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Toward children's cognitive development from the perspective of neurolaw: implications of *Roper v Simmons*

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After reaching the age of criminal responsibility, children are deemed capable of having committed criminal offenses. In this regard, the level of criminal responsibility depends on cognitive development and the type of offense committed. Cognitive development is a process of the growth of perception, thinking and reasoning in children. This concept is frequently referred to in cognitive neuroscience literature. Recently, the U.S. Supreme Court's decision in *Roper v Simmons* has substantially changed attitudes toward juvenile delinquency, considering the fact that cognitive development continues until early adulthood. The present study attempts to scrutinize this case and explain cognitive development by its factors from an interdisciplinary perspective, combining methods and theories from neuroscience and criminal law.

Key words: Cognitive development; juvenile delinquency; neurolaw; *Roper v Simmons*; U.S. Supreme Court.

Introduction

Owing to new scientific discoveries made in the twenty-first century about human cognitive development, the definition of the child in legal systems and how to deal with adolescents' delinquency are dramatically changed (Demetriou et al., 2016; Hoffman, 2000; Kelly et al., 2009; Nunner-Winkler, 2007; Perlman & Pelphrey, 2010; Tamnes et al., 2013). Legally, the term *child* (any person below the age of 18) refers to a person who has not reached the age of physical and mental development necessary for social life. Their actions, therefore, are not subject to the criminal responsibility of adults (Kramers-Olen, 2015). However, it does not mean that a child is not criminally responsible and should not be held accountable for their criminal behavior. Based on the levels of criminal responsibility dictated by the cognitive development and the type of offense committed, a delinquent child is subject to the penalties for juvenile offenders, including socio-educational measures, non-punitive orders, youth detention, custody order and behavioral program order (Kavanaugh & Grisso, 2020). Cognitive development in this context means the growth of the mental ability of a delinquent child to reasonably think about the immoral features of the crime committed and its consequences (Petoft, 2015). The concept is fundamentally rooted in cognitive neuroscience (Herring, 2016; Petoft, 2020; Petoft & Momenirad, 2015). With the develop-

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ment of 'neurolaw'[1] as a new interdisciplinary field, scholars have made valuable findings in juvenile criminal justice systems (Petoft & Abbasi, 2019). That is why the recent U.S. Supreme Court's ruling in the *Roper v Simmons* case (543 U.S. 551, 2005) has substantially changed attitudes towards juvenile delinquency. Hence, the present study takes a deep look at this case and strives to explain children's cognitive development in the light of neurolaw; it simply seeks to investigate significant factors involved in children's cognitive development by identifying them in the nature of the Court's decision. This study provides judges with a new approach regarding the evaluation of children's cognition. The present study does not seek to depict a comprehensive and accurate picture of the U.S. legal system. Legal foundations of juvenile delinquency in its multi-level system (federal, state and local) are strikingly extensive in detail to discuss (if not impossible) and beyond the scope of this study. Furthermore, the study aims to provide a conceptual analysis of the children's cognition as a factor in determining juvenile criminal responsibility and does not explain its legal dimensions reflected in statutes.

Looking deep into the case

Today, criminal justice systems address the general rule that children shall not be held criminally responsible in the same way as adults for similar crimes. Most of them even abolished the death penalty for children (Regoli et al., 2013). They are fundamentally opposed to the death sentence, let alone the execution of a child although before the advancement of neuroscience in developed legal systems such as the United States, we have witnessed death sentences for crimes committed by adolescents aged 15–18 years (Cothern, 2000). Their approach has radically changed by prohibiting the execution of delinquent children. The Court in the *Roper v Simmons* case took a big step in this direction.

Christopher Simmons was a 17-year-old high school student in the state of Missouri. He, together with his two friends, Charles Benjamin and John Tessmer, had a plan to murder his neighbor, Shirley Nite Crook. They planned to break the window and enter the victim's home to rob. They met at about 2.00am on the night, but Tessmer did not cooperate with them. After breaking into Crook's home, Simmons and Benjamin bound her hands, wrapped her whole face in duct tape, stole her money, drove her to a state park and finally threw her off a bridge in the state park. Later Crook was found dead by drowning. Once the case was brought to trial, Simmons confessed to the crimes. Tessmer, who dropped out of the plot, also testified against Simmons. The jury judged Simmons to be delinquent and recommended a death sentence, even considering mitigating factors (his age and lack of a prior criminal record). The trial court sentenced Simmons to death, and the appeal court upheld the decision. Eventually, he filed a new petition for state post-conviction relief based on the ruling in *Atkins v Virginia* (536 U.S. 304, 2002) in which the U.S. Supreme Court overturned the death penalty for patients with intellectual disabilities. The Supreme Court of Missouri held that such punishment now violated the Eighth Amendment's prohibition of cruel and unusual punishment and sentenced Simmons to life imprisonment without parole. When the case was appealed to the U.S. Supreme Court, it ruled:

> *The prohibition against 'cruel and unusual punishments', like other expansive languages in the Constitution, must be interpreted … [we] affirmed the necessity of referring to 'the evolving standards of decency that mark the progress of a maturing society' to determine which punishments are so disproportionate as to be cruel and*

[1]Neurolaw is an interdisciplinary field of law and neuroscience that links the brain to law and facilitates the pathway to a better understanding of human behavior. Neurolaw scholars strive 'to know the relationship between law and brain by taking into account neuroscience findings' (Petoft, 2015).

> *unusual. … Once the diminished culpability of juveniles is recognized, it is evident that the penological justifications for the death penalty apply to them with lesser force than to adults. … A majority of States have rejected the imposition of the death penalty on juvenile offenders under 18, and we now hold this is required by the Eighth Amendment (para. 1 III B).*

The Court indicated that since the death penalty is the most severe punishment, it must be limited to the worst offenders who commit 'a narrow category of the most serious crimes' and whose extreme culpability makes them 'the most deserving of execution'. We cannot, however, with reliability, classify delinquent children among them. In *Graham v Florida* (560 U.S. 48, 2010), the court also calls attention to the fact that the concept of cruelty reflected in the Eighth Amendment necessarily embodies a moral judgment, which

> *… forbids the imposition of otherwise permissible punishments when they are disproportionate to the offense or to the offender's culpability. … Our cases have established that juveniles have lessened the culpability and so are less deserving of the most severe punishment. … A life without parole sentence is the second harshest sentence available. It is especially hard for a juvenile. … These offender's diminished moral culpability makes the sentence disproportionate on retributive grounds.*

Having these assumptions in mind, to give a delinquent juvenile some meaningful opportunity to obtain release based on demonstrated maturity and rehabilitation, the court found life without parole sentences to juvenile non-homicide offenders cruel and unusual. After that, in *Miller v Alabama* (567 U.S. 460, 2012), the Court ruled that mandatory sentence of life without the possibility of parole for juveniles no matter how serious the crimes, whether homicide or non-homicide, violates the Eighth Amendment's clause. Because this decision substantively creates a constitutional right to parole for juvenile offenders mandatorily sentenced to life imprisonment, the court gave it a retroactive effect in *Montgomery v. Louisiana*, 577 U.S. 190 (2016), holding that 'when a new substantive rule of constitutional law controls the outcome of the case the Constitution does require collateral review courts to give retroactive effect to that substantive rule'. However, as recently held in *Jones v Mississippi* (593 U.S. ___, 2021), the rule formed on a discretionary sentencing system does not require a judge to make a separate factual finding of permanent incorrigibility before sentencing a child who committed homicide. In *Miller v Alabama*, the court points up the two pertinent matters. First, children have lesser culpability and greater capacity for change; therefore, harshest sentences, such as execution or life without parole, may not constitutionally be imposed on them even when they commit terrible crimes. Second, jurors are expected to consider the mitigating factors of age and maturity in youth, the impulsiveness in children, their weak perception of risks or consequences, and sometimes terrible yet inescapable family circumstances in a child's life. The court describes children as individuals who:

> *… are constitutionally different from adults for sentencing purposes. Their lack of maturity and underdeveloped sense of responsibility lead to recklessness, impulsiveness, and heedless risk-taking. They are more vulnerable to negative influences and lack ability to extricate themselves from horrific, crime-producing settings. A child's actions are less likely to be evidence of irretrievable depravity (p. 460).*

A child is less culpable than an adult owing to the fact that they are not mentally mature (Cauffman & Steinberg, 2000). Current studies in cognitive neuroscience clearly show that the brain continues to develop until at least the mid-twenties (Edgin et al., 2015; Preedy et al., 2011). Children are naturally less perceptive than adults (Stiles et al., 2015). A child's

cognition is in the developmental stages insomuch they reach maturity in adulthood (Nelson, et al., 2015). During the development process, children try to gain multiple experiences by understanding their surroundings. They are under the influence of environmental factors, especially the behavior and thinking of adults. For this reason, children are relatively more susceptible (Cross et al., 2017). Their continued cognitive development also puts their moral personality under a step-by-step process of development. In general, the development of a child's moral character depends on the complete bio-cognitive maturation of the brain subnetwork called the 'moral brain', which establishes the physiological basis of morality and good behavior (Fumagalli & Priori, 2012; May et al., 2021). Judge Kennedy asserts that 'characteristics of juveniles make those judgments questionable' (*Graham v Florida*, 560 U.S. 48, 2010).[2] In *Roper v Simmons*, the Court highlighted these general differences as maturity, vulnerability, and personality:

> *First, as the scientific and sociological studies confirm, 'a lack of maturity and an underdeveloped sense of responsibility are found in youth more often than in adults and are more understandable among the young. These qualities often result in impetuous and ill-considered actions and decisions' (*Johnson *v* Texas, 509 U. S. 350, 1993*). 'Even the normal 16-year-old customarily lacks the maturity of an adult' (*Eddings *v* Oklahoma, 455 U. S. 104, 1982*). The second is that 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. The third is that 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 (para. 3–5 III B).*

[2]Anthony M. Kennedy. Opinion Announcement, 17 May 2010.

The perception of a criminal situation entails understanding its complex moral issues and the normative consequences of violating social conventions. Morality includes several components that require moral perception. A child's moral character is in the growth stages because their brain is in continuous functional and physiological development. Since moral perception is a core factor in cognitive development (Petoft & Abbasi, 2019b), the criminal responsibility of a delinquent child cannot be regarded as the same as that of an adult offender. For that reason, the Court put forward the famous opinion in the *Thompson v Oklahoma* (487 U. S. 815, 1988) case that:

> *The reasons why juveniles are not trusted with the privileges and responsibilities of an adult also explain why their irresponsible conduct is not as morally reprehensible as that of an adult. For most teens, [risky or antisocial] behaviors are fleeting; they cease with maturity as individual identity becomes settled. Only a relatively small proportion of adolescents who experiment in risky or illegal activities develop entrenched patterns of problem behavior that persist into adulthood (para. 6 & 7 III B).*

Children are highly teachable and impressionable. A child is typically a mirror, reflecting images of adult behavior, especially when they are abused or victimized and have traumatic experiences. Indeed, we believe that they are somehow victims of adult criminality. Some scholars express a similar view: 'a concern about protecting children and recognizing their vulnerability for abuse became part of the narrative that raised awareness of children as victims' (Benekos & Merlo, 2019, p. 110). That is why, in *Roper v Simmons*, the Court states about children that:

> *Their own vulnerability and comparative lack of control over their immediate surroundings mean juveniles have a greater claim than adults to be forgiven for failing to escape negative influences in their whole environment (para. 6 III B).*

Children express more fleeting emotions that intensify risk-taking and the tendency to break norms in complex situations. Only a relatively small number of teens who experience such situations develop well-established patterns of problem behavior that persist into adulthood (Steinberg, 2008). For most children, such risky or antisocial behaviors are momentary. During the development of cognitive functions of the brain neural networks, inhibitory control decreases children's risk-taking by progressive control over reflexive responses and overemotional behaviors. Acknowledging the fact that children's instability and emotional imbalance may often be a factor in delinquency, the Court paid regard to an idea from *Johnson v Texas* that:

> *The 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 (para. 6 III B).*

These arguments clearly show that children are different from adults in terms of cognition and criminal responsibility. As Robert stated in *Graham v. Florida*, 'Now, we know from *Roper v Simmons* that death is different, and we know from *Roper v Simmons* that juveniles are different'.[3] In the following, we explain new findings from recent neuroscience regarding children's cognitive development that uphold the Court's decisions.

Factors involved in the brain development

Recent findings in modern educational science, neuropsychology, sociology and criminology reveal significant differences between children and adults in various aspects, including brain development. It refers to a process that involves different degrees of anatomical (physical growth), physiological (biological function) and cognitive development of the brain to maturity (Goswami, 2020). At every stage of the process, therefore, we witness a degree of cognitive development. Cognition reaches its maturity in the fully developed status – that is, adulthood. Now, let us analyze these developmental factors in two separate parts.

Physio-anatomical development of the brain

Current neuroimaging studies show a great deal of evidence that the process of maturation occurs as children grow and their brains, in all anatomical and physiological aspects, develop. Neuroscientists have well realized that the brain does not reach full physical and functional development until early adulthood (Blakemore, 2012). For example, in a remarkable study by Gogtay et al. (2004), the anatomical growth of cerebral cortex gray matter through four-dimensional quantitative maps and time-lapse sequences in the functional magnetic resonance imaging (fMRI) technique between the ages of 4 and 21 years is depicted and analyzed (Gogtay et al., 2004). This study shows that the gray matter of the brain is still growing up to age 21.[4] Most of the brain's processing happens in gray matter, and for this reason, the physiological maturity of the brain directly relates to the growth of this part. The results of this study illustrate that phylogenetically older areas of the brain grow faster than new areas. In the process of anatomical development, areas with primary and major neural functions (e.g. the motor cortex) develop earlier than areas with more complex and participatory tasks (e.g. the temporal lobe). Therefore, following this process, cognitive functions are in the process of initial and advanced development. For example, moral reasoning goes through its early developmental stages in adolescence. Thus, the cortical development sequence represents the evolutionary process of functional advancement.

[3]Oral argument, 9 November 2009.

[4]Their four-dimensional model obtained by the fMRI technique shows that until the age of 21, we are still witnessing the gray matter maturation, and this illustrates the lack of complete physio-anatomical development of the human brain until adulthood.

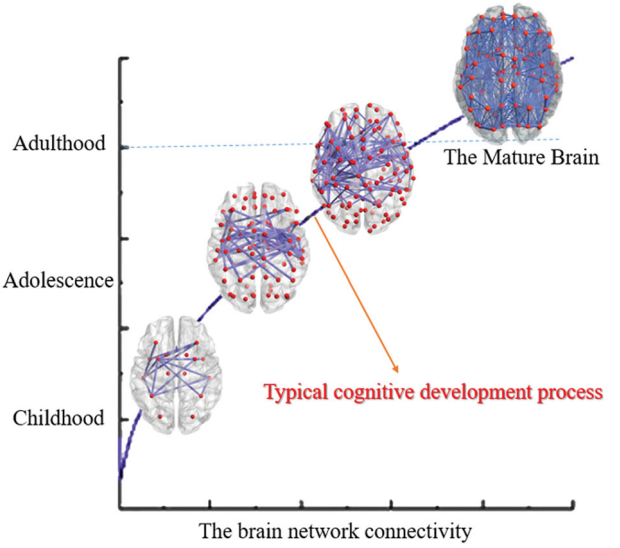

Figure 1. Schematic picture of cognitive development from childhood to adulthood. The curve is the typical process of cognitive development. The physio-anatomical maturation of the brain in this process expands the neural networks' cognitive function. It is worth noting that the use of standard scales can be a very proper way to diagnose mental retardation in children (e.g. attention deficit hyperactivity disorder, autism and Down syndrome) and to assess their cognitive responses to methods of rehabilitation (Kessler et al., 2016). To view this figure in color, please visit the online version of this Journal.

The Court somehow emphasized this fact by pointing out 'a lack of maturity'.

Cognitive development

If we do not believe in the mind–brain dualism, we can define cognition as the mental quality resulting from the complex function of brain neural networks that leads to rationality and thinking (Bubic et al., 2010). Both psychologists and neuroscientists demonstrated that cognitive development typically follows a gradual process similar to $f(x) = \sqrt{x}$ throughout childhood to adulthood (Figure 1; Bubic et al., 2010). Because of that, cognitive functioning in children is less developed than in adults. The developmental process makes a qualitative difference in the following cognitive functions, which somehow were considered by the Court to shed light on the differences between children and adults:

- Impulse control. Children are weaker than adults in controlling impulses that excite emotions. Neuroimaging studies suggest that brain cognitive processes, which support the ability to self-regulation in reflexive responses (e.g. planning and performance monitoring), reach their growth level in adulthood (Luna et al., 2010). Among them, we can mention the functional coherence in the 'executive system'[5] and the core connections of its white matter to regulate emotional behavior.
- Reward motivation. Children are always eager to be praised or rewarded. Reward motivation is much more potent in

[5]The executive system of the brain incorporates the higher level cognitive skills that individuals use to control behaviors and coordinate their other cognitive functions.

children than in adults. fMRI studies show that the reactive function of children's brains in the areas responsible for reward processing simultaneously occurs with the circuits that motivate them to engage in rewarding behaviors (Luna et al., 2010). For example, a child in the company of their peers may engage in risky or even abnormal behaviors to be seen, encouraged or admired.

- Emotional response. Emotional reactions are more intense in children than in adults. Several fMRI studies illustrate that the control systems of basic emotional behaviors (fight, flight and desire) do not reach full natural growth in children (Casey et al., 2010). The results reveal that the subcortical areas of the adolescent brain involved in the development of reflexive emotional behaviors show relatively more intense sensory responses than the anterior regions responsible for inhibitory control. Such functions in most subcortical areas are associated with risk-taking and increased dangerous reactions.
- Moral and social perception. Children may have different perceptions of what they have experienced in particular situations and behave each in their own way; this includes their response to norms and social conventions. The reason for this is the lack of maturity. As children grow, they are at different levels of the maturity hierarchy of moral personality. The development of the moral brain cognitive processes, which link moral reasoning to good behavior, reinforces children's moral character. It plays a pivotal and decisive role in directing behavior and causes adolescents to refrain from committing crimes (Fumagalli & Priori, 2012; May et al., 2021). As emphasized in *Graham v. Florida*, a child is not fully developed in morality and does not have the moral sense to the same extent as an adult.[6] Furthermore, current studies in cognitive neuroscience indicate that adolescents, compared to adults, show different patterns of cognitive function in understanding others (Blakemore, 2008). An adolescent's brain automatically organizes their 'person perception' into effective and coherent models. Although the brain supports the ability to make judgments in adolescence, the truthfulness of their thoughts and compatibility with social conventions depend on the level of 'social brain' growth (Brothers, 1990).

We found that children, compared to adults, naturally do not reach their full cognitive maturity and should be treated differently (Benekos & Merlo, 2019). However, this does not mean denying their criminal responsibility. Now we must discuss the evaluation areas of cognitive development to find an equitable way to assess juvenile criminal responsibility. Our study focuses on the three main differences addressed by the Court that comprise several cognitive development factors. Although the Court addressed these indicators to differentiate between children and adults and shed light on juveniles' incompetency (ordinary youth), we believe they also may be areas for the substantive assessment of children's mental capacity (non-ordinary youth). In fact, the present study strives to expand the *Roper v Simmons* line to the incapacity of children with congenital abnormalities (e.g. Down syndrome and fetal alcohol spectrum disorders) or those who suffer cognitive developmental delay resulting from trauma or adverse childhood experiences. Although the suggested indicators illustrate developmental incompetence, they are areas for assessing

[6]Chief Justice, Robert, stated that children 'are not fully developed, don't have moral sense to the same extent as an adult.' John G. Roberts, Jr. Oral Argument, 9 November 2009. Graham v. Florida, 560 U.S. 48 (2010).

developmental disability. Hence, the decision in *Atkins*, although relating to adult criminality (the irrationality of the execution of a mentally retarded offender), can be inspirational to affirm that delinquent children with mild to severe mental retardation[7] should face different sentencing in juvenile justice systems, considering the notion that '… mentally retarded offender [is] categorically less culpable than the average criminal … ' (*Atkins v Virginia*, 536 U.S. 304, 2002, p. 304)

Suggested areas for evaluation

Age-related factors are currently the criteria of cognitive development stages in criminal justice systems. New teachings of neurolaw indicate that the category of age in terms of sociology and neuropsychology has an undeniable effect on the gradual responsibility of children (Petoft, 2021). However, it is up to judges to determine the criminal responsibility of delinquent children at different ages, according to the quality of their cognitive development. To this end, explaining the neuropsychological parameters that reflect children's cognitive development in the following way may be fruitful. Cognitive development has several indicators that, inspired by what the Court emphasized, could be considered in the three main areas: cognitive maturity, personality growth and mental vulnerability. These areas may be helpful to assess children's cognitive development and to determine their criminal responsibility.

Cognitive maturity

Maturation is a process of growth that has numerous mental and physical factors. Undoubtedly, the Court's emphasis on maturity, in addition to the physical aspect, encompasses its most crucial psychological indicator, namely cognitive maturity. There are several ways to assess cognitive maturation (Luna et al., 2004), including those related to processing speed, intellectual reasoning (e.g. numerical, verbal, logical, diagrammatic, spatial, inductive, deductive and mechanical reasoning), voluntary response suppression (i.e. inhibitory control), working memory and task coordination evaluation. Although these indicators may not form a complete set of cognitive capabilities, they have received much attention among the many neuroscience and psychology studies that have been conducted so far on cognitive development in children (Ebaid, 2017; Fernandes, 2016; Petersen et al., 2016). Many cognitive factors are involved in the maturation of children's general thinking and reasoning abilities, and here we describe two important ones:

Processing speed

During childhood and youth, there are clear differences in the speed of brain processing. They are directly related to the function of higher order cognitive networks of the brain. Although experience can play a role in accelerating cognitive processing, there is also evidence that some experiences limit the overall mechanism of rapid brain function. Brain processing speed significantly affects the quality of cognitive function in indirect tasks such as reasoning and memory. As Kail and Salthouse pointed out in their study, regardless of the experimental factors involved, the processing speed of the human brain follows a regular course throughout life that increases during children's growth and peaks in adulthood; this rate decreases from middle age to old age.[8] If a delinquent adolescent's brain processing speed is significantly lower than the age-related standard, it indicates that their cognitive ability has not developed just right; and this can be a mitigating factor. In such

[7]As the Court stated 'recent State legislation evidences a national consensus against execution of even the mildly retarded.' Antonin Scalia. Opinion Announcement, 20 June 2002. Atkins v. Virginia, 536 U.S. 304 (2002).

[8]The diagram of processing speed in their study illustrates that the brain reaches its maximum rate during ages about 18 to 38 years (Kail & Salthouse, 1994).

cases, a judge may determine alternative legal measures, such as appropriate treatment and education.

Neuroscientists traditionally use neuropsychological testing to assess processing speed across the lifespan with paper-and-pencil tests (e.g. the Symbol Search and Coding tasks) from the Information Processing Speed (IPS) index of the Wechsler Adult Intelligence Scale (WAIS; Cornelis et al., 2015). IPS could be considered a measure of the efficiency of children's cognitive function. Ebaid et al. (2017) have recently suggested that the Simple IT task is a quick and effective additional testing to increase the accuracy of such cognitive assessments (Ebaid et al., 2017). The IT testing provides a non-motor rapid and precise evaluation of the speed of visual processing and discrimination of a visual stimulus. The combined method (IPS & IT testing) is particularly applicable to assess cognitive capabilities of children with traumatic brain injury (TBI; Newman et al., 2013) or mental retardation (Schuiringa et al., 2017), including those with fetal alcohol spectrum disorders (FASD; Burden et al., 2005) and attention deficit hyperactivity disorder (ADHD; Kofler et al., 2020).

Inhibitory control

Inhibitory control, which permits a child to inhibit their impulses and natural responses to stimuli, limits the impact of unwanted actions and thoughts. The lack of natural development of this mechanism in cognitive functions of a child's brain, while decreasing a sense of self-preservation, increases risk-taking. In fact, inhibitory control contributes to normativity and human behavioral adaptation (Aron et al., 2014). The higher order executive system employs this mechanism to regulate perceptions and self-control. Inhibitory control is a cognitive process that operates in parallel with impulse control. What is very important in complex situations that increase the risk of committing a crime is the speed of the inhibitory process compared to the motivational–impulsive process. During the growth stages, a child's brain cognitive functions increase self-prevention of the tendency to reflexive or impulsive responses. Bessette et al. (2020) demonstrated that the development process of inhibitory control follows almost the same pattern as the typical curve (i.e. Figure 1; Bessette et al., 2020). Analytical results of such studies are beneficial for measuring mental capacity. The process also can be revealed through fMRI. Luna et al. (2001) tracked brain functions in the frontal lobe, the parietal lobe, the striatum and the thalamus, which are engaged in inhibitory control. They found that the cognitive functions gradually develop in an almost certain process from childhood to adulthood (Luna et al., 2001).

There are several ways to assess inhibitory control that each has technical or analytic challenges, including the validation of results, measurement accuracy and sensitivity of experimental or observational methods. Generally, neuroscientists assess inhibitory control by response inhibition tasks, which involve the withholding (or significant delay) of a prepotent response (Garon et al., 2008). Petersen et al. (2016) meta-analyzed nearly 200 studies using measures of inhibitory control to estimate age ranges of usefulness for each one (Petersen et al., 2016). They found that evaluating inhibitory control over childhood requires the use of various measures at different time points. They differentiated between simple response inhibition (for minimal working memory) and complex inhibitory control paradigms. In any case, we strongly recommend assessing inhibitory control in a delinquent child (while measuring other cognitive factors), considering standard growth patterns obtained from significant cognitive neuroscience studies. Employing neuropsychological testing, we need to make sure whether a child has sufficient inhibitory control over their behavior to commit a crime; however, this core aspect of self-regulation is not naturally comparable to that found in adults. The results of such tests, which are

expected to conform with the standard rates in a child's age, relatively show the quality of their cognitive development in 'the ability to inhibit responses to irrelevant stimuli while pursuing a cognitively represented goal' (Carlson & Moses, 2001, p. 1033).

Mental vulnerability

From what we discussed in detail, it is clear that adults are mentally autonomous while children are non-autonomous and dependent. Because of this, they are vulnerable to their surroundings. Child vulnerability is a concept that encompasses a broad discussion in child development and children's rights literature (Schweiger, 2019). Children are naturally vulnerable in various types and degrees, considering factors related to growth and living and social environment (Jopling & Vincent, 2016). A child's vulnerability, both physically and mentally, has psychological effects (Bagattini, 2019). In other words, external and internal factors involved in the violence against children,[9] including spiritual (e.g. lack of self-confidence, depression, fear, apprehension and stress) and material (e.g. self-harm, corporal punishment, malnutrition and hard physical work), in any case, have psychological outcomes and negatively affect their cognitive development. Because of this, children always experience varying degrees of mental vulnerability.

Numerous factors are contributing to child vulnerability that can be divided into individual and environmental. Individual factors are rooted in mental and physical capabilities or personal circumstances, such as age-related pathophysiological disorders, disabilities, maltreatment and mental health difficulties. Environmental factors operating at family and community levels are associated with poverty, education, material deprivation, violence in family or neighborhood, homelessness and intimate partner violence (OECD, 2019). These factors have a mild to severe impact on the formation of a child's personality and perception (Ibáñez-Alfonso et al., 2021). In determining the criminal responsibility of a child, their personality file should be considered, including all the factors contributing to mental vulnerability. It must also be borne in mind that the negative effects of these factors on the cognitive development of children are much greater than those that adults confront. For this reason, it is fairer that judges pay more attention to possible mitigating factors and rehabilitation methods when considering juvenile delinquency. Judges are, therefore, expected to consider children's three fundamental aspects of dependence: material (e.g. food, clothing and housing), emotional (e.g. love, peace of mind, attention and family spiritual support) and social (i.e. education, social situation, relationships and health).

Eric Holder, the former U.S. Attorney General, focuses attention on the negative impact of exposure to violence on a child's physical, emotional and intellectual development: 'children exposed to violence are more likely to abuse drugs and alcohol; suffer from depression, anxiety, and post-traumatic disorders; fail or have difficulty in school, and become delinquent and engage in criminal behavior.'[10] Neuroscience studies on any of the above-mentioned factors can be inspiring and provide evidence regarding children's mental vulnerability. For example, Graham et al. (2021) have studied the role of multiple sources of pre- and postnatal adversity and biological stress mediators in brain system development and emerging behaviors relevant for psychiatric disorders. Natalucci et al. (2020) have demonstrated the psychological

[9] 'Children's exposure to violence typically refers to children who witness or are victimized by violence. This includes physical assault, peer victimization, sexual victimization, child abuse and maltreatment, as well as witnessing (seeing or hearing) in the home, school, or community' (see: https://www.crimesolutions.gov/TopicDetails.aspx?ID=60#Overview).

[10] U.S. Department of Justice. Defending childhood: Protect, heal, thrive. Washington, DC. 2010. available at http://www.justice.gov/ag/defendingchildhood/dc-factsheet.pdf

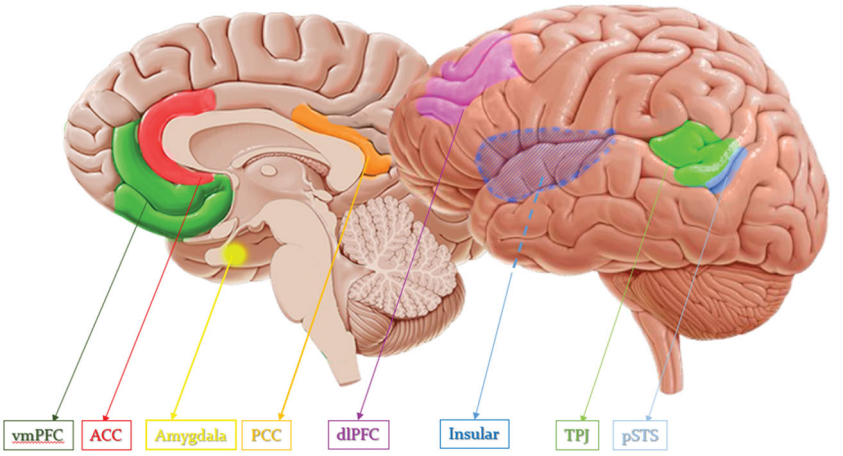

Figure 2. Cross-sectional anatomy of the moral brain. The moral brain incorporates a large functional network (including both cortical and subcortical anatomical structures), but the displayed areas seem to play the most influential roles. vmPFC = ventromedial prefrontal cortex; ACC = anterior cingulate cortex; PCC = posterior cingulate cortex; dlPFC = dorsolateral prefrontal cortex; TPJ = temporal-parietal junction; pSTS = posterior superior temporal sulcus. Other areas associated with the moral brain are as follows: orbitofrontal cortex, medial frontal gyrus, inferior parietal region, anterior/middle temporal gyrus, angular gyrus, hippocampus, thalamus, septum and caudate nucleus. To view this figure in color, please visit the online version of this Journal.

vulnerability of unaccompanied refugee minors, which has increased in Europe. In another study, Liu and his colleagues have reviewed the current theoretical and empirical literature on the development of cognitive vulnerability to depression in youth (Liu et al., 2021). However, it is beyond the scope of the present study to address a large body of neuroscience research in this area.

Personality growth

Since children go through the process of cognitive development, their perceptions are in the developmental stages (Nelson et al., 2015). Legality, by its very nature, entails the development of a child's moral and social personality (Helwig & Jasiobedzka, 2001). The former stems from their perception of moral facts, which is called 'moral perception', whereas the latter is a direct result of what neuroscientists call 'social perception' (Ferguson & Bargh, 2004). A child's normativity (adherence to norms while understanding normative consequences and social grounds) and person-perception (other perception that leads to judgments of traits and dispositions) crucially depend on their social personality growth. However, we believe that both of them are substantively rooted in the moral character of a child. Indeed, the social personality of a child is shaped to a large extent by their moral perception. Therefore, a child's moral character formed their actual personality. Criminal responsibility then tracks moral responsibility: a child should be held criminally responsible for delinquency only if they can be held morally responsible for that (Duff, 2009).

As a result, it is clear that the moral brain, which establishes the moral character as we highlighted above, could be functionally investigated to assess a child's personality growth. If the moral brain reaches complete biocognitive formation, it reflects personality growth, otherwise the brain is still on its way to maturity. For this purpose, we suggest investigating the functions of the moral brain in delinquent children (Figure 2). As it seems, fMRI is an appropriate technique for this

purpose; however, it is associated with high costs and technical limitations (Petoft, 2020). Neuroscience studies provide us with significant indicators in this regard, including the crucial role of the amygdala and the ventromedial prefrontal cortex (vmPFC) in 'gut feelings' (i.e. immediate feelings or reactions largely without reasoning), which are an integral part of moral perception (Mayeli et al., 2021). In addition, there are studies concentrated on brain areas associated with complex moral reasoning and sensitivity, especially the dorsolateral prefrontal cortex (dlPFC), the posterior cingulate cortex (PCC), the anterior cingulate cortex (ACC), the temporal-parietal junction (TPJ) and the posterior superior temporal sulcus (pSTS; Delgado-Sánchez, 2020; Greene et al., 2001; May et al., 2021; Obeso et al., 2018).

The current neuropsychological methods for personality assessment focus on the Big Five Model (i.e. Five-Factor Model, FFM),[11] which is a credible prevalent model of personality description in terms of traits (Allen & DeYoung, 2017). Although the criteria of this model do not necessarily provide the characteristics of morality in detail, they can depict a general picture of a child's moral character to a reliable extent (Koodamara et al., 2021). Personality neuroscientists strive to identify the underlying sources of personality traits in the brain's cognitive systems. In their study, Allen and DeYoung (2017) have proposed the neurobiological methods in the context of personality neuroscience and divided them into the five general categories: neuroimaging techniques (chiefly fMRI); electrophysiological techniques (mostly electroencephalography, EEG); molecular genetics (DNA analysis); psychopharmacological manipulation (drug intervention); and assays of endogenous psychoactive substances (measurements of substances such as hormones or neurotransmitter metabolites). In personality neuroscience research, however, there are numerous methodological limitations highlighted by recent reviews (DeYoung, 2010; Yarkoni, 2015). Most personality assessment studies rely on self-reports using questionnaires, while they still do not prevail over the alternative methods, including those in which several cognitive or psychological tasks may be used to assess stable personality traits. Hence, the current common measurements of a child's personality are mainly psychological rather than neuroscientific. Although the FFM was traditionally established in questionnaire data, non-questionnaire methodologies are likely to progress in personality assessments.

[11]The theory of Big Five personality traits identifies five factors: extraversion, agreeableness, openness to experience, conscientiousness and neuroticism. See Roccas et al. (2002).

Conclusion

In *Roper v Simmons*, the Court held that capital punishment for adolescent delinquency violates the Eighth Amendment clause prohibiting cruel and unusual punishment. After this revolutionary decision in the juvenile justice system, the Court, following the *Miller*, *Montgomery* and *Jones* cases, indicated the necessity of parole for juvenile offenders mandatorily sentenced to life imprisonment as a retroactive rule that roots in the content of the clause; however, it does not require judges to make a separate factual finding of permanent incorrigibility before sentencing. Recent findings of neuroscience related to the physio-anatomical and cognitive (chiefly, impulse control, reward motivation, emotional response, moral and social perception) development of the brain, somehow, validate the Court's decisions. Due to the landmark decision in *Roper v Simmons*, the court seems to believe in three notable differences between children and adults in cognitive development: maturity, vulnerability and personality. Although these indicators refer to the developmental incompetence of ordinary juveniles, we also suggested them as areas for the substantive assessment of mental capacity in non-ordinary youth, somehow, to expand the *Roper*

v Simmons and *Atkins* line to the developmental disability.

The first difference reflects the fact that the brain continues to develop until early adulthood. Cognitive maturity makes adults more perceptive than children in recognizing the immoral features of a criminal situation and its normative consequences. Numerous factors, such as speed processing and inhibitory control, contribute to the maturation of children's general thinking and reasoning abilities. A weak processing speed of a child's brain assessed by the combined IPS and IT testing may be a mitigating factor. A child whose brain's motivational–impulsive function predominates over inhibitory control should not be held responsible for a crime committed because they are not neurobiologically expected to have appropriate control over their behavior in many complex situations. Neuroscientists can assess children's inhibitory control by response inhibition tasks in several neuropsychological testing and provide judges with neuroscientific evidence.

The second difference derives from the fact that children are relatively more susceptible and vulnerable under environmental influences during gaining objective experiences. We strongly recommend considering a delinquent child's material, emotional and social aspects of dependence since they always experience varying degrees of mental vulnerability. The third draws our attention to the fact that a child's personality goes through a step-by-step process of cognitive development. Children are weaker than adults in controlling impulses that excite emotions, moderating the influence of eagerness to be rewarded, regulating their reflexive behavior, and understanding themselves and others. Therefore, the development of a child's personality should be regarded in assessing their criminal responsibility. We suggest assessing the functions of the moral brain to dig deep into a child's moral character. However, neuropsychologists rely on the FFM associated with an individual's both moral and social personalities.

Many factors contributing to children's cognitive development do not reach their full potential until adulthood. Therefore, the criminal responsibility of a child is different from that of an adult. Their law-breaking should be legally dealt with differently. Scrutinizing the Court's ruling, the present study attempted to introduce areas for cognitive assessment of a delinquent child while emphasizing the differences between the child and adult brain. However, we faced limitations. The sheer extent of the topics did not provide an appropriate room to debate any of the concepts and explain all theoretical and scientific aspects. We directly identified the areas and left a detailed discussion of the criteria in cognitive development and how to accurately and validly evaluate them for future research.

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Ethical standards

Declaration of conflicts of interest

Arian Petoft has declared no conflicts of interest

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Ethical approval

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