanation. (Laurence Steinberg, AGE OF OPPORTUNITY: LESSONS FROM THE NEW SCIENCE OF ADOLESCENCE (2014). As Steinberg concluded in his 2016 commentary on the adolescent brain, "Their behavior is the way it is because they are biologically wired that way." (Steinberg 2016 at 344).

B. The Phases of Adolescent Brain Development

There are three overlapping phases of brain development that occur

during adolescence. During all three phases, the brain changes through a process of synaptic pruning and myelination of particular brain regions. Pruning is the removal of unneeded connections, which strengthens and makes other connections more efficient, just as pruning a tree causes its main branches to grow stronger. Myelination is the insulation of those connections, resulting in greater white matter in the brain. This allows brain cells to transmit information up to 100 times faster along those connections while also improving the quality of those connections. The National Academy of Sciences has compared this to upgrading from driving on a single-lane dirt road to driving on a paved eight-lane expressway. (National Academies 2019 at 48).

The primary brain regions affected during adolescence are the limbic system, which regulates emotional arousal, and the prefrontal cortex, which regulates self-control and rational decision-making. Notably, the changes in these regions occur at different times, with the limbic system maturing well before the prefrontal cortex, resulting in a significant maturational imbalance. (*See, e.g.* B.J. Casey et al., *Beyond simple models of adolescence to an integrated circuit-based account: A commentary*, 17 DEVELOPMENTAL COGNITIVE NEUROSCIENCE

128-130 (2016); National Academies 2019). There is consensus among scientists that this imbalance is present and that it has a profound effect on thinking and behavior. (Casey et al. 2020; Icenogle et al. 2019). In fact, research has found that these changes follow an identifiable pattern that is consistent with the behavioral changes that occur during adolescence. Only when these brain regions complete development and become fully interconnected is development complete.

Scientists who study the adolescent brain are increasingly convinced that it is the cascade of developing connections between brain areas that leads to full cognitive maturity. (Casey et al. 2020; Icenogle et al. 2019). Research has consistently shown that these changes are not complete until the early to mid-twenties. (Beatriz Luna and Catherine Wright, *Adolescent brain development: implications for the juvenile criminal justice system*, in APA HANDBOOK OF PSYCHOLOGY AND JUVENILE JUSTICE (Kirk Heilbrun, David DeMatteo & Naomi E.S. Goldstein eds. 2016); Casey et al. 2020; Icenogle et al. 2019).

The first phase of adolescent brain development is triggered by the hormonal changes accompanying puberty. (Laurence Steinberg, *Adolescent brain science and juvenile justice policymaking*, 23

PSYCHOLOGY, PUBLIC POLICY, AND LAW 410–420 (2017); Steinberg, 2016). Puberty, which typically starts between ages 10 and 12, remodels the brain and makes it more plastic, or moldable. (Delia Fuhrmann, Lisa J. Knoll, & Sarah-Jayne Blakemore, *Adolescence as a Sensitive Period of Brain Development*, 19 TRENDS IN COGNITIVE SCIENCE 558-566 (2015); Steinberg 2016). The hormones released during puberty have a profound effect on the limbic system, which is deep in the center of the brain. (Megan M. Herting & Elizabeth R. Sowell, *Puberty and structural brain development in humans*, 44 FRONTIERS OF NEUROENDOCRINOLOGY 122–137 (2017); Nandita Vijayakumar et al. *Puberty and the human brain: Insights into adolescent development,* 92 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS 417–436 (2018)). This leads to both structural and functional changes in the limbic system, which affect the ability to process both emotion and memory. (Eveline A. Crone & Ronald E. Dahl, *Understanding adolescence as a period of social– affective engagement and goal flexibility*, 13 NATURE REVIEWS NEUROSCIENCE, 636-650 (2012)). These changes increase the brain's sensitivity to novelty, rewards, threats and peers. (Casey et al. 2020; National Academies 2019; Erika E.

Forbes & Ronald E. Dahl, *Pubertal development and behavior: hormonal activation of social and motivational tendencies*, 72 BRAIN AND COGNITION 66-72 (2010)).

One functional change that occurs due to puberty is an alteration in the way the brain, and especially the limbic system, responds to the neurotransmitters dopamine and serotonin. Neurotransmitters are chemicals that transmit nerve impulses from one brain cell to the next. Dopamine affects how the brain responds to rewards and serotonin plays an important role in mood regulation. As a result, the adolescent brain becomes much more easily emotionally aroused and more sensitive to rewards, including the social rewards of approval by peers. (Laurence Steinberg & Grace Icenogle, *Using Developmental Science to Distinguish Adolescents and Adults Under the Law*, 1 ANNUAL REVIEW OF DEVELOPMENTAL PSYCHOLOGY 21-40 (2019); Anita Cservenka et al., *High and low sensation seeking adolescents show distinct patterns of brain activity during reward processing*. 66 NEUROIMAGE 184–193 (2013)).

It also becomes less sensitive to negative outcomes, as rewards become more salient. This is why adolescents typically seek out intense

and exciting experiences and are greatly influenced by the presence of peers, while discounting possible negative consequences. So, during this phase, the limbic system is responsible for the dramatic ups and downs of emotion experienced by adolescents, their greater sensitivity to the influence of their peers, and their greater sensation-seeking. (B. R. Braams et al., *Longitudinal Changes in Adolescent Risk-Taking: A Comprehensive Study of Neural Responses to Rewards, Pubertal Development, and Risk-Taking Behavior*, 35 JOURNAL OF NEUROSCIENCE 7226–7238 (2015); Adriana Galván, *The Teenage Brain*, 22 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 88–93 (2013); James M. Bjork et al., *Brain Maturation and Risky Behavior: The Promise and the Challenges of Neuroimaging-Based Accounts*, CHILD DEVELOPMENT PERSPECTIVES (2012)).

One of the primary structures of the limbic system, the amygdala, undergoes significant changes in response to puberty that affect the adolescent brain's response to threat cues. In comparison to both children and adults, adolescents show greater activity in the amygdala in response to such cues and consequently become much more fearless and prone to impulsive responses to threats. (B. J. Casey, *Beyond Simple*

Models of Self-Control to Circuit-Based Accounts of Adolescent Behavior, 66 ANNUAL REVIEW OF PSYCHOLOGY 295–319 (2015); Michael Dreyfuss et al., *Teens impulsively react rather than retreat from threat*, 36 DEVELOPMENTAL NEUROSCIENCE 220–227 (2014); Fuhrmann et al. 2015). This fearlessness can be adaptive as they explore new settings and make important life transitions but can also result in risky behavior with potential negative consequences.

The second phase begins during preadolescence and occurs gradually, ending around age 16. During this phase, the prefrontal cortex, which is responsible for self-regulation, becomes better organized. This occurs through a process of pruning of unneeded connections between neurons in the prefrontal cortex, and myelination, or increasing insulation around connections, which strengthens those connections. (Linn B. Norbom et al., *Probing brain developmental patterns of myelination and associations with psychopathology in youths using gray/white matter contrast*, 85 BIOLOGICAL PSYCHIATRY 389-398 (2019); Matthew B. Johnson & Beth Stevens, *Pruning hypothesis comes of age*, 554 NATURE 438-439 (2018)). In other words, the pathways in the prefrontal cortex that are most needed for decision-making, problem-

solving and planning ahead ("executive functions") become clearer and stronger. (D. B. Dwyer et al., *Large-Scale Brain Network Dynamics Supporting Adolescent Cognitive Control*, 34 JOURNAL OF NEUROSCIENCE 14096–14107 (2014); Ashley R. Smith, Jason Chein & Laurence Steinberg, *Peers increase adolescent risk taking even when the probabilities of negative outcomes are known.*, 50 DEVELOPMENTAL PSYCHOLOGY 1564–1568 (2014)).

These so-called "executive functions" have sometimes been described as a "braking system" in the brain. (Steinberg, 2014). During this stage, despite improvements in the organization of the prefrontal cortex, this "braking system" is not yet completely online. This is because the connections between the limbic system and the prefrontal cortex are not yet fully in place. As a result, the prefrontal cortex is still very vulnerable to interference. It can be easily derailed by emotional arousal and fatigue. Thus, younger adolescents have more difficulty than older adolescents demonstrating self-control when they are upset, excited or tired. (Bernd Figner & Elke U. Weber, *Who Takes Risks When and Why?* 20 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 211–216 (2011); Anna C. K. Van Duijvenvoorde et al., *Affective and Cognitive*

Decision-Making in Adolescents, 35 DEVELOPMENTAL NEUROPSYCHOLOGY 539–554 (2010). Under such circumstances, they are more likely to engage in risky behavior and make decisions without considering the consequences of their actions.

The third phase of brain development, which takes place in late adolescence, helps that "braking system" to become more stable, reliable and resistant to interference. This is the result of the development of increased interconnections between the prefrontal cortex and the limbic system. (Lauren E. Sherman et al., *Development of the Default Mode and Central Executive Networks across early adolescence: A longitudinal study*, 10 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 148–159 (2014); Nico U. F. Dosenbach, Steven E. Petersen & Bradley L. Schlaggar, *The Teenage Brain*, 22 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 101–107 (2013)).

This increase in structural and functional connectivity allows multiple brain systems to work together much more efficiently, with different brain systems activating together during particular tasks. (Monique Ernst et al., *fMRI Functional Connectivity Applied to Adolescent Neurodevelopment*, 11 ANNUAL REVIEW OF CLINICAL

PSYCHOLOGY 361–377 (2015); Sherman et al. 2014). As a result, the executive functions of the prefrontal cortex are no longer as vulnerable to the emotional arousal of the limbic system. This allows adolescents towards the end of development to gain better control of their impulses, think about the long-term consequences of their decisions, and better resist the rewards of peer attention.

Diffusion tensor imaging has allowed us to visualize these weak connections that become stronger as adolescence progresses. These structural imaging studies have revealed immature connections within the fronto-parietal-striatal brain system that affect executive functioning. (Vincent J. Schmithorst & Weihong Yuan, *White matter development during adolescence as shown by diffusion MRI*, 72 BRAIN AND COGNITION 16–25 (2010); Justin L. Vincent et al., *Evidence for a Frontoparietal Control System Revealed by Intrinsic Functional Connectivity*, 100 JOURNAL OF NEUROPHYSIOLOGY 3328– 3342 (2008). As these connections strengthen over the course of adolescence, greater impulse control is seen, which results in significant improvements in self-regulation. (M.A.J. van Tetering et al. *Sex differences in self-regulation in early, middle and late adolescence: A*

large-scale cross-sectional study, 15 PLoS ONE 1-17 (2020); Casey 2015; Beatriz Luna, Aarthi Padmanabhan & Kirsten O'Hearn, *What has fMRI told us about the Development of Cognitive Control through Adolescence?* 72 BRAIN AND COGNITION 101–113 (2010)).

These findings have been demonstrated in various studies using functional MRI. Using functional MRI, a number of studies have also shown greater neural activity during adolescence in parts of the brain that play an important role in the processing of emotional and social information and in the prediction of reward and punishment, the ventral striatum and the ventromedial prefrontal cortex. (Monica Luciana & Paul F. Collins, *Incentive Motivation, Cognitive Control, and the Adolescent Brain: Is It Time for a Paradigm Shift?* CHILD DEVELOPMENT PERSPECTIVES (2012); Todd A. Hare et al., *Biological Substrates of Emotional Reactivity and Regulation in Adolescence During an Emotional Go-Nogo Task*, 63 BIOLOGICAL PSYCHIATRY 927–934 (2008); Adriana Galván et al., *Earlier Development of the Accumbens Relative to Orbitofrontal Cortex Might Underlie Risk-Taking Behavior in Adolescents*, 26 JOURNAL OF NEUROSCIENCE 6885–6892 (2006)). In addition, functional MRI has

revealed changes in patterns of activation during tasks that require working memory, planning and response inhibition. (Matthew Peverill et al., *Working memory filtering continues to develop into late adolescence*, 18 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 78–88 (2016); Casey 2015; Luna et al. 2010). These processes are important for impulse control and planning ahead. Research has consistently revealed that this process is not complete until the mid-twenties. (Budhachandra S. Khundrakpam et al., *Brain connectivity in normally developing children and adolescents*, 134 NEUROIMAGE 192-203 (2016); Nico U. F. Dosenbach et al., *Prediction of Individual Brain Maturity Using fMRI*, 329 SCIENCE 1358–1361 (2010); Tomas Paus, *Brain Development, in* HANDBOOK OF ADOLESCENT PSYCHOLOGY (R. Lerner and L. Steinberg eds. 2009).

Notably, research has demonstrated that the first phase, triggered by puberty, is occurring earlier due to a range of environmental influences. (Heidi Ledford, *The shifting boundaries of adolescence,* 554 NATURE 429-431 (2018); Steinberg 2016). Because the second phase still occurs at the same time, adolescents are left with a longer period of time during which they seek out risks but do not yet have the capacity for self-

control necessary to manage those risks. (Steinberg 2014). Thus, they are pressing on the accelerator longer despite the fact that their braking system is not yet online.

C. The Behavioral Science of Adolescence

The imbalance in the maturation of the aforementioned areas of the brain during adolescence directly results in the many psychosocial differences adolescents exhibit compared to both younger children and adults. While these changes prime adolescents to learn in new ways, the ensuing maturational imbalance also results in a multitude of risks and vulnerabilities for adolescents. (Dahl et al. 2018).

In 2013, a panel organized by the National Research Council, the primary organizing agency of the National Academy of Sciences, concluded a review of the research on adolescent development and its impact on juvenile justice. (National Research Council, REFORMING JUVENILE JUSTICE: A DEVELOPMENTAL APPROACH (Committee on Assessing Juvenile Justice Reform, Richard J. Bonnie, Robert L. Johnson, Betty M. Chemers and Julie A. Schuck eds. 2013)). They came to three primary conclusions.

The first was that in emotionally charged situations, adolescents do

not have a mature capacity for self-regulation compared to adults. (Leah H. Somerville, Negar Fani & Erin B. McClure-Tone, *Behavioral and Neural Representation of Emotional Facial Expressions Across the Lifespan*, 36 DEVELOPMENTAL NEUROPSYCHOLOGY 408–428 (2011)). Self-regulation is the process by which individuals initiate, adjust, interrupt, stop, or otherwise change thoughts, feelings, or actions in order to achieve personal goals or plans. (Todd F. Heatherton, Neuroscience of Self and Self-Regulation, 62 ANNUAL REVIEW OF PSYCHOLOGY, 363-390 (2011)). On a fundamental level, self-regulation requires the capacity to inhibit impulses. There is significant growth in this capacity during adolescence, which coincides with the growth of, and connections to, the prefrontal cortex. Research indicates that "adolescents do not evince adult levels of self-regulation until age 18 or later." (Steinberg and Icenogle 2019 at 29).

Their second finding was that, relative to adults, adolescents are much more vulnerable to peer influence and immediate incentives. (Bernd Figner et al., *Risky choice in children, adolescents, and adults: Affective versus deliberative processes and the role of executive functions*. 35 JOURNAL OF EXPERIMENTAL PSYCHOLOGY:

LEARNING, MEMORY, AND COGNITION 709-730 (2009); Margo Gardner & Laurence Steinberg, *Peer Influence on Risk Taking, Risk Preference, and Risky Decision Making in Adolescence and Adulthood: An Experimental Study.*, 41 DEVELOPMENTAL PSYCHOLOGY 625–635 (2005)). As noted by Steinberg and Icenogle, "decision making does not occur in a vacuum." (Steinberg and Icenogle 2019 at 28). There is an extensive body of literature that confirms that adolescents act differently and take more risks when peers are present. (Laurence Steinberg & Kathryn C. Monahan, *Age differences in resistance to peer influence.*, 43 DEVELOPMENTAL PSYCHOLOGY1531–1543 (2007)). Persuasive research has found that this effect holds true even when peers are in another room and cannot communicate with the adolescent. (Jason Chein et al., *Peers increase adolescent risk taking by enhancing activity in the brain's reward circuitry*, 14 DEVELOPMENTAL SCIENCE (2011)).

Research has also demonstrated that when an immediate reward is present, adolescents are likely to discount the potential consequences of possible future events. (Eveline A. Crone & Elly A. Konijn, *Media use and brain development during adolescence*, 9 NATURE COMMUNICATION 588–598 (2018); Galván et al. 2006). Immediate rewards are much more

salient to adolescents than potential longer-term consequences. More recent research has demonstrated that attention from peers can have a similar impact on adolescents, serving as an immediate incentive to engage in a behavior despite the potential longer-term consequences. (Steinberg and Icenogle 2019).

The third finding of the National Research Council was that adolescents lack time perspective, impairing their ability to make judgments and decisions that require future orientation. (Laurence Steinberg et al., *Age Differences in Future Orientation and Delay Discounting*, 80 CHILD DEVELOPMENT 28–44 (2009)). Though by mid-adolescence, most adolescents have the cognitive capacity to reason in a manner similar to adults, they often make worse decisions. The National Research Council noted that "[t]he limited experiences of adolescents may also explain why they are more likely than adults to overestimate their own understanding of a situation, underestimate the probability of negative outcomes, and make judgments based on incorrect or incomplete information. Together these findings suggest that adolescents are less capable than adults of envisioning the longer-term consequences of their decisions and actions." (National Research Council 2013). This has been

observed in a legal context as well relative to reasoning regarding plea bargaining. (Allison Redlich & Reveka V. Shteynberg, *To plead or not to plead: a comparison of juvenile and adult true and false plea decisions*, 40 LAW AND HUMAN BEHAVIOR 611–625 (2016); Tarika Daftary-Kapur & Tina M. Zottoli, *A first look at the plea deal experiences of juveniles tried in adult court*, 12 INTERNATIONAL JOURNAL OF FORENSIC MENTAL HEALTH 323–336 (2014)).

The National Research Council observed that "when judged from the constricted time perspective of an adolescent, even sentences that are shorter than those imposed on adults may be experienced as longer." (National Research Council 2013 at 133).

All of these factors contribute to greater risk-taking in adolescence. A substantial body of research has demonstrated that from mid to late adolescence there is a peak in risk-taking behavior. (National Research Council, THE SCIENCE OF ADOLESCENT RISK-TAKING: WORKSHOP REPORT (Committee on the Science of Adolescence, Laurence Steinberg, Chair 2011); Steinberg & Icenogle, 2019).

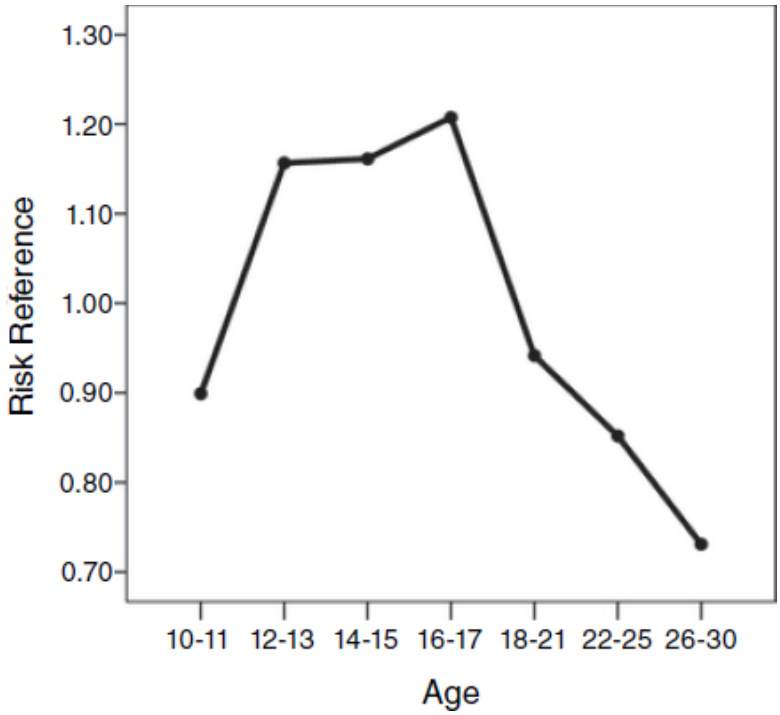

Figure 1. *Age differences in preference for risky behaviors (e.g., unprotected sex, shoplifting, smoking) (Steinberg 2009)*

As noted by Scott and Steinberg (2019), "[a]dolescents' criminal choices are likely to be driven by influences linked to immature brain development, such as poor impulse control and emotion regulation, and heightened reward seeking." Not surprisingly, a similar peak is seen in involvement in violent crime.

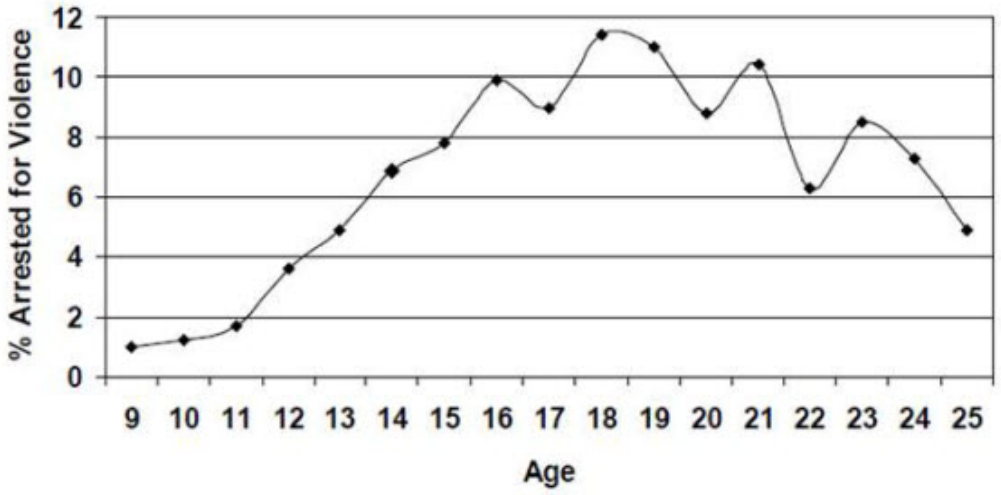

Figure 2. *"The relationship between age and crime is of an asymmetrical bell shape, showing that the prevalence of offending (the percentage of offenders in a population) tends to increase from late childhood, peaks in the teenage years (around ages 15–19), and then declines from the early 20s, often with a long tail." (Loeber and Farrington 2014; Graph from Loeber et al. 2011).*

These findings are seen by researchers around the world. For example, in one of the largest studies to date, some of the leading researchers in this area studied 5,277 individuals from 11 countries in Africa, Asia, Europe and the Americas between the ages of 10 and 30. They found that adolescents around the world showed the same patterns of development in psychosocial maturity, demonstrating heightened sensation-seeking and immature self-regulation during adolescence, resulting in increased risk-taking behavior. (Icenogle et al. 2019; Natasha Duell et. al., *Correction to: Age Patterns in Risk Taking Across the World*, 48 J. YOUTH ADOLESCENCE, 835-836 (2019); Natasha

Duell et. al., *Age Patterns in Risk Taking Across the World*, 47 J. YOUTH ADOLESCENCE, 1052-1072 (2018); Laurence Steinberg et al., *Around the world, adolescence is a time of heightened sensation seeking and immature self-regulation*, DEVELOPMENTAL SCIENCE (2018)).

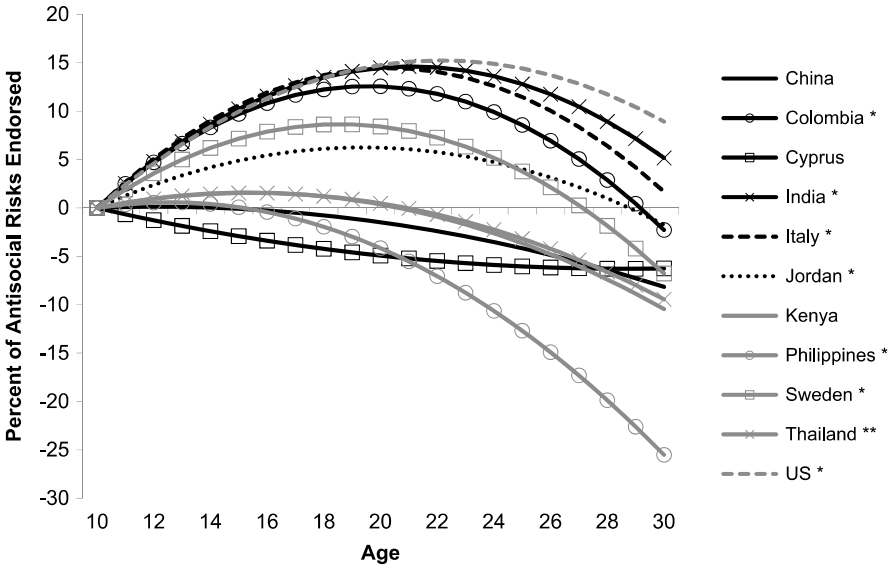

Figure 3. *"Age patterns in self-reported antisocial risk taking across countries. Values are percentage (%) of antisocial risks (vandalizing, stealing, fighting, walking through a dangerous neighborhood, and threatening someone) endorsed." Duell et al. 2019 at 836.*

This peak occurs because the development of the limbic system outpaces the development of the prefrontal cortex. (Steinberg, 2017; Steinberg et al., 2018). In other words, adolescents have a strong desire to seek out risks but lack the judgment and decision-making abilities necessary to keep them safe. "In essence, the brain changes in ways that

may provoke individuals to seek novelty, reward and stimulation several years before the complete maturation of the brain systems that regulate judgment, decision making and impulse control." (Laurence Steinberg, ADOLESCENCE (12*th* ed. 2020)).

As Steinberg explains in his 2017 review of the literature, "[t]he heightened responsiveness of this socioemotional incentive processing system is thought to overwhelm, or at the very least, tax, the capacities of the self-regulatory system, compromising adolescents' abilities to temper strong positive and negative emotions and inclining them toward sensation seeking, risk-taking, and impulsive antisocial acts." (Steinberg 2017). Steinberg and Icenogle (2019) concluded that "the maturation of the capacity to reason and deliberate systematically precedes, by as much as five years, the maturation of the ability to exercise self-regulation, especially in socially and emotionally arousing contexts." (Steinberg and Icenogle 2019 at 21).

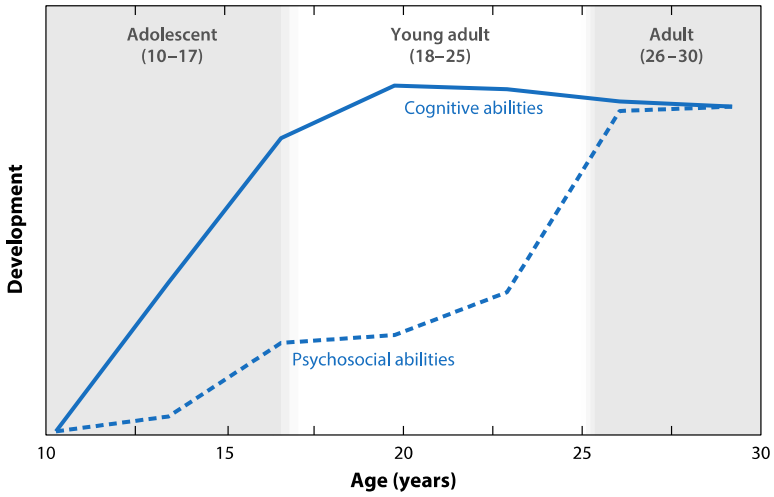

Figure 4. *Age gap in psychological abilities (Casey et al. 2020 adapted from Icenogle et al. 2019)*

In the decades since the *Roper* decision, research in this area has expanded extensively. In his 2017 review of the literature, Laurence Steinberg explained that numerous studies have shown that:

> Compared to adults, adolescents are more impulsive, less likely to consider the future consequences of their actions, more likely to engage in sensation seeking, and more likely to attend to the potential rewards of a risky decision than to the potential costs. Other studies have provided support for the contention that adolescents are indeed more vulnerable to coercive pressure than adults; that the presence of peers makes adolescents more sensitive to rewards; are especially attentive to immediate rewards; and that the presence of peers increases risky decision-making among adolescents but not older individuals.

(Steinberg 2017 at 414) (internal citations omitted).

D. <u>The Impact of Adolescence on Antisocial Behavior</u>

It has been well-established in the research literature that most

juveniles engage in antisocial behavior to some degree during adolescence. It has also been well-established that most do not continue that behavior into adulthood. (Terrie E. Moffitt, *Male antisocial behaviour in adolescence and beyond,* 2 Nature Human Behaviour 177-186 (2018)). This was confirmed by the Pathways to Desistance study, which followed 1,354 serious juvenile offenders ages 14–18 for seven years, making it the largest study of recidivism in juvenile offenders to date. As can be seen below, they found that only approximately 10% of serious offenders (the "persister" group), continued to report high levels of antisocial acts. (Kathryn C. Monahan et al., *Trajectories of antisocial behavior and psychosocial maturity from adolescence to young adulthood.*, 45 DEVELOPMENTAL PSYCHOLOGY 1654– 1668 (2009)).

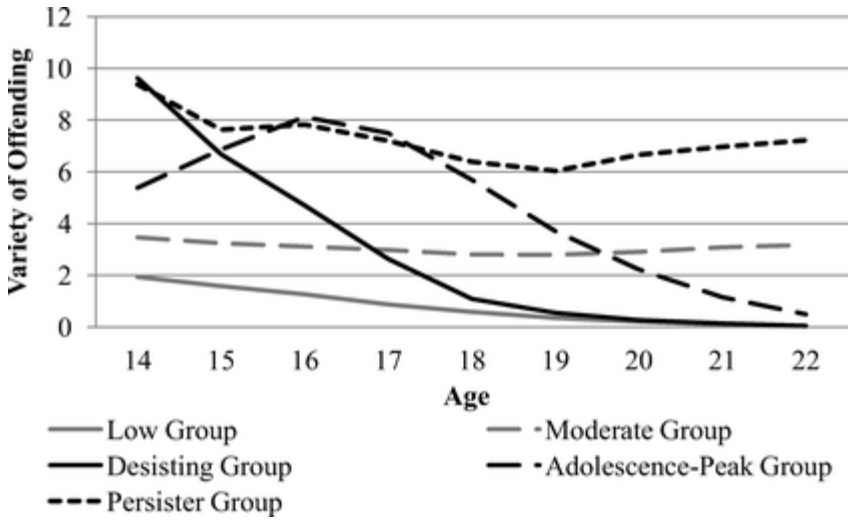

Figure 5. *Trajectories of antisocial behavior (Monahan et al. 2009)*

That study also revealed that longer stays in correctional institutions did not reduce recidivism in juvenile offenders. (Edward P. Mulvey, *Highlights from Pathways to Desistance: A Longitudinal Study of Serious Adolescent Offenders,* Office of Juvenile Justice and Delinquency Prevention (2011)). Confirming the transient nature of juvenile offending, they found that "The most important conclusion of the study is that even adolescents who have committed serious offenses are not necessarily on track for adult criminal careers." (Mulvey 2011). They found that "the original offense—whether a felony assault with a weapon or a property offense —has little relation to the path the youth follows over the next seven years." (Models for Change, RESEARCH ON PATHWAYS TO DESISTANCE (2012) at 4).

In a 2017 presentation to the Joint Ad-hoc Tennessee Blue Ribbon Task Force on Juvenile Justice in Tennessee, Professor Edward P. Mulvey, Ph.D., the lead researcher on that study presented it and other recent research and concluded that there is "[n]o convincing evidence that confinement of juvenile offenders beyond a minimum amount required to provide intense services reduces [the] likelihood of subsequent offending." (National Research Council 2013 at 181).

Scott and Steinberg argued in their 2019 review of the literature that "the developmental model has been influential largely because it provides a guide for youth crime regulation that has the potential to reduce crime. The reason is simple: because much juvenile crime is the product of youthful immaturity, most juvenile offenders will mature out of their inclination toward criminal activities if the justice system response does not undermine their ability to do so."

E. Juveniles Should Be Treated Differently Than Adults For the Purposes of Sentencing

Our understanding of adolescent brain development has grown dramatically since 2000. In the years since the Court decided *Graham, Miller* and *Montgomery*, the scientific evidence has grown even stronger. That research continues to confirm what parents have always known and what the Supreme Court has already concluded, namely that adolescents are different from adults in important ways. They are more emotional, more impulsive, more vulnerable to peer influence, take greater risks without considering the consequences, and are not as capable of planning and making decisions. Perhaps most importantly, they also differ from adults because they will continue to mature, and in the case of juvenile offenders, be more capable of rehabilitation. All of these differences

weigh heavily against treating juvenile offenders in the same way as adults for the purposes of sentencing.

The maturation of the adolescent brain follows a specific and predictable pattern that is consistent with the well-documented patterns of change observed in behavior during adolescence. In recent years, we have gained the ability to visualize the changes that occur between childhood and adulthood in the developing adolescent brain as structures change and different parts of the brain respond differently to different hormones and neurotransmitters. We can now watch these structures interconnect and begin to work together as the brain matures. Recent studies have even demonstrated that these changes occur in the same consistent patterns across cultures and across species. (Steinberg and Icenogle 2019; Steinberg et al. 2018).

One of those patterns of behavior change that has been consistently observed is that the risky, impulsive and sometimes antisocial behavior demonstrated by adolescents does not continue into adulthood in the vast majority of adolescent offenders. It should thus come as no surprise that research has also found that incarceration beyond the time necessary to provide intensive services does not reduce offending.

As a group, adolescents' immaturity is a transient state and not an enduring part of their character. As Justice Kennedy wrote in *Roper*, "The reality that juveniles still struggle to define their identity means it is less supportable to conclude that even a heinous crime committed by a juvenile is evidence of irretrievably depraved character." Since *Roper*, the research on adolescent brain development, adolescent behavior patterns and, specifically, desistance both confirms and strengthens this assertion.

The research leaves little doubt that juvenile offenders are fundamentally different from adult offenders. They will continue to develop and mature after being convicted, and the vast majority will desist from criminal behavior. Because we know this will happen, they deserve the opportunity to obtain release based on a demonstration that such maturity, and subsequent rehabilitation, has taken place.

V. CONCLUSION

For the foregoing reasons, *amicus curiae* Julie A. Gallagher, Psy.D ABPP urges the Court to grant Tyshon's Booker's appeal in his favor.

Respectfully submitted,

s/ Gibeault C. Creson
Gibeault C. Creson (#32049)
Alexandra Ortiz Hadley (#36892)
Robert R. McLeod (#36120)
Butler Snow LLP
The Pinnacle at Symphony Place
150 Third Avenue, South, Suite 1600
Nashville, Tennessee 37201
Phone: (615) 651-6700
Beau.Creson@butlersnow.com
Alexa.Hadley@butlersnow.com
Robert.McLeod@butlersnow.com

Counsel for Julie A. Gallagher

CERTIFICATE OF ELECTRONIC FILING COMPLIANCE

I hereby certify that this brief contains 5,830 words as calculated by Microsoft Word and complies with Tennessee Supreme Court Rule 46(3.02).

s/ Gibeault C. Creson

CERTIFICATE OF SERVICE

I certify that a true and exact copy of the foregoing motion was served electronically via the electronic filing system on all parties and mailed via U.S. first class mail, postage prepaid, this 24th day of November 2020 to:

Nicholas Spangler
Attorney General's Office
Criminal Justice Division
PO Box 20207
Nashville, TN 37202

Jonathan Harwell
Assistant Public Defender
1101 Liberty Street
Knoxville, TN 37919

/s/ Gibeault C. Creson

APPENDIX A

REFERENCES

Cases

Graham v. Florida, 560 U.S. 48 (2010)

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

Montgomery v. Louisiana, 136 S. Ct. 718 (2016)

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

Briefs

Brief for the American Medical Association and the American Academy of Child and Adolescent Psychiatry as Amici Curiae in Support of Neither Party, *Miller v. Alabama*, 567 US 460 (2012), (Nos. 10-9646 & 10-9647).

Brief for the American Psychological Association et al. as Amici Curiae in Support of Petitioners, *Miller v. Alabama*, 567 US 460 (2012), (Nos. 10-9646 & 10-9647).

Brief of Amici Curiae J. Lawrence Aber et al. in Support of Petitioners, *Miller v. Alabama*, 567 US 460 (2012), (Nos. 10-9646 & 10-9647).

Research Articles and Books

Aaron Alexander-Bloch et al., *The convergence of maturational change and structural covariance in human cortical networks*. 33 JOURNAL OF NEUROSCIENCE 2889– 2899 (2013).

Aarthi Padmanabhan et al., *Developmental changes in brain function underlying the influence of reward processing on inhibitory control*, 1 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 517–529 (2011).

Adriana Galván, *Adolescent development of the reward system*, FRONTIERS IN HUMAN NEUROSCIENCE (2010).

Adriana Galván, *The Teenage Brain*, 22 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 88–93 (2013).

Adriana Galván, THE NEUROSCIENCE OF ADOLESCENCE (2017).

Adriana Galván et al., *Earlier Development of the Accumbens Relative to Orbitofrontal Cortex Might Underlie Risk-Taking Behavior in Adolescents*, 26 JOURNAL OF NEUROSCIENCE 6885–6892 (2006).

Alexander Weigard et al., *Effects of anonymous peer observation on adolescents preference for immediate rewards*, 17 DEVELOPMENTAL SCIENCE 71–78 (2014).

Allison Redlich & Reveka V. Shteynberg, *To plead or not to plead: a comparison of juvenile and adult true and false plea decisions*, 40 LAW AND HUMAN BEHAVIOR 611–625 (2016).

Anita Cservenka et al., *High and low sensation seeking adolescents show distinct patterns of brain activity during reward processing*. 66 NEUROIMAGE 184–193 (2013).

Anna C. K. Van Duijvenvoorde et al., *Affective and Cognitive Decision-Making in Adolescents*, 35 DEVELOPMENTAL NEUROPSYCHOLOGY 539–554 (2010).

Ashley R. Smith, Jason Chein & Laurence Steinberg, *Peers increase adolescent risk*
taking even when the probabilities of negative outcomes are known., 50 DEVELOPMENTAL PSYCHOLOGY 1564–1568 (2014).

B. J. Casey, *Beyond Simple Models of Self-Control to Circuit-Based Accounts of Adolescent Behavior*, 66 ANNUAL REVIEW OF PSYCHOLOGY 295–319 (2015).

B. J. Casey et al., *Imaging the developing brain: what have we learned about cognitive development?* 9 TRENDS IN COGNITIVE SCIENCES 104–110 (2005).

B. J. Casey et al., *The storm and stress of adolescence: Insights from human imaging and mouse genetics*, 52 DEVELOPMENTAL PSYCHOBIOLOGY 225 (2010).

B.J. Casey et al., *Beyond simple models of adolescence to an integrated circuit-based account: A commentary*, 17 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 128-130 (2016).

B. J. Ellis et al., *The evolutionary basis of risky adolescent behavior: implications for science, policy, and practice*, 48 DEVELOPMENTAL PSYCHOLOGY 598–623 (2012).

B. R. Braams et al., *Longitudinal Changes in Adolescent Risk-Taking: A Comprehensive Study of Neural Responses to Rewards, Pubertal Development, and Risk-Taking Behavior*, 35 JOURNAL OF NEUROSCIENCE 7226–7238 (2015).

Beatriz Luna and Catherine Wright, *Adolescent brain development: implications for the juvenile criminal justice system*, in APA HANDBOOK OF PSYCHOLOGY AND JUVENILE JUSTICE (Kirk Heilbrun, David DeMatteo & Naomi E.S. Goldstein eds. 2016)

Beatriz Luna, Aarthi Padmanabhan & Kirsten O'Hearn, *What has fMRI told us about the Development of Cognitive Control through Adolescence?* 72 BRAIN AND COGNITION 101–113 (2010).

Bernd Figner et al., *Risky choice in children, adolescents, and adults: Affective versus deliberative processes and the role of executive functions*. 35 JOURNAL OF EXPERIMENTAL PSYCHOLOGY: LEARNING, MEMORY, AND COGNITION 709-730 (2009).

Bernd Figner & Elke U. Weber, *Who Takes Risks When and Why?* 20 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 211–216 (2011).

Bernd Figner et al. *Affective and deliberative processes in risky choice: Age differences in risk taking in the Columbia Card Task*, 35 JOURNAL OF EXPERIMENTAL PSYCHOLOGY: LEARNING MEMORY AND COGNITION 709-730 (2009).

Budhachandra S. Khundrakpam et al., *Brain connectivity in normally developing children and adolescents*, 134 NEUROIMAGE 192-203 (2016).

Catalina J. Hooper et al., *Adolescents Performance on the Iowa Gambling Task: Implications for the Development of Decision Making and Ventromedial Prefrontal Cortex.*, 40 DEVELOPMENTAL PSYCHOLOGY 1148–1158 (2004).

Cecile D. Ladouceur et al., *White matter development in adolescence: The influence of puberty and implications for affective disorders*, 2 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 36–54 (2012).

Conor Liston et al., *Frontostriatal Microstructure Modulates Efficient Recruitment of Cognitive Control*, 16 CEREBRAL CORTEX 553–560 (2006).

D. B. Dwyer et al., *Large-Scale Brain Network Dynamics Supporting Adolescent Cognitive Control*, 34 JOURNAL OF NEUROSCIENCE 14096–14107 (2014).

Delia Fuhrmann, Lisa J. Knoll, & Sarah-Jayne Blakemore, *Adolescence as a Sensitive Period of Brain Development*, 19 TRENDS IN COGNITIVE SCIENCE 558-566 (2015).

Edward P. Mulvey, *Highlights from Pathways to Desistance: A Longitudinal Study of Serious Adolescent Offenders,* Office of Juvenile Justice and Delinquency Prevention, *available at* https://www.ncjrs.gov/pdffiles1/ojjdp/230971.pdf. (2011)

Edward P. Mulvey, *Juvenile Justice Research: Implications for Intervention and Policy*, (2017).

Elizabeth Cauffman et al., *Age differences in affective decision making as indexed by performance on the Iowa Gambling Task.*, 46 DEVELOPMENTAL PSYCHOLOGY 193–207 (2010).

Elizabeth P. Shulman et al., Sex differences in the developmental trajectories of impulse control and sensation-seeking from early adolescence to early adulthood, 44 JOURNAL OF YOUTH AND ADOLESCENCE 1–17 (2015).

Elizabeth P. Shulman et al., *The dual systems model: Review, reappraisal, and reaffirmation*, 17 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 103–117 (2016).

Elizabeth S. Scott & Laurence D. Steinberg, RETHINKING JUVENILE JUSTICE (2010).

Elizabeth S. Scott & Laurence D. Steinberg, *In Defense of Developmental Science in Juvenile Sentencing: A Response to Christopher Berk*, 44 LAW & SOCIAL INQUIRY 780-786 (2019).

Erika E. Forbes & Ronald E. Dahl, *Pubertal development and behavior: hormonal activation of social and motivational tendencies*, 72 BRAIN AND COGNITION 66-72 (2010).

Eveline A. Crone & Elly A. Konijn, *Media use and brain development during adolescence*, 9 NATURE COMMUNICATION 588–598 (2018).

Eveline A. Crone & Ronald E. Dahl, *Understanding adolescence as a period of social– affective engagement and goal flexibility*, 13 NATURE REVIEWS NEUROSCIENCE, 636-650 (2012).

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 LAW & HUMAN BEHAVIOR 69-85 (2019).

Heidi Ledford, *The shifting boundaries of adolescence,* 554 NATURE 429-431 (2018).

James M. Bjork et al., *Brain Maturation and Risky Behavior: The Promise and the Challenges of Neuroimaging-Based Accounts*, CHILD DEVELOPMENT PERSPECTIVES (2012).

Janice M. Juraska & Jari Willing, *Pubertal onset as a critical transition for neural development and cognition.* 1654 BRAIN RESEARCH 87–94 (2017).

Jason Chein et al., *Peers increase adolescent risk taking by enhancing activity in the brain's reward circuitry*, 14 DEVELOPMENTAL SCIENCE (2011).

Justin L. Vincent et al., *Evidence for a Frontoparietal Control System Revealed by Intrinsic Functional Connectivity*, 100 JOURNAL OF NEUROPHYSIOLOGY 3328– 3342 (2008).

Kai Hwang, Michael N. Hallquist & Beatriz Luna, *The Development of Hub Architecture in the Human Functional Brain Network*, 23 CEREBRAL CORTEX 2380–2393 (2013).

Karol Silva et al., *Peers Increase Late Adolescents Exploratory Behavior and Sensitivity to Positive and Negative Feedback*, 26 JOURNAL OF RESEARCH ON ADOLESCENCE 696–705 (2015).

Kathryn C. Monahan et al., *Trajectories of antisocial behavior and psychosocial maturity from adolescence to young adulthood.*, 45 DEVELOPMENTAL PSYCHOLOGY 1654– 1668 (2009).

L. D. Selemon, *A role for synaptic plasticity in the adolescent development of executive function*, 3 TRANSLATIONAL PSYCHIATRY (2013).

Lauren E. Sherman et al., *Development of the Default Mode and Central Executive Networks across early adolescence: A longitudinal study*, 10 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 148–159 (2014).

Laurence Steinberg, *Adolescent Development and Juvenile Justice*, 5 ANNUAL REVIEW OF CLINICAL PSYCHOLOGY 459–485 (2009).

Laurence Steinberg, *Should the science of adolescent brain development inform public policy?* 64 AMERICAN PSYCHOLOGIST 739-750 (2009).

Laurence Steinberg, AGE OF OPPORTUNITY: LESSONS FROM THE NEW SCIENCE OF ADOLESCENCE (2014).

Laurence Steinberg, *Commentary on Special Issue on the Adolescent Brain: Redefining Adolescence*, 70 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS 343–346 (2016).

Laurence Steinberg, *Adolescent brain science and juvenile justice policymaking*, 23 PSYCHOLOGY, PUBLIC POLICY, AND LAW 410–420 (2017).

Laurence Steinberg, ADOLESCENCE (12*th* ed. 2020).

Laurence Steinberg et al., *Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: Evidence for a dual systems model.*, 44 DEVELOPMENTAL PSYCHOLOGY 1764–1778 (2008).

Laurence Steinberg et al., *Age Differences in Future Orientation and Delay Discounting*, 80 CHILD DEVELOPMENT 28–44 (2009).

Laurence Steinberg et al., *Around the world, adolescence is a time of heightened sensation seeking and immature self-regulation*, DEVELOPMENTAL SCIENCE (2018).

Laurence Steinberg & Grace Icenogle, *Using Developmental Science to Distinguish Adolescents and Adults Under the Law*, 1 ANNUAL REVIEW OF DEVELOPMENTAL PSYCHOLOGY 21-40 (2019).

Laurence Steinberg & Kathryn C. Monahan, *Age differences in resistance to peer influence.*, 43 DEVELOPMENTAL PSYCHOLOGY1531–1543 (2007).

Leah Somerville, *The Teenage Brain: Sensitivity to Social Evaluation*, 22 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 121-127 (2013).

Linda Patia Spear *The adolescent brain and age-related behavioral manifestations*, 24 NEUROSCIENCE AND BIOBEHAVIORAL REVIEWS 417–463 (2000).

Linda Patia Spear, *Adolescent neurodevelopment*, 52 JOURNAL OF ADOLESCENT HEALTH S7–S13 (2013).

Linda Patia Spear, *Consequences of adolescent use of alcohol and other drugs- Studies using rodent models*, 70 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS 228-243 (2016).

Linda P. Spear. *Effects of adolescent alcohol consumption on the brain and behaviour*, 19 NATURE REVIEWS NEUROSCIENCE 197–214 (2018).

Linda Van Leijenhorst et al., *What Motivates the Adolescent? Brain Regions Mediating Reward Sensitivity across Adolescence*, 20 CEREBRAL CORTEX 61–69 (2010).

Linn B. Norbom et al., *Probing brain developmental patterns of myelination and associations with psychopathology in youths using gray/white matter contrast*, 85 BIOLOGICAL PSYCHIATRY 389-398 (2019).

Leah H. Somerville, Negar Fani & Erin B. McClure-Tone, *Behavioral and Neural Representation of Emotional Facial Expressions Across the Lifespan*, 36 DEVELOPMENTAL NEUROPSYCHOLOGY 408–428 (2011).

Matthew B. Johnson & Beth Stevens, *Pruning hypothesis comes of age*, 554 NATURE 438-439 (2018).

Matthew Peverill et al., *Working memory filtering continues to develop into late adolescence*, 18 DEVELOPMENTAL COGNITIVE NEUROSCIENCE 78–88 (2016).

Megan M. Herting & Elizabeth R. Sowell, *Puberty and structural brain development in humans*, 44 FRONTIERS OF NEUROENDOCRINOLOGY 122–137 (2017).

Michael Dreyfuss et al., *Teens impulsively react rather than retreat from threat*, 36 DEVELOPMENTAL NEUROSCIENCE 220–227 (2014).

Nandita Vijayakumar et al. *Puberty and the human brain: Insights into adolescent development,* 92 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS 417–436 (2018).

Natasha Duell et. al., *Age Patterns in Risk Taking Across the World*, 47 J. YOUTH ADOLESCENCE, 1052-1072 (2018).

Natasha Duell et. al., *Correction to: Age Patterns in Risk Taking Across the World*, 48 J. YOUTH ADOLESCENCE, 835-836 (2019).

National Academies of Sciences, Engineering and Medicine, THE PROMISE OF ADOLESCENCE: REALIZING OPPORTUNITY FOR ALL YOUTH (Committee on the Neurobiological and Socio-behavioral Science of Adolescent Development and Its Applications, Richard J. Bonnie and Emily P. Backes eds. 2019).

National Research Council, THE SCIENCE OF ADOLESCENT RISK-TAKING: WORKSHOP REPORT (Committee on the Science of Adolescence, Laurence Steinberg, Chair 2011).

National Research Council, REFORMING JUVENILE JUSTICE: A DEVELOPMENTAL APPROACH (Committee on Assessing Juvenile Justice Reform, Richard J. Bonnie, Robert L. Johnson, Betty M. Chemers and Julie A. Schuck eds. 2013).

Nico U. F. Dosenbach et al., *Prediction of Individual Brain Maturity Using fMRI*, 329 SCIENCE 1358–1361 (2010).

Nico U. F. Dosenbach, Steven E. Petersen & Bradley L. Schlaggar, *The Teenage Brain*, 22 CURRENT DIRECTIONS IN PSYCHOLOGICAL SCIENCE 101–107 (2013).

M.A.J. van Tetering et al. *Sex differences in self-regulation in early, middle and late adolescence: A large-scale cross-sectional study*, 15 PLoS ONE 1-17 (2020).

Margo Gardner & Laurence Steinberg, *Peer Influence on Risk Taking, Risk Preference, and Risky Decision Making in Adolescence and Adulthood: An Experimental Study.*, 41 DEVELOPMENTAL PSYCHOLOGY 625–635 (2005).

Michael C. Stevens et al., *Functional neural networks underlying response inhibition in adolescents and adults*, 181 BEHAVIOURAL BRAIN RESEARCH 12–22 (2007).

Models for Change, RESEARCH ON PATHWAYS TO DESISTANCE (2012).

Monica Luciana & Paul F. Collins, *Incentive Motivation, Cognitive Control, and the Adolescent Brain: Is It Time for a Paradigm Shift?* CHILD DEVELOPMENT PERSPECTIVES (2012).

Monique Ernst et al., *fMRI Functional Connectivity Applied to Adolescent Neurodevelopment*, 11 ANNUAL REVIEW OF CLINICAL PSYCHOLOGY 361–377 (2015).

Pernille J. Olesen et al., *Combined analysis of DTI and fMRI data reveals a joint maturation of white and grey matter in a fronto-parietal network*, 18 COGNITIVE BRAIN RESEARCH 48–57 (2003).

Rolf Loeber & David P. Farrington, *Age-Crime Curve,* in ENCYCLOPEDIA OF CRIMINOLOGY AND CRIMINAL JUSTICE (G. Bruinsma & D. Weisburd eds. 2014)

Rolf Loeber & Rebecca Stallings, *Modeling the Impact of Interventions on Local Indicators of Offending, Victimization, and Incarceration*, in YOUNG HOMICIDE OFFENDERS AND VICTIMS: RISK FACTORS, PREDICTION, AND PREVENTION FROM CHILDHOOD (Rolf Loeber and David P. Farrington eds. 2011).

Ronald Dahl et al. *Importance of investing in adolescence from a developmental science perspective*, 554 NATURE 441–450 (2018).

Siobhan S. Pattwell et al., *Selective early- acquired fear memories undergo temporary suppression during adolescence*, 108 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 1182–1187 (2011).

Siobhan S. Pattwell et al. *Altered fear learning across development in both mouse and human*, 109 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 16318-16323 (2012).

Tamara L. Doremus-Fitzwater & Linda P. Spear, *Reward-centricity and attenuated aversions - An adolescent phenotype emerging from studies in laboratory animals*, 70 NEUROSCIENCE & BIOBEHAVIORAL REVIEWS, 121-134 (2016).

Tarika Daftary-Kapur & Tina M. Zottoli, *A first look at the plea deal experiences of juveniles tried in adult court*, 12 INTERNATIONAL JOURNAL OF FORENSIC MENTAL HEALTH 323–336 (2014).

Terrie E. Moffitt, *Male antisocial behaviour in adolescence and beyond,* 2 Nature Human Behaviour 177-186 (2018).

Thomas Grisso et al., *Juveniles' competence to stand trial: a comparison of adolescents' and adults' capacities as trial defendants*, 27 LAW AND HUMAN BEHAVIOR 333– 363 (2003).

Todd A. Hare et al., *Biological Substrates of Emotional Reactivity and Regulation in Adolescence During an Emotional Go-Nogo Task*, 63 BIOLOGICAL PSYCHIATRY 927–934 (2008).

Todd F. Heatherton, Neuroscience of Self and Self-Regulation, 62 ANNUAL REVIEW OF PSYCHOLOGY, 363-390 (2011).

Tomas Paus, *Brain Development, in* HANDBOOK OF ADOLESCENT PSYCHOLOGY (R. Lerner and L. Steinberg eds. 2009).

Vincent J. Schmithorst & Weihong Yuan, *White matter development during adolescence as shown by diffusion MRI*, 72 BRAIN AND COGNITION 16–25 (2010).