



Review

Dignity neuroscience: universal rights are rooted in human brain scienceTara L. White^{1,2,3,4}  and Meghan A. Gonsalves⁵ ¹Department of Behavioral and Social Sciences, School of Public Health, Brown University, Providence, Rhode Island.²Center for Alcohol and Addiction Studies, Brown University, Providence, Rhode Island. ³Carney Institute for Brain Science, Brown University, Providence, Rhode Island. ⁴University of Cambridge, England, Cambridge, UK. ⁵Neuroscience Graduate Program, Brown University, Providence, Rhode Island

Address for correspondence: Tara L. White, Department of Behavioral and Social Sciences, School of Public Health, Brown University, Box G-S121-5, 121 South Main St., Providence, RI 02912. Tara_White@Brown.edu

Universal human rights are defined by international agreements, law, foreign policy, and the concept of inherent human dignity. However, rights defined on this basis can be readily subverted by overt and covert disagreements and can be treated as distant geopolitical events rather than bearing on individuals' everyday lives. A robust case for universal human rights is urgently needed and must meet several disparate requirements: (1) a framework that resolves tautological definitions reached solely by mutual, revocable agreement; (2) a rationale that transcends differences in beliefs, creed, and culture; and (3) a personalization that empowers both individuals and governments to further human rights protections. We propose that human rights in existing agreements comprise five elemental types: (1) agency, autonomy, and self-determination; (2) freedom from want; (3) freedom from fear; (4) uniqueness; and (5) unconditionality, including protections for vulnerable populations. We further propose these rights and protections are rooted in fundamental properties of the human brain. We provide a robust, empirical foundation for universal rights based on emerging work in human brain science that we term *dignity neuroscience*. Dignity neuroscience provides an empirical foundation to support and foster human dignity, universal rights, and their active furtherance by individuals, nations, and international law.

Keywords: neuroscience; universal human rights; international law; public policy; sustainable development goals

Introduction

Securing and furthering human rights is urgent given today's ethnonationalism, intolerance, inequality, and political unrest. Human rights are currently based in international treaties and human rights law. Treaties in force include the Universal Declaration of Human Rights,¹ the International Covenants on Civil and Political Rights (ICCPR),² Economic, Social and Cultural Rights (ICECSR),³ and the 2030 Sustainable Development Goals (SDGs) of the United Nations.^{4,5} These treaties state the rights to life, liberty, and security; equality before the law; protection from discrimination; freedom of movement; a nationality; free and full consent to marriage; founding a family; free-

dom of thought, conscience, and religion; work and free choice of employment; and a standard of living adequate for the health and well-being of oneself and one's family.¹ These rights are held to derive from the inherent dignity of the human person and to be universal.¹⁻⁵ These rights have their origins in early cultural, religious, and legal texts, such as the Code of Hammurabi (1795–1750 BCE), the Cyrus cylinder (539 BCE), the Magna Carta (1215 CE), and the U.S. Declaration of Independence (1776 CE).^{6,7}

Universal rights defined by consensus and dignity have several limitations and unintended consequences that predate existing agreements, reducing their uptake and impact.⁸ First, rights

doi: 10.1111/nyas.14670

defined solely by mutual revocable agreement are readily subverted by overt and covert disagreement. This basis puts universal rights at risk of local, regional, and national dispute. This risk is particularly acute in an age of rising ethnonationalism, when one or more nations may peremptorily withdraw from, ignore or fail to enforce the international agreements upon which human rights protections rely. Second, universal rights are currently grounded solely in the concept of human dignity, the “worth, stature, or value that human beings have simply because they are human.”⁹ This concept is distilled from cultural and philosophical traditions but is only sparsely described in existing treaties, providing an incomplete rationale for human rights in international law. Third, treaties currently in force address only a subset of discriminations relevant to human flourishing (i.e., race, sex, language, and religion).¹ A more inclusive approach is needed that provides for greater diversity in discriminations explicitly addressed, including (but not limited to) nationality, disability, sexual orientation, age, social class/caste, and economic strata/resources.¹⁰ Fourth, existing covenants devote less attention to ethical communities, where rights are widely honored and respected.⁸ A focus on community would bridge across collectivist and western societies and cultures. Finally, human rights are anything but remote; protections and abuses occur to and by individuals well before violations reach community, national and international awareness. An approach that fails to empower systematic human rights awareness, education, and action by *individuals*, in addition to governments, will not protect well-being, social peace, vulnerable people, and global public health.

A robust framework for universal human rights must thus address several disparate, fundamental needs: (1) rights must be defined in a manner that resolves the current tautology of definition by mutual and revocable agreement; (2) a compelling rationale for universality must transcend authentic differences in regional belief, creed, and culture; and (3) rights must be personalized, such that individuals are empowered to further systemic rights protections, awareness and interventions within their own, often-expansive spheres of influence, including work, school, family, communities, nation, and online world.

We propose that human rights are deeply rooted in human brain science, which provides a novel evidentiary base informing the universality, scope, and content of human rights and their relationship to human dignity.^{1–5}

Universal human rights and dignity are grounded in brain science

Universal human rights are legally grounded in intrinsic human dignity through multiple treaties and covenants.^{1–5,9} We propose that universal rights can be coalesced into five main categories: (1) agency, autonomy, and self-determination; (2) freedom from want; (3) freedom from fear; (4) uniqueness; and (5) unconditionality (Table 1), with elevated risks in vulnerable populations (Table 2). Because intrinsic dignity concerns the value of each individual human being,⁹ respecting intrinsic dignity requires respecting the health and development of each individual person. As a result, universal human rights and protections necessarily relate to fundamental, species-typical features of the human central nervous system. Specifically, we posit that the five categories described above reflect fundamental features of brain structure, function, and development in humans, with special protections reflecting the lifelong, inherent plasticity of the human brain. We discuss the human neurobiological grounding of these rights below.

The neuroscience of agency, autonomy, and self-determination

Agency is the ability to shape one’s own choices and action in the world.¹¹ Autonomy is the independence or freedom of one’s will or actions. Self-determination is the ability to determine for oneself without outside influence.¹² The human brain contains regions and circuits that support these essential processes, illustrated in Figure 1A. As discussed below, we propose that defined brain functions underpin the universal rights to life, liberty, security, freedom of movement, thought, and expression (see details in Table 1).

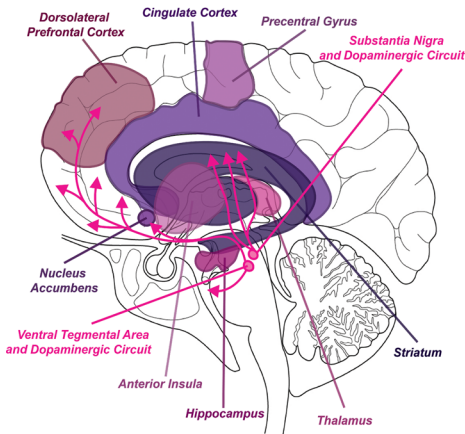
Agency

Agency is intrinsic to the brain and is informed by studies on emotion.^{11,13} *Positive agency* is the capacity for goal-directed behavior, positive

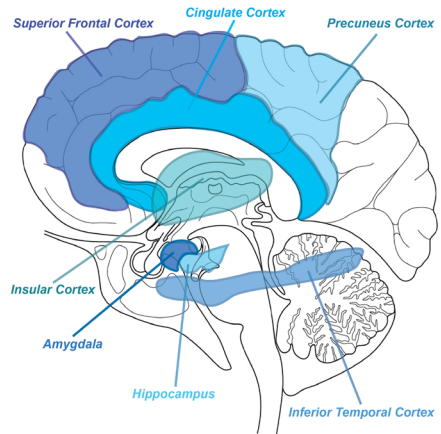
Table 1. Neuroscience framework for human rights

Neuroscience concept	International agreements on Human Rights and Sustainable Development
Agency	Universal Declaration of Human Rights (1948). <i>Articles 3, 12, 13.1-2, 16.1-2, 18, 19, 20.1-2, 21.1-3, 23, 27.1-2</i>
Autonomy	Everyone has the right to life, liberty and the security of person (Article 3)
Self-determination	Everyone has the right to freedom of movement (Article 13.1) Men and women of full age... have the right to marry and found a family (Article 16.1) Everyone has the right to freedom of thought, conscience and religion (Article 18) Everyone has the right to work, to free choice of employment (Article 23) Everyone has the right to freely participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits (Article 27.1) International Covenant on Civil and Political Rights (1966a). <i>Preamble, Articles 1.1, 7, 8.1, 8.2, 8.3a, 9.1, 9.3, 11.2, 18.1, 18.2, 19.1, 19.2, 21, 22.1, 23.3, 24.3, 25.a</i> All peoples have the right to self-determination (Article 1.1) No one shall be held in slavery or servitude (Article 8.1-2) Everyone has the right to liberty (Article 9.1) Everyone shall have the right to hold opinions without interference. (Article 19.1) International Covenant on Economic, Social and Cultural Rights (1966b). <i>Preamble, 1.1, 6.1, 8.d, 15.1.c, 15.2</i> [T]he ideal of free human beings (Preamble) [T]he right to work, which includes the right of everyone to the opportunity to gain his living by work which he freely chooses or accepts (Article 6.1) [T]he right to strike (Article 8.d) [R]espect the freedom indispensable for scientific research and creative activity (Article 15.2) Transforming our world: the 2030 Agenda for Sustainable Development (2015; 2017) <i>Sustainable Development Goals #1,2,3,4,5,6,8,9,10,11,16</i>
Privation/freedom from want	Universal Declaration of Human Rights (1948). <i>Articles 22, 25.1, 26.1</i> Everyone, as a member of society, has the right to social security (Article 22) [R]ight to a standard of living adequate for the health and well-being of himself and his family (Article 25.1) Everyone has the right to education (Article 26.1) International Covenant on Civil and Political Rights (1966a). <i>Preamble</i> [F]reedom from... want (Preamble) International Covenant on Economic, Social and Cultural Rights (1966b). <i>Preamble, 9, 11.1, 11.2, 12.1, 12.2.d, 13.1</i> [T]he fundamental right of everyone to be free from hunger (Article 11.2) [T]he right of everyone to the enjoyment of the highest attainable standard of physical and mental health (Article 12.1) [C]onditions which would assure to all medical service and medical attention in the event of sickness (Article 12.2.d) Transforming our world: the 2030 Agenda for Sustainable Development (2015; 2017) <i>Sustainable Development Goals #1,2,3,4,5,6,7,8,9,10,12,13,14,15</i>
Maltreatment/freedom from fear	Universal Declaration of Human Rights (1948). <i>Articles 3, 6, 12, 14.1, 17.1, 17.2, 24</i> Everyone has the right to... the security of person (Article 3) Protection from discrimination (Article 6) Everyone has the right to seek and to enjoy in other countries asylum from persecution (Article 14.1) International Covenant on Civil and Political Rights (1966a). <i>Preamble, 6.1, 7, 9.1, 14.3.g, 14.7, 17.1, 20.1, 20.2, 26</i> [F]reedom from fear (Preamble) Every human being has the inherent right to life (Article 6.1) No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment (Article 7) Any propaganda for war shall be prohibited by law (Article 20.1) [I]ncitement to discrimination, hostility or violence shall be prohibited by law. (Article 20.2) [T]he law shall prohibit any discrimination and guarantee to all persons equal and effective protection against discrimination on any ground such as race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status (Article 26) International Covenant on Economic, Social and Cultural Rights (1966b). <i>Preamble</i> [F]reedom from fear (Preamble) Transforming our world: the 2030 Agenda for Sustainable Development (2015; 2017) <i>Sustainable Development Goals #1,2,3,5,10,11,16</i>
Uniqueness	Universal Declaration of Human Rights (1948). <i>Articles 22, 27.2, 29</i> Everyone...is entitled to the realization... of the economic, social and cultural rights indispensable for his dignity and the free development of his personality (Article 22) Everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author (Article 27.2) International Covenant on Economic, Social and Cultural Rights (1966b). <i>Articles 13.1, 13.2.c, 15.1.c</i> [E]ducation shall be directed to the full development of the human personality (Article 13.1) [T]he right of everyone... [t]o benefit from the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author (Article 15.1.c) Transforming our world: the 2030 Agenda for Sustainable Development (2015; 2017) <i>Sustainable Development Goals #1,2,3,4,5,8,10</i>
Unconditionality	Universal Declaration of Human Rights (1948). <i>Articles 1, 2, 6, 15.1, 24.3, 28, 30</i> All human beings are born free and equal in dignity and rights (Article 1) Everyone has the right to a nationality (Article 15.1) Everyone is entitled to a social and international order in which the rights and freedoms set forth in this Declaration can be fully realized (Article 28) International Covenant on Civil and Political Rights (1966a). <i>Preamble, Articles 14, 16, 26, 27</i> [T]hese rights derive from the inherent dignity of the human person (Preamble) [T]he obligation of States under the Charter of the United Nations to promote universal respect for, and observance of, human rights and freedoms (Preamble) All persons are equal before the law and are entitled ... to the equal protection of the law (Article 26) International Covenant on Economic, Social and Cultural Rights (1966b). <i>Articles 2.2, 3</i> [R]ights... will be exercised without discrimination of any kind as to race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status (Article 2.2) [T]he equal right of men and women to the enjoyment of all economic, social and cultural rights (Article 3) Transforming our world: the 2030 Agenda for Sustainable Development (2015; 2017) <i>Sustainable Development Goals #1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17</i>

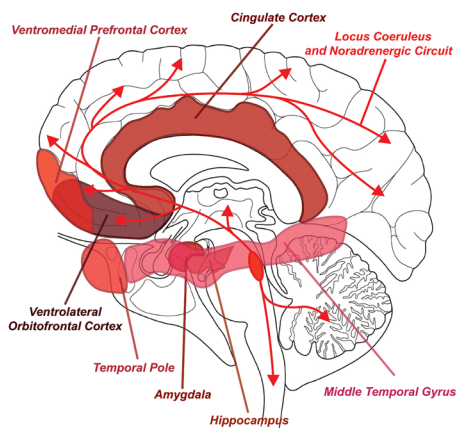
A. AGENCY, AUTONOMY & SELF DETERMINATION



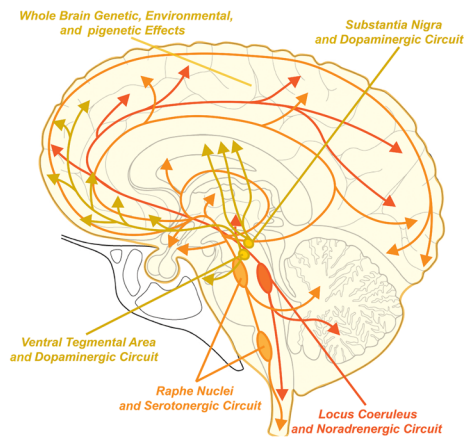
B. PRIVATION



C. MALTREATMENT



D. UNIQUENESS



E. UNCONDITIONALITY

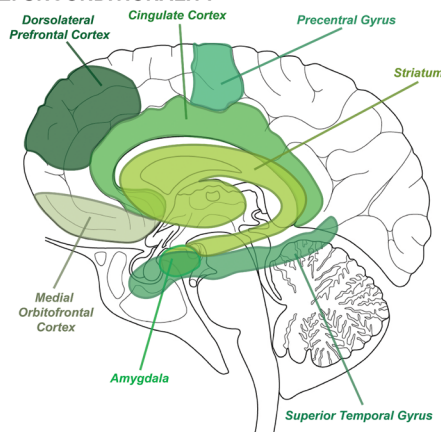


Figure 1. Neural facets of human dignity. Representation of neural structures and circuits that support universal human rights. (A) Human agency, autonomy, and self-determination; (B) deprivation; (C) maltreatment; (D) uniqueness; and (E) unconditionality.

Table 2. Plasticity and protection of vulnerable individuals and populations

Neuroscience concept	International agreements on human rights and sustainable development
Plasticity	<p>Universal Declaration of Human Rights (1948). <i>Articles 16.3, 25.2</i></p> <p>The family is the natural and fundamental group unit of society and is entitled to protection (Article 16.3)</p> <p>Motherhood and childhood are entitled to special care and assistance (Article 25.2)</p> <p>International Covenant on Civil and Political Rights (1966a). <i>Articles 5, 10.3, 14.4, 24.1</i></p> <p>Sentence of death shall not be imposed for crimes committed by persons below eighteen years of age (Article 5)</p> <p>The penitentiary system shall comprise treatment of prisoners the essential aim of which shall be their reformation and social rehabilitation (Article 10.3)</p> <p>Juvenile offenders shall be segregated from adults and be accorded treatment appropriate to their age and legal status (Article 10.3)</p> <p>In the case of juvenile persons, the [court] procedure shall be such as will take account of their age and the desirability of promoting their rehabilitation (Article 14.4)</p> <p>Every child shall have, without any discrimination as to race, colour, sex, language, religion, national or social origin, property or birth, the right to such measures of protection as are required by his status as a minor (Article 24.1)</p> <p>International Covenant on Economic, Social and Cultural Rights (1966b). <i>Articles 10.1-3</i></p> <p>The widest possible protection and assistance should be accorded to the family ... particularly for its establishment and while it is responsible for the care and education of dependent children (Article 10.1)</p> <p>Special protection should be accorded to mothers during a reasonable period before and after childbirth (Article 10.2)</p> <p>Special measures of protection and assistance should be taken on behalf of all children and young persons without any discrimination (Article 10.3)</p> <p>Transforming our world: the 2030 Agenda for Sustainable Development (2015; 2017)</p> <p><i>Sustainable Development Goals #1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16</i></p>

emotion, and leadership. Positive agency also facilitates states of positive affect, vigor, engagement, and enthusiasm.^{11,13,14} Cortical circuits involved in human agency include ascending mesocortical and mesolimbic dopamine pathways originating in the ventral tegmental area of the midbrain. These circuits support internal motivation, positive emotion, and agentic extraversion.¹³ Agency is associated with gray matter volume in the cingulate gyrus, precentral gyrus, caudate, parahippocampal gyrus, medial orbital frontal cortex (mOFC), and nucleus accumbens.¹⁴ These regions contribute to cognitive control, incentive motivation, goal-directed action, learning, memory, and reward.¹³⁻¹⁶ Agency also relates to the levels of brain chemicals, including *N*-acetylated compounds, which provide a marker of neuronal health, and glutamatergic compounds, which mediate excitatory neurotransmission and metabolism.¹¹ This association with agency has been documented in the anterior cingulate cortex (ACC), a network hub that supports behavioral activation, agentic emotion, salience, and attention monitoring.¹¹

Autonomy

The neural basis of autonomy can be accessed by studies of rewards and actions freely selected by an individual. Autonomy has major impact on emotion, choice, and empowerment.¹² The impact of autonomy on learning is informed by experiments using a yoked-control study design in which autonomy (self-control over one's choices) and contingency (one's choices have meaningful consequences) are maintained in one condition, but eliminated in a second condition. In the first condition, termed the *autonomous*, or *contingent*, condition, participants' choices are freely made and determine subsequent events in the experiment. In the second condition, termed the *yoked-control*, or *noncontingent*, condition, events are scripted in advance and are predetermined by the choices of the first group such that the participant's own choices have no effect on subsequent events of the experiment. This second condition thus minimizes autonomy and decouples the contingency of ensuing events from prior actions. These studies reveal that autonomy and contingency are critical for learning a

wide range of human skills ranging from simple motor functions to complex athletic feats,^{17–20} balance abilities,^{21,22} visual discrimination,^{23,24} perceptual learning,²⁵ biofeedback,²⁶ drug abstinence,²⁷ electroencephalographic (EEG) control,²⁸ reading speed,²⁹ time estimation,³⁰ and cognitive decision-making skills.³¹ Autonomy is thus critical for human learning across motor, perceptual, attentional, cognitive, and emotional domains. Evidence indicates autonomy-induced changes in functional connectivity, gene expression, and reward and punishment learning.^{12,26,32} Autonomy also improves learning in people who are neurologically vulnerable. For example, self-directed choice improves task engagement in individuals with traumatic brain injury (TBI)³³ and behavioral learning in individuals with severe mental disabilities.³⁴ Autonomy is thus a major contributor to robust human learning, a foundational property of the human brain.

Self-determination

Self-determination can be studied in experiments where control over aversive stimuli has been revoked (i.e., denial of self-determination). EEG analysis has revealed that such revocation of self-determination induces a large increase in the postimperative negative slow brain potential shift (PINV) of the EEG response in the frontal lobe.³⁵ The PINV indicates a response to uncertainty, which increases when self-determination is revoked.³⁵ Distinct brain circuits are activated in response to yoked or nonyoked stimuli. Aversive stimuli that cannot be controlled by one's own actions increase pain perception, activate pain and uncertainty processing regions, such as the insula, ACC, and thalamus, and increase the connectivity in other pain processing regions, such as the anterior insula and medial prefrontal cortex (PFC).^{26,36} Uncontrollable stimuli also reduce protective connections between regions that reduce pain, such as the dorsolateral PFC and the insula.²⁶ Denial of autonomy thus has a discrete neural signature in humans.

Long-term denial of autonomy results in profoundly adverse brain effects. In addiction and drug dependence, self-determination is hijacked by the supranormal effects of drugs to rewire the neural circuitry supporting agency, emotion, motivation, and volitional behavior. Drug depen-

dence systematically disrupts brain structure, function, and connectivity, with long-lasting and severe effects in the striatum, dopaminergic projections to the cerebral cortex, and dynamic control of dopamine and glutamate levels, responses, and receptor sensitivities.^{37–39} These alterations are the result of the addiction process, and involve complex, temporal changes involved in drug-related learning.³⁷

The neuroscience of privation

Privation is the denial of basic requirements for human life, health, and flourishing. Privation characterizes the global hardships of poverty and discrimination. The neuroscience of privation informs universal rights to freedom from hunger and want (extreme poverty and destitution),⁴⁰ the rights to an adequate living, education, and physical and mental health (Table 1). The neural mechanisms underlying privation are depicted in Figure 1B.

Poverty

Poverty has profound impact on brain structure and function, with major effects on brain regions mediating executive function, learning, emotion, and language.^{41–44} Poverty is associated with reduced cortical surface area in the human inferior and superior frontal cortex, inferior temporal cortex, cingulate, precuneus, and insula, thus inflicting adverse effects on cognition.⁴⁵ Poverty is associated with reduced volume of the amygdala, medial prefrontal cortex, anterior cingulate, and hippocampus, resulting in degradation of learning, memory, and the regulation and processing of emotion.^{43,46,47} Functional effects of poverty are often qualitative, particularly in children, as poverty reduces the ability to filter out irrelevant sounds and activates differential networks during cognition.^{48–51}

Discrimination

Discrimination inflicts similar damage to poverty. The everyday experience of discrimination is associated with higher spontaneous activity in the amygdala and increased connectivity between the amygdala and other brain regions (e.g., the thalamus, anterior cingulate, putamen, anterior insula, caudate, and medial frontal gyrus).⁵² Discrimination against one's ethnic group is associated with greater activation of the perigenual ACC, ventral striatum, and stronger anterior cingulate connectivity to stress.⁵³ Poverty and discrimination are

experienced jointly at the intersection of multiple disparities, including gender, race, disability, and orientation, inflicting compound insults to the brain (Fig. 1B).

The neuroscience of maltreatment

Violence inflicted by childhood maltreatment, intimate partners, and exposure to war has profound effects on the brain. The neuroscience findings discussed below inform the universal rights to freedom from fear and cruel, inhuman, and degrading treatment as well as rights to life, liberty, and security of person. They also inform protections for those most at-risk for maltreatment, such as women, children, vulnerable populations, and victims of intolerance (Table 1 and Fig. 1C).

Childhood maltreatment

Violence experienced in childhood has direct adverse impact on brain structure and function with often life-long impacts. Childhood maltreatment results in long-term alterations in PFC and amygdala connectivity, white matter integrity, and gray matter volume.^{54–56} Children who experience physical and/or sexual abuse have reduced cortical thickness in the ventromedial PFC, ventrolateral orbitofrontal cortex, temporal pole, and bilateral parahippocampal gyrus.⁵⁷ Structural alterations in these regions during childhood are associated with deficits in impulse control and affective processing as adults.^{55,57} Maltreatment also alters function in brain regions responsible for emotional processing.^{58–60} These effects are long-lasting, with childhood physical, sexual, and emotional abuse associated with prolonged neurobiological abnormalities and neuropsychiatric conditions throughout life.^{54,61}

Intimate partner violence

Intimate partner violence (IPV) is physical, sexual, and/or psychological violence inflicted by a current or former partner.⁶² IPV induces alterations in brain connectivity in networks involved in cognitive and emotional control. Substantial adverse effects are seen in specific brain regions mediating emotion processing, planning, attentional control, learning, and memory, such as the caudal ACC, amygdala, and middle temporal gyrus.^{63,64} IPV has high comorbidity with post-traumatic stress disorder (PTSD), concussion, and TBI,⁶⁵ which have adverse impact on regional volumes, surface area,

and cortical thickness.⁶⁶ Violence experienced at the hands of a “loved one” thus has direct, adverse impact on neural structure and function.

Exposure to war

Adverse brain effects are found in individuals exposed to war as observers, victims, or combatants. For example, combat veterans with and without PTSD show hyperactivation in noradrenergic circuits.⁶⁷ These findings indicate combat-related trauma in brain systems involved in stress, attention, negative emotion, and physical danger.⁶⁸ A large number of combat troops serving in the Iraq and Afghanistan conflicts experienced “signature injury” of blast-related concussion and mild traumatic brain injury.^{69,70} This brain injury causes impairments in cognition and emotional regulation, physical damage to white matter, and hyperactivity in networks for working memory. These impairments persist for years after war exposure.^{70–72} These data demonstrate a lasting, insidious neurological effect of combat. Individuals unwittingly or unwillingly exposed to war are similarly affected. War increases methylation of the gene for brain-derived neurotrophic factor (BDNF), an important neural growth factor, in the placenta in pregnant women in combat zones.⁷³ BDNF gene methylation also correlates with mothers’ war-related stress and thus has the potential to affect brain development across generations.⁷³

The neuroscience of uniqueness

Brain individuation is shaped by several potent factors. These findings support universal rights to economic, social, and cultural engagement, and the free and full development of each human being’s unique personality and capacities (Table 1 and Fig. 1D).

Each human has a unique genetic and epigenetic landscape. The odds that any person is born with a given combination of genes is estimated to be ~ 1 in $10^{11,847}$, an infinitesimally small number.⁷⁴ The uniqueness of this genetic endowment is then amplified over time by: (1) “noisy” processes of human neural development; (2) environmental factors that work primarily through unique rather than fixed or “shared” experiences; (3) acquired neuronal mosaicism; and (4) modularization of gene expression within the human brain.

Noisy neural development

Human brain cells follow messy rather than fixed paths of development.⁷⁵ Noisy processes are those for which “the precise state or value is unpredictable,” in contrast to deterministic processes, for which “any future state ... is precisely predictable ... [and] always produces the same outcome.”⁷⁵ Synaptic wiring occurs through noisy processes, such as stochastic filopodial growth and splicing of cell adhesion molecules, which foster elaboration of dendritic trees.^{75–78} Growth of dendrites and axons occurs through autonomous responses to the local environment that are independent of conditions elsewhere in the brain or even a given neuron.⁷⁵ Directionality of growth is similarly local, autonomous, and stochastic, with a propensity toward the “leading edge” of growth factor gradients producing variability in the final direction of neural growth.^{75,76} The code for human brain development is thus not deterministic; rather, to adapt a phrase from popular film, “the code is more what you’d call ‘guidelines’ than actual rules.”⁷⁹ The result is a unique wiring of neurons and networks within the brain of each human being.

Nonshared input

Environmental input works predominantly through unique, nonshared experiences in humans, with lesser input from fixed or shared factors once the basic requirements of nutrition, education, and safety have been met.^{80,81} Shared environment is defined as within-family experiences for which siblings are correlated, leading to similarities between children over time. Nonshared environment, in contrast, is defined as experiences that are not correlated between siblings, leading to differences between children over time.⁸² Prime evidence comes from studies of personality and emotion in identical twins, where nonshared factors explain 45–55% of the variance, while shared environment contributes 10–15% of the variance in emotion.^{80,83} This input affects multiple systems, including dopamine, which contributes to agentic extraversion; serotonin, which contributes to behavioral control; norepinephrine, which contributes to negative affective traits; GABA, which contributes to behavioral impulsivity; and acetylcholine, which contributes to emotional learning.^{13,68,84–89} The same environment thus makes individuals more, rather than less, different from each other over

time.⁸² Nonshared input ensures robust variation in the population and phenotypic differences between people from the same family.

Acquired mosaicism

Multiple developmental processes encourage additional genetic differentiation within the brain after birth. Somatic genetic and epigenetic changes occur throughout life via mechanisms, such as mutations and copy-number variation, DNA methylation, and histone acetylation, which collectively result in individually unique cell lineages even in monozygotic (MZ) twins who are genetically identical at conception.^{75,90,91} These changes thus produce increasingly divergent genetic profiles for neurons over time.⁹¹ Transposable element mobilization and retrotransposon LINE-1 activity create further genetic diversity in neurons.^{75,92,93} As such, “identical genes do not encode identical processes or outcomes during neural development.”⁷⁵

Modular gene expression

Differences in gene expression within the human brain are strikingly modular, with nearest-neighbor similarities, functional similarities, and posterior to anterior gradients in human cortex.^{94–101} Gene expression also varies over time, with specific genes overexpressed and underexpressed at different time periods in diverse brain regions.^{94,97} These spatial and temporal differences in gene expression within and across neurons map onto differences in regional function and connectivity.^{95,98,99,101} Non-coding genes, which serve a regulatory function in the brain, are also modular and time-dependent.¹⁰² As a result, heritable effects on the size and thickness of human cortex affect large, modular swaths of human cortex.¹⁰³ Nonshared environmental effects on gene expression in neurons, such as methylation, further shape the phenotypic development of individual brains.¹⁰⁴ Brain development thus has emergent properties that involve multiple processes of individuation: initial genetics, acquired changes, noisy neural development, and unique experiences. These processes affect different genes at different times to uniquely and emergently shape the structure and function of each human brain.

Multiple factors thus amplify and facilitate uniqueness within the brain. This diversification yields differences in brain anatomy that are distinguishable to the naked eye, even in MZ twins who are otherwise identical.^{75,105} The

neurobiological uniqueness of each brain is thus augmented, not reduced, by normal processes of neural development.¹⁰⁶

The neuroscience of unconditionality

Unconditionality comprises the foundation of attachment and human bonding. Unconditionality is relevant to universal rights to freedom, dignity, equality under the law, and the right to a nationality¹ (Table 1). These rights are particularly germane for migrants, refugees, individuals seeking asylum, and stateless individuals.^{107,108} Associated neural mechanisms are given in Figure 1E.

Affiliative bonding

Human development, psychology, and developmental neuroscience illuminate the profound role of unconditionality in human brain development. Secure attachment, which is learned in childhood based on interactions with available caregivers, plays an essential role in the ability to navigate threat and stress. Secure attachment requires unconditional, reliable caregiver responses and fosters a wide range of positive emotional and cognitive outcomes.¹⁰⁹ Secure attachment facilitates the activation of networks that support goal-directed approach behavior, reduction of networks involved in behavioral avoidance, and the rapid recovery of physiological homeostasis after exposure to stressful events.¹¹⁰ Securely attached children show greater activation in the striatum, dorsolateral prefrontal cortex, amygdala, and cingulate cortex, which are regions involved in reward processing, motivation, and approach.¹¹¹ Unconditionality also affects structure, with secure attachment at 15 months of age predicting gray matter volume in multiple brain regions at 10 years of age.¹¹² Regions include the superior temporal sulcus and gyrus, temporoparietal junction, and precentral gyrus, which shape social, emotional, and cognitive function.¹¹² Moreover, unconditionality is the foundation for human bonding across the lifespan,¹⁰⁹ and permits and sparks curiosity, autonomy, exploration, and context-sensitivity. Recent findings indicate a foundational role in white matter integrity and brain connectivity.^{110,113} The warmth of relationships, facilitated by secure attachment, relates to gray matter volume in the mOFC, and endogenous opiate processes in frontal, striatal, and

limbic regions,¹¹⁴ which shape reward learning.¹⁴ Unconditionality thus provides an invisible underpinning for brain structure and function that supports well-being and relationships across the lifespan.¹¹⁵

Additional protections relate to human brain plasticity

Responsibilities to vulnerable populations are also informed by the neuroscience of brain plasticity. Additional protections are unequivocally outlined in multiple treaties and covenants (Table 2) and systematically address the distinctive needs and rights of children and adolescents, for whom development is still ongoing; and imprisoned individuals, for whom reformation rather than retribution is consistent with brain plasticity in adulthood.

The human brain remains robustly plastic long after development. At the molecular level, homeostatic processes are constantly activated to maintain and refresh the stores of biochemical compounds mediating neural transmission and tissue maintenance.^{116,117} At the cellular level, ensembles of connected neurons form the basis for learning and memory, modification of these ensembles allows for learning, and activation of prior ensembles allows for retrieval of past learning.¹¹⁸ An underlying, continuous process of brain plasticity (termed *basal dynamics*) actively remodels synaptic connections within ensembles, enabling the stability of learning and memory over time.¹¹⁹

Adult neurogenesis is prominent in the human hippocampus and striatum, regions which shape learning, emotion, motivation, and goal-directed behavior.¹²⁰ New neurons are born in the subgranular zone of the hippocampus and the subventricular zone lining the wall of the lateral ventricle. In humans, the subventricular zone supplies the striatum with new neurons throughout life.^{121–123} Adult neurogenesis contributes a significant proportion of neurons in these regions of the brain. Atmospheric nuclear-bomb-test-derived C¹⁴ dating models that trace human adult neurogenesis estimate that the vast majority of hippocampal dentate gyrus neurons are subject to turnover in humans, with a turnover rate of ~1.75% per year and modest age-related decline, compared with ~10% of neurons and major age-related decline in other species.^{121,123,124} Interneurons in the striatum are subject to continuous turnover in humans, with a rate of ~2.7%

per year in adulthood.^{121,123,124} Notably, such adult-born neurons are not observed in Huntington disease patients.¹²³ Adult neurogenesis thus has major impact on regions of the brain involved in human learning, emotion, motivation, and action. Neural plasticity is also essential for recovery of function in adults after brain disorder.^{125–127} Specific biochemical compounds found in neurons, such as *N*-acetylaspartate (NAA), may serve as useful biomarkers of these neurogenesis-related processes (see Refs. 11, 128, and 129). For example, cortical NAA predicts agency and the capacity for immersive emotion in young adults.¹¹ The level of NAA in gray matter displays a developmental trajectory strikingly similar to that of new neurons generated by adult neurogenesis (see Refs. 11, 121, and 130). Moreover, there is considerable interindividual variation in adult neurogenesis in humans,¹²⁴ indicating an additional role of neurogenesis in the individuation of the brain over time.

Dignity neuroscience

The novel framework we present here supports the grounding of human rights in intrinsic human dignity. Data from human neuroscience support and motivate human rights education, protection, and awareness efforts, rights-based approaches to international development, and broader inclusivity of human rights protections. Together, this framework constitutes a new area of multidisciplinary science to address universal rights. The relevant work is inherently multidisciplinary, but the underlying scholarship is currently separated into silos within and across the biological and social sciences, medicine, public health, public policy, humanities, international development, and legal theory and practice. This new field—which we here term *dignity neuroscience* or, more generally, *dignity science*—provides a natural venue through which lay people, researchers, and scholars can coordinate efforts and expertise to further the original aims and goals of the 1948 Universal Declaration of Human Rights.¹ Dignity science can integrate across biopsychosocial phenomena to develop social, interpersonal, and psychological interventions that support human rights. Dignity science may also be a forum through which to explore nonbrain-based rights and supraindividual rights, which may emerge from traditions other than neuroscience. This field stands

to have significant impact, as many human rights goals remain unmet.

Relationship of dignity neuroscience with cultural, religious, and philosophical traditions

Dignity neuroscience bolsters and extends the concept of intrinsic human dignity, an idea distilled from longstanding cultural, religious, and philosophical traditions. Fundamental, species-typical features of the human nervous system undergird universal rights already articulated in existing agreements,^{1–5} providing insight as to why so many people around the world believe in and act upon the concept of human dignity.^{1–5} The present neuroscience domains encompass western and eastern concepts, Indigenous perspectives, and perspectives from the global south, spanning universal human needs for autonomy, competence, and belonging, which demonstrate cross-cultural validity.¹³¹ As such, dignity neuroscience may provide common ground to connect diverse cultural approaches to human rights.

Human brain science undergirds both our interrelationships and uniqueness, underscoring our intrinsic human dignity in tandem with our social embeddedness in the surrounding community. This view provides new opportunities to create meaning, belonging, connection, and to form and maintain ethical communities. These attributes in turn provide an important backstop for human rights protections.⁸

Universalism and relativism are cross-disciplinary topics for future inquiry in dignity science. The debate over universalism and relativism has been wide ranging and has included contestation over the conceptualization of these categories.^{132–135} Fundamental questions of anthropologists and Indigenous communities regarding “whose rights” and “whose ‘universals’” are critical and predate the 1948 Universal Declaration.¹ Moreover, for many Indigenous people, all humans are part of the moral circle and are thus considered moral subjects, a category also shared by nonhuman animals, plants, earth, and water.^{136–141} In this view, people are regarded as having social relationships and reciprocity with nonhumans, with the scope of ethics and rights extending beyond individual persons.^{136,138–141} Thus, the idea that having a human brain is what makes someone a

moral subject may itself be controversial, providing a starting point for larger discussion of the conceptualization, scope, and content of rights across cultures and in respect to environmental health. This issue not only concerns treatment of animals and the environment,^{142,143} but the very category of the human, with vulnerable and exploited persons long excluded from that category in past history, facilitating systematic dehumanization and abuse (e.g., women, Jewish people, enslaved individuals of color, and communities from marginalized backgrounds, see Refs. 144–146). These issues provide opportunities for dignity science going forward, with an eye toward multidisciplinary collaboration, intersectional approaches, and solutions that respect diversity within and across cultures.

Conclusions and recommendations

We conclude that universal rights have robust expression in the human brain. Agency, autonomy, self-determination, freedom from want, and freedom from fear are essential for human brain health. Moreover, each human being enters the world fundamentally unique. This uniqueness is systematically amplified by noisy processes of neural development, nonshared environmental input, acquired neuronal mosaicism, and modularization of gene expression within the brain. This uniqueness continues to evolve in adulthood through ongoing processes of brain plasticity, basal dynamics, and adult neurogenesis. Universal rights are thus based on fundamental features of human brain structure, function, and development. A broad neuroscience-based framework for universal human rights provides a new infrastructure to advance human rights locally, nationally, and internationally. This novel evidentiary base, here termed dignity neuroscience, may forward human rights efforts by individuals, communities, and nations, allowing hearts and minds to be changed in the open space that lies between international treaties and human rights law.

Acknowledgments

T.L.W. conceived the ideas, prepared Tables 1 and 2, and wrote the original draft of the manuscript. T.L.W. and M.A.G. prepared Figure 1 and edited and revised the manuscript. Both authors read and approved the final manuscript. Figure 1 used the

sagittal template “brain_hypothalamus-28Sep17” created by Gill Brown and the Centre for Neuroimaging Sciences at King’s College London (www.neuroscience-graphicdesign.com). We are grateful for discussion and input from A. Harris, University of Calgary; C. Beard, Harvard University; and M. McQuillan, O. McKissick, R. Meir, V. Luckenbaugh, K. Kaun, C. Zimmerman, D. Hoffman-Kim, T. Nummedal, T. Lewis, and J. Fallon of Brown University, and the positive, constructive input of two anonymous reviewers. Finally, we thank the staff and speakers at the 2018 British Academy Conference “Working Together: Human Rights, the Sustainable Development Goals and Gender Equality,” which motivated this work.

Funding

This research was supported by the British Academy International Visiting Fellowship (BA #VF1-102524; T.L.W.); the Clare Hall International Visiting Fellowship, University of Cambridge, England, U.K. (T.L.W.); the Brown University Neuroscience Graduate Program (M.A.G.); and the Zimmerman Fund for Scientific Innovation Awards in Brain Science, the Robert J. and Nancy D. Carney Institute for Brain Science (T.L.W.).

Competing interests

The authors declare no competing interests.

References

1. United Nations. 1948. Universal Declaration of Human Rights, Resolution adopted by the General Assembly on 10 December 1948, A/RES/217(III)A-E. Accessed October 16, 2020. [https://undocs.org/en/A/RES/217\(III\)](https://undocs.org/en/A/RES/217(III)).
2. United Nations. 1966a. International Covenant on Civil and Political Rights, Resolution adopted by the General Assembly on 16 December 1966, United Nations, Treaty Series. Accessed October 16, 2020. <https://www.refworld.org/docid/3ae6b3aa0.html>.
3. United Nations. 1966b. International Covenant on Economic, Social and Cultural Rights, Resolution adopted by the General Assembly on 16 December 1966, United Nations, Treaty Series. Accessed October 24, 2020. <https://www.refworld.org/docid/3ae6b36c0.html>.
4. United Nations. 2015. Transforming our world: the 2030 Agenda for Sustainable Development, Resolution adopted by the General Assembly on 21 October 2015, A/RES/70/1. Accessed October 16, 2020. <https://undocs.org/en/A/RES/70/1>.
5. United Nations. 2017. Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development, Resolution adopted by the General Assembly on 6

- July 2017, A/RES/71/313. Accessed December 22, 2020. <https://undocs.org/en/A/RES/71/313>.
6. Shelton, D.L. 2007. *An Introduction to the History of International Human Rights Law*. GW Law Faculty Publications & Other Works.
 7. Mende, J. 2019. Are human rights western—and why does it matter? A perspective from international political theory. *J. Int. Polit. Theory* **17**: 1–20.
 8. Brown, C. 1997. Universal human rights: a critique. *Int. J. Hum. Rights* **1**: 41–65.
 9. Sulmasy, D.P. 2013. The varieties of human dignity: a logical and conceptual analysis. *Med. Health Care Philos.* **16**: 937–944.
 10. Ibhawoh, B. 2014. Human rights for some: universal human rights, sexual minorities, and the exclusionary impulse. *Int. J.* **69**: 612–622.
 11. White, T.L., M.A. Gonsalves, R.A. Cohen, et al. 2021. The neurobiology of wellness: (1)H-MRS correlates of agency, flexibility and neuroaffective reserves in healthy young adults. *Neuroimage* **225**: 117509.
 12. Di Domenico, S.I. & R.M. Ryan. 2017. The emerging neuroscience of intrinsic motivation: a new frontier in self-determination research. *Front. Hum. Neurosci.* **11**: 145.
 13. Depue, R.A. & P.F. Collins. 1999. Neurobiology of the structure of personality: dopamine, facilitation of incentive motivation, and extraversion. *Behav. Brain Sci.* **22**: 491–517; discussion 518–469.
 14. Grodin, E.N. & T.L. White. 2015. The neuroanatomical delineation of agentic and affiliative extraversion. *Cogn. Affect. Behav. Neurosci.* **15**: 321–334.
 15. Rosch, K.S. & S. Mostofsky. 2019. Development of the frontal lobe. *Handb. Clin. Neurol.* **163**: 351–367.
 16. Kim, B. & H.I. Im. 2019. The role of the dorsal striatum in choice impulsivity. *Ann. N.Y. Acad. Sci.* **1451**: 92–111.
 17. Janelle, C.M., D.A. Barba, S.G. Frehlich, et al. 1997. Maximizing performance feedback effectiveness through videotape replay and a self-controlled learning environment. *Res. Q. Exerc. Sport* **68**: 269–279.
 18. Janelle, C.M., J. Kim & R.N. Singer. 1995. Subject-controlled performance feedback and learning of a closed motor skill. *Percept. Mot. Skills* **81**: 627–634.
 19. Iwatsuki, T., R. Abdollahipour, R. Psotta, et al. 2017. Autonomy facilitates repeated maximum force productions. *Hum. Mov. Sci.* **55**: 264–268.
 20. Wulf, G. & R. Lewthwaite. 2016. Optimizing performance through intrinsic motivation and attention for learning: the OPTIMAL theory of motor learning. *Psychon. Bull. Rev.* **23**: 1382–1414.
 21. Wulf, G. & N. Adams. 2014. Small choices can enhance balance learning. *Hum. Mov. Sci.* **38**: 235–240.
 22. Dong, X., K. Yoshida & T.A. Stoffregen. 2011. Control of a virtual vehicle influences postural activity and motion sickness. *J. Exp. Psychol. Appl.* **17**: 128–138.
 23. Madelain, L. & R.J. Krauzlis. 2003. Effects of learning on smooth pursuit during transient disappearance of a visual target. *J. Neurophysiol.* **90**: 972–982.
 24. Paeye, C. & L. Madelain. 2011. Reinforcing saccadic amplitude variability. *J. Exp. Anal. Behav.* **95**: 149–162.
 25. Brosvic, G.M., M.M. Rowe-Boyer & R.E. Dihoff. 1991. Acquisition and retention of perceptual learning and the horizontal-vertical illusion. *Percept. Mot. Skills* **72**: 587–592.
 26. Brascher, A.K., S. Becker, M.E. Hoeppli, et al. 2016. Different brain circuitries mediating controllable and uncontrollable pain. *J. Neurosci.* **36**: 5013–5025.
 27. Stoops, W.W., J. Dallery, N.M. Fields, et al. 2009. An internet-based abstinence reinforcement smoking cessation intervention in rural smokers. *Drug Alcohol Depend.* **105**: 56–62.
 28. Sommer, W. & S. Schweinberger. 1992. Operant conditioning of P300. *Biol. Psychol.* **33**: 37–49.
 29. Faubert, J. & O. Overbury. 1987. Active-passive paradigm in assessing CCTV-aided reading. *Am. J. Optom. Physiol. Opt.* **64**: 23–28.
 30. van der Veen, F.M., M.W. van der Molen, E.A. Crone, et al. 2004. Phasic heart rate responses to performance feedback in a time production task: effects of information versus valence. *Biol. Psychol.* **65**: 147–161.
 31. Memmert, D. 2006. Self-controlled practice of decision-making skills. *Percept. Mot. Skills* **103**: 879–882.
 32. Jacobs, E.H., A.B. Smit, T.J. de Vries, et al. 2005. Long-term gene expression in the nucleus accumbens following heroin administration is subregion-specific and depends on the nature of drug administration. *Addict. Biol.* **10**: 91–100.
 33. Tasky, K.K., E.H. Rudrud, K.A. Schulze, et al. 2008. Using choice to increase on-task behavior in individuals with traumatic brain injury. *J. Appl. Behav. Anal.* **41**: 261–265.
 34. Hekkema, N. & P.E. Freedman. 1978. Effects of imitation training on immediate and delayed imitation by severely retarded children. *Am. J. Ment. Defic.* **83**: 129–134.
 35. Elbert, T., B. Rockstroh, W. Lutzenberger, et al. 1982. Slow brain potentials after withdrawal of control. *Arch. Psychiatr. Nervenkr. (1970)* **232**: 201–214.
 36. Yamanaka, K., Y. Hori, T. Minamimoto, et al. 2018. Roles of centromedian parafascicular nuclei of thalamus and cholinergic interneurons in the dorsal striatum in associative learning of environmental events. *J. Neural Transm. (Vienna)* **125**: 501–513.
 37. Volkow, N.D., J.S. Fowler, G.J. Wang, et al. 2007. Dopamine in drug abuse and addiction: results of imaging studies and treatment implications. *Arch. Neurol.* **64**: 1575–1579.
 38. White, T.L. 2011. Imaging substance use and misuse: psychostimulants. In *Brain Imaging in Behavioral Medicine and Clinical Neuroscience*. R.A. Cohen & L.H. Sweet, Ed.: 163–177. New York: Springer Science + Business Media.
 39. Ersche, K.D., T.V. Lim, A.G. Murley, et al. 2021. Reduced glutamate turnover in the putamen is linked with automatic habits in human cocaine addiction. *Biol. Psychiatry.* **89**: 970–979.
 40. Roosevelt, F.D. 1941. Four Freedoms speech. Annual Message to Congress on the State of the Union. Washington, DC.
 41. Farah, M.J. 2018. Socioeconomic status and the brain: prospects for neuroscience-informed policy. *Nat. Rev. Neurosci.* **19**: 428–438.
 42. Hackman, D.A. & M.J. Farah. 2009. Socioeconomic status and the developing brain. *Trends Cogn. Sci.* **13**: 65–73.

43. Johnson, S.B., J.L. Riis & K.G. Noble. 2016. State of the art review: poverty and the developing brain. *Pediatrics* **137**: e20153075.
44. Farah, M.J. 2017. The neuroscience of socioeconomic status: correlates, causes, and consequences. *Neuron* **96**: 56–71.
45. Noble, K.G., S.M. Houston, N.H. Brito, *et al.* 2015. Family income, parental education and brain structure in children and adolescents. *Nat. Neurosci.* **18**: 773–778.
46. Merz, E.C., N. Tottenham & K.G. Noble. 2018. Socioeconomic status, amygdala volume, and internalizing symptoms in children and adolescents. *J. Clin. Child. Adolesc. Psychol.* **47**: 312–323.
47. Yang, J., H. Liu, D. Wei, *et al.* 2016. Regional gray matter volume mediates the relationship between family socioeconomic status and depression-related trait in a young healthy sample. *Cogn. Affect. Behav. Neurosci.* **16**: 51–62.
48. D'Angiulli, A., A. Herdman, D. Stapells, *et al.* 2008. Children's event-related potentials of auditory selective attention vary with their socioeconomic status. *Neuropsychology* **22**: 293–300.
49. D'Angiulli, A., P.M. Van Roon, J. Weinberg, *et al.* 2012. Frontal EEG/ERP correlates of attentional processes, cortisol and motivational states in adolescents from lower and higher socioeconomic status. *Front. Hum. Neurosci.* **6**: 306.
50. Stevens, C., B. Lauinger & H. Neville. 2009. Differences in the neural mechanisms of selective attention in children from different socioeconomic backgrounds: an event-related brain potential study. *Dev. Sci.* **12**: 634–646.
51. Demir, O.E., J. Prado & J.R. Booth. 2015. Parental socioeconomic status and the neural basis of arithmetic: differential relations to verbal and visuo-spatial representations. *Dev. Sci.* **18**: 799–814.
52. Clark, U.S., E.R. Miller & R.R. Hegde. 2018. Experiences of discrimination are associated with greater resting amygdala activity and functional connectivity. *Biol. Psychiatry Cogn. Neurosci. Neuroimaging* **3**: 367–378.
53. Akdeniz, C., H. Tost, F. Streit, *et al.* 2014. Neuroimaging evidence for a role of neural social stress processing in ethnic minority-associated environmental risk. *JAMA Psychiatry* **71**: 672–680.
54. Teicher, M.H., J.A. Samson, C.M. Anderson, *et al.* 2016. The effects of childhood maltreatment on brain structure, function and connectivity. *Nat. Rev. Neurosci.* **17**: 652–666.
55. Lim, L., J. Radua & K. Rubia. 2014. Gray matter abnormalities in childhood maltreatment: a voxel-wise meta-analysis. *Am. J. Psychiatry* **171**: 854–863.
56. Herringa, R.J., R.M. Birn, P.L. Ruttle, *et al.* 2013. Childhood maltreatment is associated with altered fear circuitry and increased internalizing symptoms by late adolescence. *Proc. Natl. Acad. Sci. USA* **110**: 19119–19124.
57. Gold, A.L., M.A. Sheridan, M. Peverill, *et al.* 2016. Childhood abuse and reduced cortical thickness in brain regions involved in emotional processing. *J. Child Psychol. Psychiatry* **57**: 1154–1164.
58. Taylor, S.E., N.I. Eisenberger, D. Saxbe, *et al.* 2006. Neural responses to emotional stimuli are associated with childhood family stress. *Biol. Psychiatry* **60**: 296–301.
59. McCrory, E.J., S.A. De Brito, P.A. Kelly, *et al.* 2018. Amygdala activation in maltreated children during pre-attentive emotional processing. *Br. J. Psychiatry* **202**: 269–276.
60. De Bellis, M.D. & S.R. Hooper. 2012. Neural substrates for processing task-irrelevant emotional distracters in maltreated adolescents with depressive disorders: a pilot study. *J. Trauma Stress* **25**: 198–202.
61. Andersen, S.L., A. Tomada, E.S. Vincow, *et al.* 2008. Preliminary evidence for sensitive periods in the effect of childhood sexual abuse on regional brain development. *J. Neuropsychiatry Clin. Neurosci.* **20**: 292–301.
62. Miller, E. & B. McCaw. 2019. Intimate partner violence. *N. Engl. J. Med.* **380**: 850–857.
63. Roos, A., J.P. Fouché & D.J. Stein. 2017. Brain network connectivity in women exposed to intimate partner violence: a graph theory analysis study. *Brain Imaging Behav.* **11**: 1629–1639.
64. Mao, C.V., M.F. Araujo, H. Nishimaru, *et al.* 2017. Pregenual anterior cingulate gyrus involvement in spontaneous social interactions in primates—evidence from behavioral, pharmacological, neuropsychiatric, and neurophysiological findings. *Front. Neurosci.* **11**: 34.
65. Wong, J.Y., D.Y. Fong, V. Lai, *et al.* 2014. Bridging intimate partner violence and the human brain: a literature review. *Trauma Violence Abuse* **15**: 22–33.
66. Daugherty, J.C., J. Verdejo-Román, M. Pérez-García, *et al.* 2020. Structural brain alterations in female survivors of intimate partner violence. *J. Interpers. Violence* <https://doi.org/10.1177/0886260520959621>
67. Misaki, M., R. Phillips, V. Zotev, *et al.* 2018. Connectome-wide investigation of altered resting-state functional connectivity in war veterans with and without posttraumatic stress disorder. *Neuroimage Clin.* **17**: 285–296.
68. White, T.L. & R.A. Depue. 1999. Differential association of traits of fear and anxiety with norepinephrine- and dark-induced pupil reactivity. *J. Pers. Soc. Psychol.* **77**: 863–877.
69. Terrio, H., L.A. Brenner, B.J. Ivins, *et al.* 2009. Traumatic brain injury screening: preliminary findings in a US Army Brigade Combat Team. *J. Head Trauma Rehabil.* **24**: 14–23.
70. Cogan, A. 2016. White matter abnormalities in blast mild traumatic brain injury in the military. *J. Occup. Sci.* **23**: 339–351.
71. Pagulayan, K.F., E.C. Petrie, D.G. Cook, *et al.* 2020. Effect of blast-related mTBI on the working memory system: a resting state fMRI study. *Brain Imaging Behav.* **14**: 949–960.
72. Vasterling, J.J., M. Verfaellie & K.D. Sullivan. 2009. Mild traumatic brain injury and posttraumatic stress disorder in returning veterans: perspectives from cognitive neuroscience. *Clin. Psychol. Rev.* **29**: 674–684.
73. Kertes, D.A., S.S. Bhatt, H.S. Kamin, *et al.* 2017. BDNF methylation in mothers and newborns is associated with maternal exposure to war trauma. *Clin. Epigenet.* **9**: 68.
74. [jacobstx]. 2017. How many genetically unique babies can a human couple produce?. In *r/theydidthemath*. [Online forum post]. Accessed November 19, 2020. https://www.reddit.com/r/theydidthemath/comments/5f5ibe/request_how_many_genetically_unique_babies_can_a/.

75. Hiesinger, P.R. & B.A. Hassan. 2018. The evolution of variability and robustness in neural development. *Trends Neurosci.* **41**: 577–586.
76. Hassan, B.A. & P.R. Hiesinger. 2015. Beyond molecular codes: simple rules to wire complex brains. *Cell* **163**: 285–291.
77. Kise, Y. & D. Schmucker. 2013. Role of self-avoidance in neuronal wiring. *Curr. Opin. Neurobiol.* **23**: 983–989.
78. Zipursky, S.L. & W.B. Grueber. 2013. The molecular basis of self-avoidance. *Annu. Rev. Neurosci.* **36**: 547–568.
79. Verbinski, G. 2003. *Pirates of the Caribbean: The Curse of the Black Pearl*. Walt Disney Pictures.
80. Tellegen, A., D.T. Lykken, T.J. Bouchard, Jr., et al. 1988. Personality similarity in twins reared apart and together. *J. Pers. Soc. Psychol.* **54**: 1031–1039.
81. Hetherington, E.M., D. Reiss & R. Plomin. 1994. *Separate Social Worlds of Siblings: the Impact of Nonshared Environment on Development*. Hillsdale, NJ: L. Erlbaum.
82. Plomin, R. & D. Daniels. 1987. Why are children in the same family so different from one another? *Behav. Brain Sci.* **10**: 1–16.
83. Goldsmith, H.H. 1983. Genetic influences on personality from infancy to adulthood. *Child Dev.* **54**: 331–355.
84. Coccaro, E.F., J.R. Fanning, K.L. Phan, et al. 2015. Serotonin and impulsive aggression. *CNS Spectr.* **20**: 295–302.
85. Ende, G. 2015. Proton magnetic resonance spectroscopy: relevance of glutamate and GABA to neuropsychology. *Neuropsychol. Rev.* **25**: 315–325.
86. Likhtik, E. & J.P. Johansen. 2019. Neuromodulation in circuits of aversive emotional learning. *Nat. Neurosci.* **22**: 1586–1597.
87. Boy, F., C.J. Evans, R.A. Edden, et al. 2011. Dorsolateral prefrontal gamma-aminobutyric acid in men predicts individual differences in rash impulsivity. *Biol. Psychiatry* **70**: 866–872.
88. Depue, R.A. & T.L. White. 2015. Personality: neurobehavioral foundation and pharmacological protocols. In *Encyclopedia of Psychopharmacology*. I.P. Stolerman & L.H. Price, Eds.: 1258–1266. Heidelberg: Springer.
89. White, T.L. 2017. Beyond sensation seeking: a conceptual framework for individual differences in psychostimulant drug effects in healthy humans. *Curr. Opin. Behav. Sci.* **13**: 63–70.
90. Bruder, C.E., A. Piotrowski, A.A. Gijbbers, et al. 2008. Phenotypically concordant and discordant monozygotic twins display different DNA copy-number-variation profiles. *Am. J. Hum. Genet.* **82**: 763–771.
91. Fraga, M.F., E. Ballestar, M.F. Paz, et al. 2005. Epigenetic differences arise during the lifetime of monozygotic twins. *Proc. Natl. Acad. Sci. USA* **102**: 10604–10609.
92. Faulkner, G.J. & J.L. Garcia-Perez. 2017. L1 mosaicism in mammals: extent, effects, and evolution. *Trends Genet.* **33**: 802–816.
93. Lapp, H.E. & R.G. Hunter. 2016. The dynamic genome: transposons and environmental adaptation in the nervous system. *Epigenomics* **8**: 237–249.
94. Nowakowski, T.J., A. Bhaduri, A.A. Pollen, et al. 2017. Spatiotemporal gene expression trajectories reveal developmental hierarchies of the human cortex. *Science* **358**: 1318–1323.
95. Negi, S.K. & C. Guda. 2017. Global gene expression profiling of healthy human brain and its application in studying neurological disorders. *Sci. Rep.* **7**: 897.
96. Myers, E.M., C.W. Bartlett, R. Machiraju, et al. 2015. An integrative analysis of regional gene expression profiles in the human brain. *Methods* **73**: 54–70.
97. Gomez, J., Z. Zhen & K.S. Weiner. 2019. Human visual cortex is organized along two genetically opposed hierarchical gradients with unique developmental and evolutionary origins. *PLoS Biol.* **17**: e3000362.
98. Liu, J., M. Xia, X. Wang, et al. 2020. The spatial organization of the chronnectome associates with cortical hierarchy and transcriptional profiles in the human brain. *Neuroimage* **222**: 117296.
99. Romero-Garcia, R., K.J. Whitaker, F. Vasa, et al. 2018. Structural covariance networks are coupled to expression of genes enriched in supragranular layers of the human cortex. *Neuroimage* **171**: 256–267.
100. Alexander-Bloch, A.F., S.R. Mathias, P.T. Fox, et al. 2019. Human cortical thickness organized into genetically-determined communities across spatial resolutions. *Cereb. Cortex* **29**: 106–118.
101. Vertes, P.E., T. Rittman, K.J. Whitaker, et al. 2016. Gene transcription profiles associated with inter-modular hubs and connection distance in human functional magnetic resonance imaging networks. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* **371**: 20150362.
102. Zhang, X.Q., Z.L. Wang, M.W. Poon, et al. 2017. Spatial-temporal transcriptional dynamics of long non-coding RNAs in human brain. *Hum. Mol. Genet.* **26**: 3202–3211.
103. Chen, C.H., E.D. Gutierrez, W. Thompson, et al. 2012. Hierarchical genetic organization of human cortical surface area. *Science* **335**: 1634–1636.
104. Krubitzer, L.A. & T.J. Prescott. 2018. The combinatorial creature: cortical phenotypes within and across lifetimes. *Trends Neurosci.* **41**: 744–762.
105. Mohr, A., M. Weisbrod, P. Schellinger, et al. 2004. The similarity of brain morphology in healthy monozygotic twins. *Brain Res. Cogn. Brain Res.* **20**: 106–110.
106. Linden, D.J. 2020. *Unique: The New Science of Human Individuality*. New York: Basic Books.
107. United Nations. 1954. Convention Relating to the Status of Stateless Persons, adopted by the General Assembly on 28 September 1954, United Nations Treaty Series. Accessed December 28, 2020. <https://www.refworld.org/docid/3ae6b3840.html>.
108. United Nations. 1961. Convention on the Reduction of Statelessness, adopted by the General Assembly on 30 August 1961, United Nations Treaty Series. Accessed December 28, 2020. <https://www.refworld.org/docid/3ae6b39620.html>.
109. Hong, Y.R. & J.S. Park. 2012. Impact of attachment, temperament and parenting on human development. *Korean J. Pediatr.* **55**: 449–454.
110. Long, M., W. Verbeke, T. Ein-Dor, et al. 2020. A functional neuro-anatomical model of human attachment (NAMA):

- insights from first- and second-person social neuroscience. *Cortex* **126**: 281–321.
111. Choi, E.J., M.J. Taylor, S.B. Hong, *et al.* 2018. The neural correlates of attachment security in typically developing children. *Brain Cogn.* **124**: 47–56.
 112. Leblanc, E., F. Degeilh, V. Daneault, *et al.* 2017. Attachment security in infancy: a preliminary study of prospective links to brain morphometry in late childhood. *Front. Psychol.* **8**: 2141.
 113. Serra, M., N. De Pisapia, P. Rigo, *et al.* 2015. Secure attachment status is associated with white matter integrity in healthy young adults. *Neuroreport* **26**: 1106–1111.
 114. Depue, R.A. & J.V. Morrone-Strupinsky. 2005. A neurobehavioral model of affiliative bonding: implications for conceptualizing a human trait of affiliation. *Behav. Brain Sci.* **28**: 313–350; discussion 350–395.
 115. Laurita, A.C., C. Hazan & R.N. Spreng. 2019. An attachment theoretical perspective for the neural representation of close others. *Soc. Cogn. Affect. Neurosci.* **14**: 237–251.
 116. Mira, R.G. & W. Cerpa. 2020. Building a bridge between NMDAR-mediated excitotoxicity and mitochondrial dysfunction in chronic and acute diseases. *Cell. Mol. Neurobiol.* <https://doi.org/10.1007/s10571-020-00924-0>
 117. Zundorf, G. & G. Reiser. 2011. Calcium dysregulation and homeostasis of neural calcium in the molecular mechanisms of neurodegenerative diseases provide multiple targets for neuroprotection. *Antioxid. Redox. Signal.* **14**: 1275–1288.
 118. Titley, H.K., N. Brunel & C. Hansel. 2017. Toward a neurocentric view of learning. *Neuron* **95**: 19–32.
 119. Chambers, A.R. & S. Rumpel. 2017. A stable brain from unstable components: emerging concepts and implications for neural computation. *Neuroscience* **357**: 172–184.
 120. Kempermann, G., F.H. Gage, L. Aigner, *et al.* 2018. Human adult neurogenesis: evidence and remaining questions. *Cell Stem Cell* **23**: 25–30.
 121. Ernst, A. & J. Frisen. 2015. Adult neurogenesis in humans—common and unique traits in mammals. *PLoS Biol.* **13**: e1002045.
 122. Spalding, K.L., R.D. Bhardwaj, B.A. Buchholz, *et al.* 2005. Retrospective birth dating of cells in humans. *Cell* **122**: 133–143.
 123. Ernst, A., K. Alkass, S. Bernard, *et al.* 2014. Neurogenesis in the striatum of the adult human brain. *Cell* **156**: 1072–1083.
 124. Spalding, K.L., O. Bergmann, K. Alkass, *et al.* 2013. Dynamics of hippocampal neurogenesis in adult humans. *Cell* **153**: 1219–1227.
 125. Rahman, A.A., N. Amruta, E. Pinteaux, *et al.* 2020. Neurogenesis after stroke: a therapeutic perspective. *Transl. Stroke Res.* **12**: 1–14.
 126. Frisen, J. 2016. Neurogenesis and gliogenesis in nervous system plasticity and repair. *Annu. Rev. Cell Dev. Biol.* **32**: 127–141.
 127. Jurkowski, M.P., L. Bettio, E.K. Woo, *et al.* 2020. Beyond the hippocampus and the SVZ: adult neurogenesis throughout the brain. *Front. Cell. Neurosci.* **14**: 576444.
 128. Glodzik-Sobanska, L., J. Li, L. Mosconi, *et al.* 2007. Pre-frontal N-acetylaspartate and poststroke recovery: a longitudinal proton spectroscopy study. *AJNR Am. J. Neuroradiol.* **28**: 470–474.
 129. Zhang, W., G.J. Gu, Q. Zhang, *et al.* 2017. NSCs promote hippocampal neurogenesis, metabolic changes and synaptogenesis in APP/PS1 transgenic mice. *Hippocampus* **27**: 1250–1263.
 130. Pouwels, P.J., K. Brockmann, B. Kruse, *et al.* 1999. Regional age dependence of human brain metabolites from infancy to adulthood as detected by quantitative localized proton MRS. *Pediatr. Res.* **46**: 474–485.
 131. Deci, E.L. & R.M. Ryan. 2011. Levels of analysis, regnant causes of behavior and well-being: the role of psychological needs. *Psycholog. Inquiry* **22**: 17–22.
 132. Zhang, X. & Z. Taisu. 2009. The philosophical feature of Confucianism and its position in inter-cultural dialogue: universalism or non-universalism? *Front. Philos. China* **4**: 483–492.
 133. Cox, N. 2013. The clash of unprovable universalisms—international human rights and Islamic law. *Oxford J. Law Relig.* **2**: 307–329.
 134. Tumulty, P. 2009. Recognizing varieties of objectivity in promoting a global culture of human rights: remarks in the tradition of Plato, Kierkegaard and Wittgenstein. *Int. Philos. Quart.* **49**: 473–484.
 135. Hogemann, E.R. 2020. Human rights beyond dichotomy between cultural universalism and relativism. *Age Hum. Rights J.* **14**: 19–36.
 136. Valandra, E. 2019. Mni Wiconi water is [more than] life. In *Standing with Standing Rock*. N. Estes & J. Dhillon, Eds.: 71–89. University of Minnesota Press.
 137. James, L.A. 2015. Indigenous spirituality: insights for a life-affirming and life-sustaining economy of life. *Ecumenical Rev.* **67**: 203–207.
 138. Sólón, P. 2018. The rights of mother earth. In *The Climate Crisis*. V. Satgar, Ed.: 107–130. Wits University Press.
 139. McLaughlin, R.P. 2012. Non-violence and nonhumans: foundations for animal welfare in the thought of Mohandas Gandhi and Albert Schweitzer. *J. Relig. Ethics* **40**: 678–704.
 140. Cunshan, L. & Y. Xin. 2008. A differentiation of the meaning of “Qi” on several levels. *Front. Philos. China* **3**: 194–212.
 141. Verbos, A.K. & M. Humphries. 2014. A native American relational ethic: an indigenous perspective on teaching human responsibility. *J. Bus. Ethics* **123**: 1–9.
 142. Rossello, D. 2017. All in the (human) family? Species aristocratism in the return of human dignity. *Polit. Theory* **45**: 749–771.
 143. Leib, L.H. 2011. Historical and philosophical underpinnings of the environmental movement. In *Human Rights and the Environment*. L.H. Leib, Ed.: 11–40. Brill.
 144. Hunt, L. 2007. *Inventing Human Rights: A History*. 1st ed. New York: W.W. Norton & Co.
 145. de Gouges, O. 1791. Declaration of the Rights of Woman and the Citizen. Accessed June 24, 2021. <http://www.historywiz.com/primarysources/declrightswomen.html>.
 146. Wilkerson, I. 2020. *Caste: The Origins of Our Discontents*. New York: Random House.