

A HISTORIC AND CONTEMPORARY LANDSCAPE OF THE EVOLUTIONARY AND PSYCHOLOGICAL PERSPECTIVES ON BRAIN DEVELOPMENT

Komal Mahmood*

Department of Pharmacology, Dow University of Health Sciences, Karachi, Pakistan

Email: mahmoodkomal43@gmail.com

ABSTRACT

The emergence of present psychological theories to evaluate cognitive function and further development of neurological study was not an isolated event. It took almost a century of racially charged pseudo-scientific theories that gradually enabled advances in neuro-behavioral science. The article introduces 19th-century German scholars such as Paul de Lagarde and Julius Langbehn, who owing to their disillusionment with academia inextricably intertwined nationalist ideologies with academic insights to promote the belief that certain intellectual traits were racially and culturally determined. The article traces how these ideologies impacted the conceptualization of brain hierarchy, as seen in the works of Arthur de Gobineau, who theorized racial inequality as a factor in civilization's progress. Transitioning to the biological and psychological mechanisms of brain development, the article reviews foundational theories from pioneering scientists. Jean Pierre Flourens and Franz Joseph Gall were early proponents of brain localization, proposing that specific brain regions correlate with distinct functions, a concept that lent credibility to phrenology and influenced later cognitive psychology. Furthermore, the article discusses the evolutionary growth of brain structures such as the neocortex and highlights how cytogenic niches facilitate neurogenesis, enabling cognitive flexibility and adaptability.

Keywords: Neurogenesis, Neuroplasticity, Racial theory, Social Darwinism

1) INTRODUCTION

Paul de Lagarde and Julius Langbehn were disillusioned intellectuals. Failure to recognize one's potential and a distinct intellect form an unhappy pair, but this combination was uniquely dangerous in nineteenth-century Germany (Mosse, 2021). Serving as a Gymnasium teacher for more than a decade before acquiring a chair at the University of Gottingen, Langbehn not only thought little of other academics, he also believed that the sinister incursion onto Germanic lands of the alienating industrial impulse, consumerism, and capitalism was causing a decline in the innate art that every German is born with. In his worldview, art was not a profession, but a tool which when combined with the inherent Germanic trait of mysticism "transmute (d) science into art". This was the subject of his "Rembrandt as Educator" (Langbehn, 1890).

But deep within this academic inclination was a sinister drive to cull at the roots the growing ebbs of anti-romanticism that had, apparently, hitherto flourished in a Germany unpolluted with Bismarckian policies. The Volkisch unity with nature was promulgated as the penultimate drive every German should work towards (Mosse, 2021). Thus all forces that defied nature were perpetuated as unworthy of being declared human. To this end, vicious ideologies were lent rational and academic backing to widen their appeal to the masses, both the peasant class and the educated elite. The blame for this sudden incursion of anti-mystic tendencies was placed with full force on the Jews (Mosse, 2021).

The hierarchy of organisms

To claim Arthur de Gobineau was the father of the Nazi ideology of racism may not be entirely wrong. Arthur de Gobineau, born on the 14th of July, 1816 had spent considerable time theorizing the natural inequality between different races. He expounded on this philosophy with spunk in his 1853 essay "The Inequality of Human Races" wherein he illustrated how this precise inequality had contributed to the development of civilizations (Comte de Gobineau, 1915). In his racial hierarchy, the white Aryan man sat at the pinnacle of near perfection while the 'yellows' and the 'blacks' sat on an inferior rung. Thus, the white race was responsible for all the good that contemporary social structure had to offer. The biophysicist and anthropologist, Jared Diamond gives a different reason in "Guns, Germs, and Steel" (Diamond and Ordunio, 1999) regarding the benefit that enabled the Caucasians of the Western plains to dominate the world, instead of vice versa. It had to do with the ease of domesticating animals and traveling across an east-west landmass naturally afforded to the white people rather than the north-south movement of the remaining world. The natural endowment of geographic advantage allowed the White race to gain

authority. Thus geography, and not race, is the primary reason for the white people's global success in Diamond's theory. Once colonized, the colonizers had access to animals, weaponry, and novel germs that were later weaponized for further self-propagation across the world. There are stories of how the colonizers gave the Native Americans smallpox and other infectious disease-infested blankets to make invasion easy (Diamond and Ordunio, 1999; Duffy, 2020).

Although Charles Darwin's natural selection sufficed for the further propagation of a racially charged science coupled with the Christian soteriology, of a Scandinavian-looking figurehead amidst a population of otherwise warm-toned people of Galilee, Christian-inclined academics were required (Weikart, 2016). Darwin had already brought upon his head the wrath of the Catholics for, indirectly suggesting the idea that the first man Adam, may not have been fashioned by Divine Intellect as religiously believed, but rather refined and perfected under environmental pressures from an imperfect model, the chimpanzee. To this end, the German academics, borrowing strongly from other European and English philosophers constructed their own ideas of race (Mosse, 2010).

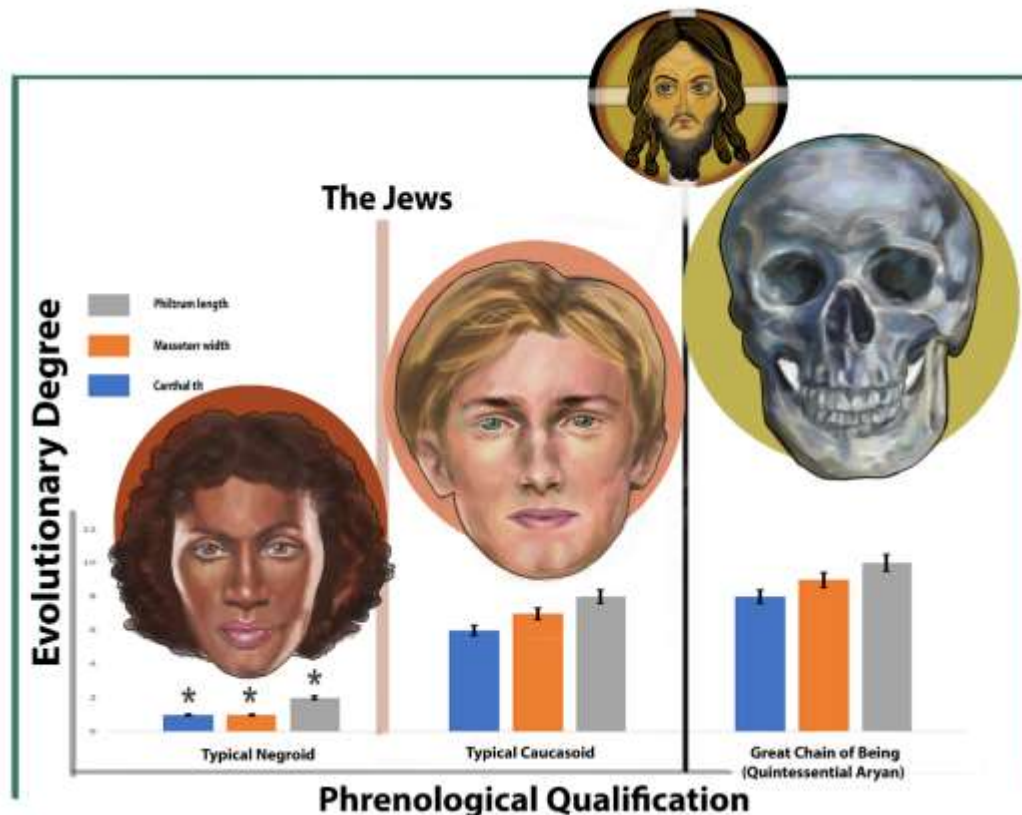


Fig. 1. The image depicts a hypothetical chart for the phrenological qualification of races against the evolutionary development of the physical form. The Aristotelean 'Great Chain of Being' depicts an idealized skull shape that bears a greater likeness with the white 'Aryan' archetype embodied by the quintessential European look. The Jews are depicted betwixt the African and the European. An additional feature of the Nazi judgmental racism was to classify the Aryan look with the pinnacle of Christian virtue to be found with Christ.

2) The Great Chain of Being

De Gobineau's theory did not emerge in a vacuum. The ancient Aristotle had already laid the groundwork for racial ideology, albeit unwittingly. His 'Great Chain of Being' described a hierarchy where God sat at the center with His absolute perfection, below him were the Angels, and somewhere down along that ladder was mankind. It was thus not difficult to subdivide human beings into further classifications with its hierarchy (Biddiss, 1966).

Jared Diamond's good sense in accounting for the 'racial superiority' in terms of the current global domination of the white race, is not in the same vein as that depicted by the educated lot in the late nineteenth to early twentieth century Nazi Germany. Rather, a type of apolitical aspect of irrational philosophy was applied to all sciences to justify whatever means necessary to hold all the non-white folks culpable (Mosse, 2010). Publishing houses, such as the one founded by Eugen Deiderichs made it a point to print works of philosophers to be read in the light of the

growing 'German dilemma'. The 'Intuition' of Bergson found readership among the youth, for intuition was an innate human quality and closer to nature. Bergson's concept of visual development explained how prior to the evolutionary formation of eyes, man was able to traverse due to his intuiting abilities (Mosse, 2021). A German peasant's proximity to nature and his inherent intuition made him superior to the Jew.

The Jewish people had elevated themselves to positions of money-lenders and tax-collectors. The high taxes imposed by the new regime subjected the peasant and the farming community to considerable adversity and the Jews became an automatic part of that equation that caused them pain. In Hermann Hesse's 1927 novel 'Steppenwolf', a middle-aged man embroiled in a similar predicament embraces his 'inner wolf' (Mosse, 2021), a Freudian base nature if you will, and goes on a murderous rampage, the receiving end of which is the bourgeoisie (Reich, 1970). This shows that the Third Reich's brutality did not emerge overnight, it was a seething mass of terrible racism and messianic expectations that had burst to bear the like of Adolf Hitler (Mosse, 2021; Reich, 1970).

It was under these circumstances that Phrenology acquired the status of a science. The use of measuring tapes and calipers to measure the precise measurements of the body and the face in German schools and camps assisted in 'winnowing' the pure Aryan from the impure (Mosse, 2010). Stern measures eventually followed in this process and lives were put at stake. This Golgotha of wasted lives is a part of European history that is most shameful. Named after the hill on which Christ was crucified, shaped like a skull, where the Wandering Jew rejected Christ and was condemned to wander the earth for perpetuity.

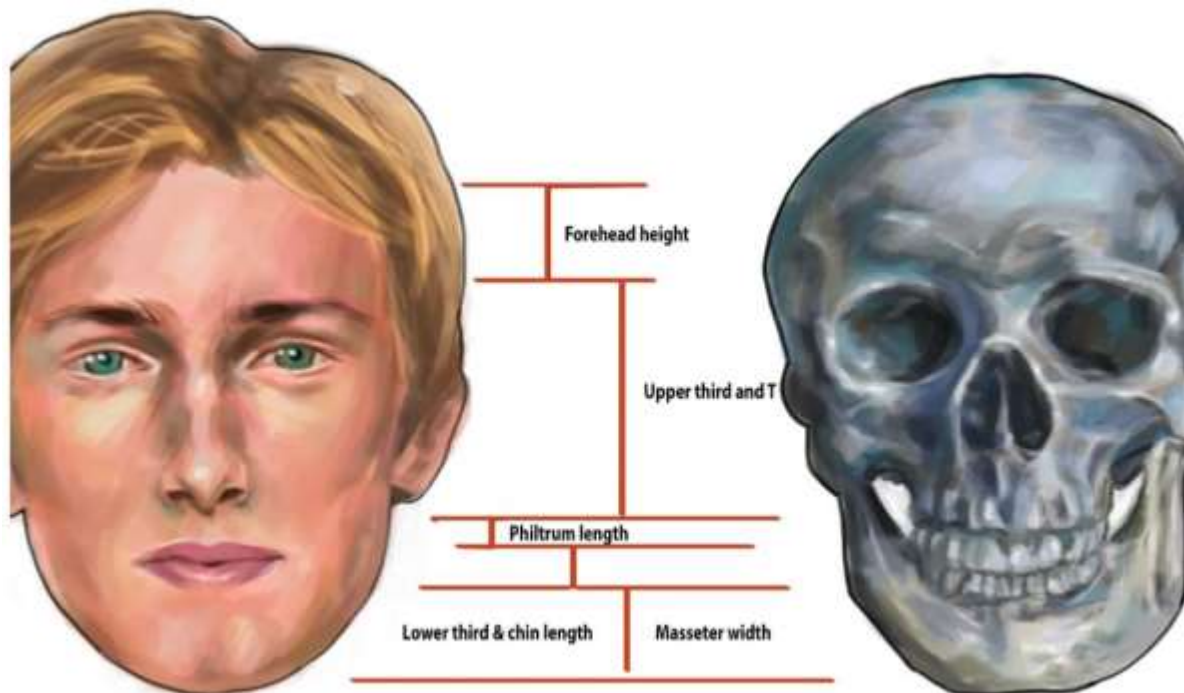


Fig. 2. The figure depicts a typical example of phrenology, measuring facial angles to account for the Nazi 'racial superiority' in the manner explicated in George L Mosse's 'Toward the Final Solution'.

3) Delegating specific functions to specialized brain regions

Jean Pierre Flourens and Franz Joseph Gall (Bermudez-Rattoni, 2007) both promulgated the fascinating and equally scandalous idea that individual brain regions correspond to distinct functions (Bermudez-Rattoni, 2007; Belzung *et al.*, 2013). It is a biological concept we accept as fact today, but it had met severe criticism back then. Pierre Flourens however would reduce human beings to reproductive drive and mere survival instinct (Weiner and Weiner, 1985). Gall gave humans more credit than that. Although all parts of the brain are involved in one way or another in every function, certain specific regions perform more than others. This idea lent greater power to pushing Phrenology deeper into the realms of academia. If specified brain regions were responsible for specified functions, then maneuvering this theory to state that certain races had higher centers of learning would certainly make for a strong explanation.

3.1) Relating isolated brain regions with different functions:

Marie Jean Pierre Flourens, the pioneer of vertebrate brain science (Weiner and Weiner, 1985), was the first to postulate that different brain regions correspond to different functions. He laid his theory on the basis of experiments conducted on pigeons' brains wherein he would remove specific areas and test for changes in activity. He discovered that removal of cerebral hemispheres divests the animals of will and judgment; removal of the cerebellum weakens muscular; and removal of the medulla oblongata proves to be fatal. Flourens' claims were challenged by Franz Joseph Gall who believed that cerebellum being the more primitive brain region was concerned with the more baser instinct common to all animals, being reproductive drive. He contended that induction of brain lesions was a flawed procedure and thereby any conclusions drawn from it would be flawed too (Bermudez-Rattoni, 2007).

It is of note that during the protracted evolutionary development of species, the human brain has undergone considerable changes in structure, size, and connectivity (Belzung *et al.*, 2013). The increase in progenitor cell population has resulted in increased brain size, corresponding with the emergence of advanced structures such as the neocortex and the gyrencephalia (Ceanga *et al.*, 2021; Taaupin, 2008), and thereby exhorting increased connectivity between distinct brain regions which can be seen via increased complexity in behavioral patterns.

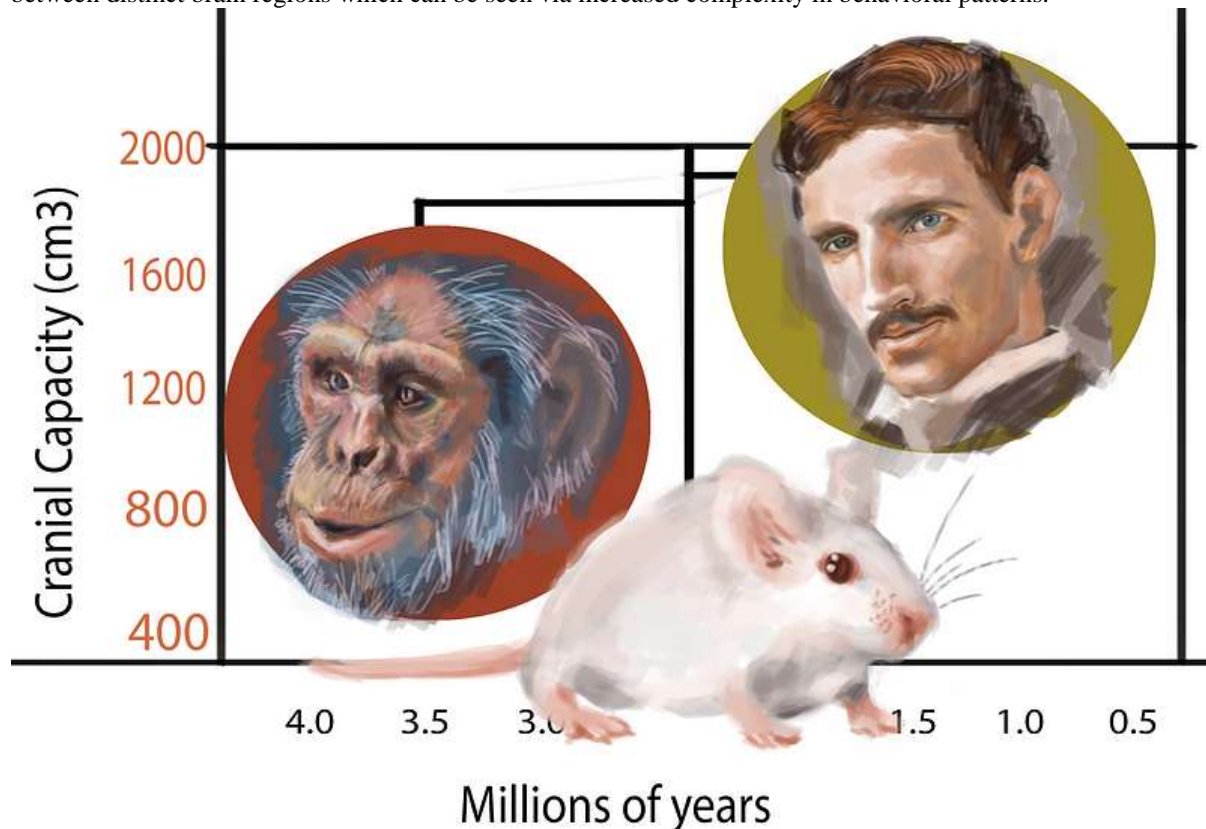


Fig. 3. "From a Rodent to Tesla" depicts the increase in brain size with a proportional increase in cranial volume across evolutionary time. The phylogenetic similarity across species given by the tree in the figure suggests that the ancient organism, the mouse has persisted in its present anatomical capacity. Latest research suggests that mice and rats have three neurogenic niches, compared to human beings who have two niches: the Subgranular Zone of the Dentate Gyrus and the Subventricular Zone of the lateral ventricles.

For long it was dogmatically held that after birth, the human body reaches a stable anatomical structure incapable of plastic changes. However at least two cytogenic niches are found in the brain and both of these house a population of neural stem cells which, on appropriate stimuli will escape their cytogenic microenvironment to differentiate into mature neuronal subtypes and incorporate themselves in the brain (Ceanga *et al.*, 2021). The modern human brain, with its remarkable cognitive capabilities, has undergone significant evolutionary changes over the course of millions of years. The expansion of brain size in the Homo lineage is a key feature of our evolution, with Homo sapiens having the largest brain relative to body size among all primates. This growth can be traced back through the fossil record, suggesting that increased brain size was favored by natural selection (Taaupin, 2008). It allowed early Homo species to develop advanced problem-solving abilities and adapt to changing

environments, ultimately leading to the emergence of our species. In terms of cytogenic niches, the development of two distinct niches is essential to accommodate the evolving brain. These niches provide an environment for neural stem cells to give rise to new neurons. These niches allow for the differentiation and integration of new neurons into the existing neural circuitry, contributing to cognitive plasticity and adaptation. Accommodating this increase in brain size, neurogenesis plays a pivotal role.

4) CRITICAL PSYCHOLOGICAL THEORIES

4.1) Donald Hebb's Dual Trace Hypothesis

Three studies in psychological research are of key importance and play a direct role in this study. Donald Hebb is credited with the aptly titled "Hebb's rule" wherein he postulated that sparse neuronal populations are in communication. He said that neuronal assembly A and neuronal assembly B are connected such that when A fires B, persistent structural changes are formed between them, and the efficiency (as a consequence of firing and exciting B) is increased (Hebb, 2018). This proved to be a revolutionary theory for it gave a mechanism for the basis of neuroplasticity (Bermudez-Rattoni, 2007).

Donald Hebb was a Canadian psychologist who had primarily concerned himself with the study of memory and cognitive psychology. He also postulated the Dual Trace Hypothesis in the 1960s. This hypothesis suggests that there are two distinct memory traces or pathways involved in the formation and retrieval of memories (Ruddy, 2008; Bermudez-Rattoni, 2007).

- Short-term Memory (STM): Short term memory, as the name implies is a temporary storage system that holds information for a limited duration. Although it consists of simple changes to synaptic connections, these are not long lasting and thus this memory type is temporal. The changes are reversible without structural alterations in the brain.
- Long-term Memory (LTM): This, as a name implies is long lasting involving permanent synaptic connections and changes in the brain. Long term memory involves consolidation and protein synthesis to stabilize the memory type. The Dual Trace Hypothesis suggests that the two memory types, Long Term Memory and Short Term Memory work in parallel and even in tandem. STM works as a filtration process; information that is deemed significant is consolidated into LTM otherwise it is forgotten. The Hebbian theory which is often summarized by the popular phrase 'cells that fire together, wire together' postulates that firing between distinct neuronal assemblies is the basis for learning and memory.

4.2) Long Term Potentiation (LTP)

Long Term Potentiation or LTP is the primary means of synaptic plasticity. Via this process, the synaptic connections are made stronger leading to a strong and stable communication between neurons. LTP is often used to examine how synaptic plasticity underlies memory and learning. It is closely associated with Hebb's Dual Trace Hypothesis in the following ways (Bermudez-Rattoni, 2007):

1. Coincidence Detection: Both theories (Dual Trace Hypothesis and Hebbian Synapse) employ the concept of coincidence detection. LTP occurs when the pre-synaptic neuronal release of neurotransmitters is coincidental with the post-synaptic neuronal depolarization. This parallel activation strengthens synapses, aligns with Hebb's "cells that fire together, wire together" (Hebb, 2018).
2. Persistent Strengthening: LTP leads to a long-lasting increase in synaptic strength, often referred to as synaptic potentiation. This long-term strengthening of synaptic connections corresponds to the idea that repeated and simultaneous firing of neurons, as proposed by Hebb, results in the formation of stronger memory traces (Forcato *et al.*, 2011).
3. Input Specificity: LTP is responsible for the long-lasting increase in synaptic strength, also referred to as 'synaptic potentiation'. This long-term synaptic strengthening corresponds with the Hebbian idea of repetitive firing between distinct and separate neuronal assemblies such that persistent connections are formed between them. The product of this process is consolidated memory.
4. Associative Nature: Both Long Term Potentiation and Hebbian Synaptic Process are essentially associative in nature. LTP induction is the result of the association between post-synaptic depolarization and pre-synaptic neurotransmitter release. Likewise, Hebb's Dual Trace postulates an association between individual collections of neurons.

4.3) Perseveration-Consolidation Hypothesis

Before Hebb's rule a prior theory had been proposed by Mueller and Pilzecker in 1900 in relation to the consolidation of long-term memory, but it had been overshadowed by the brilliance of Donald Hebb. Nonetheless, the Perseveration-Consolidation Hypothesis is a concept that states that memory consolidation is a process by which

newly acquired information is gradually transformed into a stable and long-lasting memory trace in the brain (Bermudez-Rattoni, 2007). This hypothesis emphasizes two key stages:

- Perseveration: Perseveration postulates that initial memory states are labile and susceptible to forgetfulness when information is first acquired or learned. It represents a memory trace in its fragile state. Perseveration is thus a type of recent memory.
- Consolidation: Consolidation refers to a memory processing format wherein the initial memory trace is stabilized and transferred and from a state of vulnerability to a resistant and lasting state. Consolidation is responsible for structural and functional alterations in the brain, including the strengthening of synaptic connections

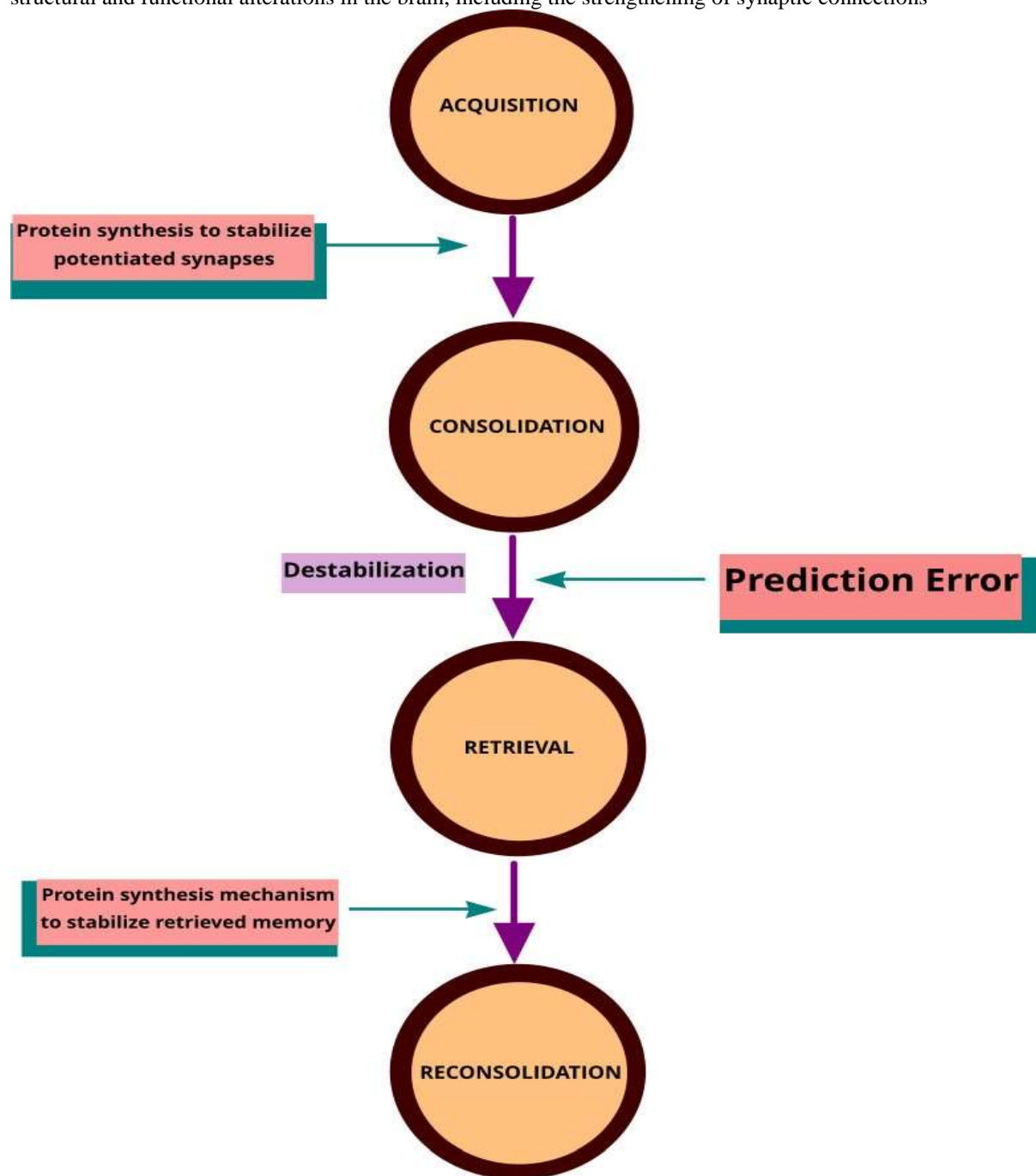


Fig. 4. A flowchart summarizing the underlying mechanisms of two memory consolidation hypotheses: the Perseveration-Consolidation Hypothesis and the Labilization-Reconsolidation Hypothesis. Memory retrieval is the

prime requisite for consolidation and each step necessitates protein synthesis, the hallmark of long-term memory storage.

4.4) Temporal Lobe Memory

The idea of synaptic strengthening between distinct neuronal assemblies as a form of generating memory traces was later reiterated by Hebb, and found behavioral basis in the work of Hebb's doctoral student, Brenda Milner (Kolb and Milner, 2022). She conducted trials on the patients of William Scoville, a neurosurgeon well versed in performing lobectomies, and had identified patients with diminished function of the medial temporal lobe (Bermudez-Rattoni, 2007). Her key patient would prove to be the very unique and tragic case of Henry Molaison (HM). HM had had a bicycle accident as a youth and suffered a brain injury. As a consequence, he developed a case of severe temporal lobe epilepsy (TLE) and thus reached out to Dr Scoville for treatment whose bilateral medial temporal lobectomy had ended HM's seizures, instead the procedure divested HM of the ability to form new memories. By the time Brenda Milner was acquainted with him, HM had been Scoville's patient for 11 years and had no recollection of any event since his procedure. She also discovered a very unique trait of HM; his memories lasted no more than thirty seconds. He soon became a model patient and his tragic albeit unique case was investigated till he passed away. Regardless, Brenda Milner highlighted the role of the temporal lobe, and specifically the role of the hippocampus in the formation, retention, and retrieval of memories. She also distinguished memory types and their role in day-to-day function. Her key contribution to the field of cognitive psychology is the segregation of brain regions and memory types. Procedural (Implicit) memory and Declarative (Explicit) memory.

As the name implies Implicit or Procedural memory seems to be a part of the innate ability of the brain to perform tasks. An emotional response, is related mostly to the autobiographical memory as an implicit memory function. Priming, perceptual learning, category learning, and procedural learning are all members of Procedural memory. Priming is a memory type wherein exposure to a stimulus (the prime) influences the processing or recognition of a related stimulus (the target).

4.5) The Great Debate by Clark Hull and Edward Tolman

Another highly popular psychological model for behavior was that between Clark Hull and Edward Tolman's battleground on the T-maze using mice model, the Great Debate was a contest between the nature of learning and motivation. Clark Hull was a proponent for behaviorism, emphasizing the role of reinforcement in the acquisition of information. MacCorquodale *et al.* (1954) on the other hand, was a cognitive psychologist who postulated the importance of mental processes in behavior. Both used the T-maze; a simple instrument with a central stem and two side arms and conducted numerous animal experiments to support their respective theories (Bermudez-Rattoni, 2007; Belzung *et al.*, 2013).

Hull's Perspective: Clark Hull had proposed the Drive Reduction Theory (Weiner and Weiner, 1985); a proponent of instrumental conditioning, he employed the T-maze to evaluate whether animals would race through the instrument to locate a reward, in this case food. Hull believed that learning was a product of reinforcement and the physiological drive such hunger, wherein the animals were motivated learn the route of the maze to actively seek a reward.

Tolman's Perspective: Tolman however employed the T-maze to understand the cognitive processes at play during the animals' traversing of the equipment (MacCorquodale *et al.*, 1954). His theory for more sophisticated and refused to reduce animals to mere physiological drives. In his view, the animals learned the layout of the maze, such that they could form a cognitive map of it. The animals were thus able to navigate the maze not merely due to a drive but because their brains had formed a mental representation of the spatial environment.

Thus, Edward Tolman helped shape a key psychological paradigm in behavioral research called Place Learning, which, as the name implies, is a form of spatial learning wherein the subject in question acquires information about an object's location or an environment's landmarks. This allows them to make cognitive maps of spaces and make navigation easier and quicker. It is essential for constructing memory traces of spatial environment. This laid the groundwork for a critical cell type called the Place Cells, these are a specific type of neurons situated in the mammalian hippocampus example mice and humans (Ruddy, 2008). So names because they are crucial in encoding spatial locations in the subjects' environment. Were an animal (who has acquired the information of a location and made spatial maps in memory) to find itself in such locations, these place cells would fire selectively and resurface these memory traces (Belzung *et al.*, 2013).

This allows for the formation and use of novel techniques, such as optogenetics, that allow researchers to activate specific neurons (the place cells). Laser light can be used to stimulate these neurons by using transgenesis to introduce a light-sensitive protein (the opsins) into the neuron of interest (Bermudez-Rattoni, 2007). For further accuracy, researchers can target and activate the place cells within the hippocampus to evaluate their role in spatial

memory. Place cells are actively involved in an animal's spatial navigation and memory. A light-sensitive gene can be placed next to the promoter for c-fos or Arc protein. When protein synthesis is initiated due to activation of specific types of neurons, the promoter for long-term memory proteins will be activated and light-sensitive genes will be transcribed simultaneously. This is a very sensitive and accurate process that can be used in tandem with the behavioral activity of an animal on a T-maze; if the subject is in a specific corner of a maze, the place cells associated with that location will fire (Rehman *et al.*, 2017).

4.6) Classical Conditioning by Ivan Pavlov

However, the most significant contribution to the correlation of behavior with psychology has been Ivan Pavlov's Classical Conditioning in dogs. A foundational example of how animals can learn to associate stimuli with specific outcomes. The experiment typically includes the following components (Rehman *et al.*, 2017).

- Unconditioned Stimulus (UCS): This is a stimulus that automatically triggers a specific response without need of prior learning. In Pavlov's experiment, the Unconditioned Stimulus was food. When food was presented to the dog, it produced the unconditioned response - salivation.
- Unconditioned Response (UCR): The unconditioned response is an automatic, unlearned reaction that occurs in response to the unconditioned stimulus. The UCR In Pavlov's experiment was salivation. The dog reflexively salivated when presented with food.
- Conditioned Stimulus (CS): The conditioned stimulus is a neutral stimulus that through repeated association with the unconditioned stimulus evokes a learned response. A neutral stimulus, in this experiment and that of Pavlov's, a bell ringing, was paired with the presentation of food. Gradually, the dog learned to associate the bell ringing (CS) with food, leading to the conditioned response.
- Conditioned Response (CR): The conditioned response is a learned response evoked by the conditioned stimulus.

In Pavlov's experiment, the CR was salivation. After multiple trials and pairings of the bell (CS) with food (UCS), the dog would naturally and reflexively salivate (CR) upon hearing the bell alone, even in the absence of food.

Presently Joseph LeDoux, a researcher and professor at the New York University has adapted Pavlov's experimentation to a mouse model. LeDoux is known for his work on the neural basis of emotion and fear conditioning in which the UCS often involves employing an aversive stimulus like a mild electric shock, which naturally induces a fear response in the mouse. Conditional Aversion towards smell and specific tastes which cause an animal to remove oneself from said aversive stimulus, is a similar example. The unconditioned response in this case would be the innate fear to the aversive unconditioned stimulus, which could include a freezing behavior, elevated heart rate, and certain others. LeDoux introduced a neutral stimulus, example a sound or light, as the conditioned stimulus which serves as a signal to predict the aversive event (shock). The conditioned response (CR) in LeDoux's model includes fear-related behaviors such as freezing, increased heart rate, and improved or heightened vigilance, positively alarming the senses. The mouse exhibits these behaviors when exposed to the conditioned stimulus (e.g., sound or light) that predicts the aversive UCS.

Conclusion

The landscape of the evolutionary and psychological perspectives of brain development depicts the impact of socially charged rhetoric on science and academia. Historically, theories such as phrenology abused biological distinctions to allow for racial discrimination to encroach the sciences and thereby justify the nineteenth to twentieth-century violence against certain classes and races within society. The Eugenists who perpetuated social Darwinism bandied the term 'inferior' to describe the 'less well-endowed'. However, it was often the phrenologists who made strides in neuroanatomy and by extension psychology and psychiatry when they were driven to either disprove or vindicate the notion that distinct brain regions are responsible for distinct functions. Experiments driven as a means to understand drive against biological impulse gave way to theories such as the Pavlovian Classical Conditioning and the historic debate between Clark Hull and Edward Tolman. These theories are still utilized in psycho-behavioral testing.

REFERENCES

- Belzung, C., P. Wigmore, *et al.* (2013). *Neurogenesis and Neural Plasticity*. Springer.
Bermúdez-Rattoni, F. (2007). *Neural Plasticity and Memory: From Genes to Brain Imaging*. CRC press.
Biddiss, M. D. (1966). Gobineau and the origins of European racism. *Race*, 7(3): 255-270.

- Ceanga, M., M. Dahab, O. W. Witte and S. Keiner (2021). Adult neurogenesis and stroke: A tale of two neurogenic niches. *Frontiers in Neuroscience*, 15: 700297.
- Comte de Gobineau, A. (1915). *The Inequality of Human Races*. GP Putnam's Sons.
- Diamond, J. M. and D. Ordunio (1999). *Guns, Germs, and Steel*. Vol 521. Books on Tape New York.
- Duffy, J. (2020). Smallpox and the Indians in the American colonies. In: *Bioterrorism: The History of a Crisis in American Society*. Routledge, p.2-19.
- Forcato, C., M. L. Rodríguez and M. E Pedreira (2011). Repeated labilization-reconsolidation processes strengthen declarative memory in humans. *PLoS One*, 6(8):e23305.
- Hebb, D. O. (2018). Elaborations of hebb's cell assembly theory. In: *Neuropsychology After Lashley*. Routledge; pp.483-496.
- Kolb, B. and B. Milner (2022). Pioneer of the study of the human frontal lobes. *Frontiers in Human Neuroscience*, 15: 786167.
- Langbehn, J. (1890). *Rembrandt as Educator*. Uthwita Press.
- MacCorquodale, K., P. E. Meehl and Edward C. Tolman (1954). *Modern learning theory*, (ed. WK Estes, S Koch, K MacCorquodale, PE Meehl, CG Mueller Jr, WN Schoenfeld & WS Verplanck). Published online, pp.177-266.
- Mosse, G. L. (2021). *The Crisis of German Ideology: Intellectual Origins of the Third Reich*. University of Wisconsin Pres.
- Mosse, G. L. (2020). *Toward the Final Solution: A History of European Racism*. University of Wisconsin Press.
- Rehman, I., N. Mahabadi, T. Sanvictores and C. I. Rehman (2017). *Classical conditioning*. Published online.
- Reich, W. (1970). *The mass psychology of fascism*. Published online.
- Rudy, J. W. (2008). *The Neurobiology of Learning and Memory*. Sinauer Associates.
- Taupin, P. (2008). *Stem Cells and Regenerative Medicine: Adult Neurogenesis and Neural Stem Cells*. Vol. 1. Nova Publishers.
- Weikart, R. (2016). *From Darwin to Hitler: Evolutionary Ethics, Eugenics and Racism in Germany*. Springer.
- Weiner, B. and B. Weiner (1985). *Drive theory. Human motivation*. Published online. pp.85-138.

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