THE HISTORY OF RACE IN ANTHROPOLOGY: PAUL BROCA AND THE QUESTION OF HUMAN HYBRIDITY

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ABSTRACT

Paul Broca (1824-1880) was a French physician and anthropologist whose belief in the polygenesis of human origins was inextricably linked to the question of human hybridity. His studies on hybridity began in 1857 after he observed leporids, the crossing of a hare and a rabbit. He applied his methods of analyzing these animal hybrids to mixed-race individuals, a task he believed would prove polygenism. His studies laid the basis for French anthropology and led to the founding of the *Société d'Anthropologie de Paris*, the world's first anthropological society. Broca's background in mathematics led him to expand upon methods of quantifying human difference and to develop new anthropometric measurements, which are arguably his greatest contribution to biological anthropology. Broca was one of the purest scientists of his age and exclusively relied on quantitative data. His portrayal in secondary literature does not demonstrate this fact and he is often considered a key figure in 19th century racist science. Drawing from the work of philosophers of science Georges Canguilhem and Ian Hacking, this paper argues that Broca develops anthropometry to classify mixed-race individuals, effectively creating the biological concept of a human hybrid, a type of person that did not exist before.

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INTRODUCTION

French physician and anthropologist Pierre Paul Broca (1824-1880), the founder of French anthropology, was one of the most influential scientists of his time, and one of the key figures in mid-19th century debates on the origins of human difference (Schiller, 1979). Though Broca originally planned to pursue studies in mathematics, the unexpected death of his sister led him to a career in medicine (Schiller, 1979, 15). He did not, however, lose his appreciation for quantitative data and his trust in numbers, rather than assertions, was the hallmark of both his medical and anthropological careers (Blanckaert, 2009, 122).

As a young physician, Broca's primary focus was neuroscience and he is perhaps best known for discovering the area of the brain associated with speech production (Broca's area) and defining the eponymous disorder (Broca's aphasia) that results from damage to this area (Schiller, 1979, 192). Though he was initially bored by osteology, his interests in natural science and anatomy grew and he would go on to become one of the greatest craniologists and physical anthropologists of the 19th century (Broca, 1886, 30, 131; Schiller, 1979, 20).

One single event sparked Broca's interest in anthropology. In 1857, he was presented a leporid, the hybrid offspring of a rabbit and a hare. He became fascinated by the creature and it led him to study the hybrid offspring of humans. As a polygenist, Broca believed in the multiplicity of human origins and primeval human difference and maintained that this view was linked to the study of human hybridity. By proving that distinct species could produce fertile offspring, Broca thought he could prove the polygenesis of the human races (Broca, 1877).

After realizing that discerning human hybrids from either pure race could not be based on hair or skin color alone, Broca developed a series of anthropometric measurements to systematically quantify human difference (Stocking, 1968, 57). He borrowed cranial measurement

techniques from anatomists before him (such as Camper, Morton, and Retzius), and to them added not only measurements of the cranium, but of the entire human body (Broca, 1871; Broca, 1861a; Broca, 1862a; Broca, 1865). Though he preferred laboratory work on skeletal remains, Broca developed a field guide to measuring and analyzing human variation among living people and he dedicated an entire section to identifying hybrids (Carson, 2007, 100; Broca, 1865).

In developing these measurements to systematically categorize the offspring of racial crossings, Broca effectively created the concept of a human hybrid, following the models of philosophers of science Georges Canguilhem and Ian Hacking. Canguilhem argues that experimentation is key in forming biological concepts, whereas Hacking's idea of "making up people" asserts that the classifications that scientists impose on individuals can create entirely new types of people. By experimenting first with leporids and then measuring human hybrids, Broca was effectively quantifying their existence. Though his work on hybridity has been largely forgotten, Broca has left a clear impact on racial science and anthropology as a discipline.

This paper aims to discuss Broca in three ways. Although he dabbles in the humanistic fields of medicine and anthropology, Broca is perhaps one of the purest scientists of the 19th century, focusing primarily on numerical data rather than *a priori* assumptions. Broca is cast as a racist in most secondary literature, a judgment that does not demonstrate his results. Finally, Broca codified many categories and methods that still exist today to some degree.

Overall, this paper will: 1) give a biographical sketch of Broca; 2) describe the history of 18th and 19th century racial theories and introduce the key figures in the study of human origins and variation prior to Broca; 3) mention early attempts to systematically measure human difference; 4) explain Broca's research on hybridity in animals and in humans, which he believed illuminated the polygenist view of human origins; 5) introduce Broca's novel anthropometric

measures and argue that they were developed to classify hybrids; and 6) connect Broca's study of hybrids and anthropometry with the work of philosophers of science, Georges Canguilhem and Ian Hacking to suggest that Broca effectively created the concept of a human hybrid.

BIOGRAPHICAL SKETCH

Pierre Paul Broca was born on June 28, 1824 to a Calvinist Protestant family in Sainte-Foy-la-Grande, Gironde, France (Schiller, 1979, 11). From childhood, he was an exceptional student, dedicating most of his time to his secondary education (Schiller, 1979, 13). As a young professor, his history lectures were his first foray into paleontology and what would later be called paleoanthropology. In August of 1840, he received a bachelor's degree in letters (history and literature). Despite his father's wishes that he attend medical school, Broca secretly pursued a bachelor's degree in mathematics and was set to matriculate into the Ecole Polytechnique de Paris the year after receiving his degree (Schiller 1979, 14). Had it not been for the unexpected death of his 18-year-old sister, Léontine, Broca would not have decided to become a physician. Abandoning his previous desires to become an engineer, in October 1841, he began his medical studies at the Collège Sainte-Barbe in Paris' Latin Quarter (Schiller, 1979, 15-6; Brace, 2005, 144).

Broca worked as a *pion*, or prefect, in order to pay his way through medical school (Schiller, 1979, 18). But when it came time to compete for the *concours*, a qualifying examination for the one-year extern and multi-year intern positions, he was forced to resign from his position to focus primarily on his studies (Schiller, 1979, 20). At the Collège Sainte-Barbe, he took courses by leaders in the sciences, many of whom continued to influence him throughout his career (Schiller, 1979, 18). Broca was fascinated by the basic experimental sciences, but ironically found osteology to be rather mundane (Broca, 1886, 30). By the end of his first year, he was one of ninety students to study anatomy at the Ecole Pratique, setting him up for a career as a surgeon. He also

received a position as extern at the *Hôtel-Dieu* to work under Dr. Philippe-Frédéric Blandin, a gifted surgeon and one of Broca's professors at the *Collège Sainte-Barbe* (Schiller, 1979, 23-4). After passing the qualifying exam for the externship in 1843, he was assigned to M. Philippe Ricord at the Hôpital du Midi to study venereal diseases (Schiller 1979, 25-6). Despite Broca's antipathy to the specialty, Ricord proved to be an excellent mentor (Schiller, 1979, 26). In 1844, he completed the qualifying exam for his internship and, much to his chagrin, was placed under the supervision of François Leuret at the Bicêtre, a mental institution. Broca was not yet aware of the impact that Leuret's work on comparative neuroanatomy would have on his future endeavors (Schiller 1979, 28-9). By the time he became Pierre Nicolas Gerdy's surgical intern at the Hôpital de la Charité in 1846, Broca had been an extern at a number of Parisian hospitals (Schiller, 1979, 32-4). No later than the spring of 1846, however, Broca was suspended from his internship, likely due to his burgeoning political interests and letters featured in the revolutionary republican publication, *Les Ecoles*, during the July Monarchy (Brace, 2005, 144; Schiller, 1979, 37). Despite this, towards the end of July 1846, Broca passed the *concours* for aide in anatomy at the top of his cohort becoming, at the age of twenty-two, the youngest to ever achieve this position (Schiller, 1979, 41). He was finally vindicated when, within the final months of 1846, he was offered an internship to work again with Blandin at the Hôtel-Dieu (Schiller 1979, 42).

Broca's intelligence and ambition were reflected in his success in his field and self-confidence. Before the end of 1847, his parents realized his full potential and allowed him to compete for the *agrégation*, the most prestigious and competitive public education qualifying examination (Schiller, 1979, 46). When, in February 1848, the July Monarchy fell and the Second Republic was declared, Broca, the young, self-proclaimed moderate was ecstatic and the revolutionary spirit was spreading among the interns (Schiller, 1979, 50-1). Mid-July 1848, Broca

completed the prosector qualifying exam and was named prosector of the Ecole Pratique (Schiller, 1979, 58).

Broca began his work on cancer research under the supervision of Hermann Lebert, whose 1845 publication, *Physiologie pathologique*, was one of the first publication on the cytology of tumors (Schiller 1979, 59-60). Lebert stressed the importance of a "dynamic" approach to pathology, combining clinical, experimental, and microscopic analyses. He separated tumors into two categories based on their tissues. Broca, too, became heavily involved with cytology, likely due to his fascination with the microscope. He bought one of his own in 1847 and declared in 1849, "the microscope has replaced hypothesis by evidence. . . Any observation unconfirmed by the microscope must be regarded as null and void," (Schiller 1979, 61). Before the microscope, cytology was based on assertions, but now the new tool microscope allowed for detailed analysis and precise measurement of microscopic organisms that was previously impossible. This marks the start of Broca's dependence on instruments and quantitative measurements, hallmarks of his anthropological career. In 1850, he won the *Prix Portal*, an award given by the Académie de Médecine de Paris, for his 364-page monograph summarizing Lebert's works, as well as Broca's own discoveries, most notably, the identification of the venous spread of cancerous tumors (Brace, 2005, 144; Schiller, 1979, 62-3). His and Lebert's microscopic work helped transform French pathology into a laboratory-based science (Schiller, 1979, 74). His doctoral dissertation entitled *De la propagation de l'inflammation -- Quelques propositions sur les tumeurs dites cancéreuses* (*On the spread of inflammation: Some Statements on tumours called cancerous*) was published in 1849 (Schiller, 1979, 78).

In the spring of 1853, Broca successfully completed the *agrégation* qualifying exam and was the first candidate to be selected as *agrégé*, the most prestigious title in higher education

(Schiller, 1979, 88-9). The rest of Broca's career is characterized by breakthrough discoveries and engagement with scholarly societies. Since the French Revolution, higher learning institutions had been stigmatized and, as a result, often operated in secret. Pre-1860, there were roughly a dozen biomedically-related societies in France; by 1902, there were 85. In the spring of 1847, 23-year-old Paul Broca became one of the greatest contributors to the Société Anatomique and was named a titular member in 1849 (Schiller, 1979, 90-1). His research, aside from cancer studies, was consecrated at this time to musculoskeletal disorders. In 1852, Broca was the first to identify the tissue modification that resulted in rickets, namely, a malnutrition-related dysregulation in ossification, for which he received a prize of 500 francs from the *Académie des Sciences*. His next topic was osteoarthritis, which he distinguished from other joint conditions and whose point of origin he identified as the synovial membrane. Additionally, he noted each of the modifications to blood vessels and connective tissue. He introduced the concept that cartilage, unlike hair and nails, was more similar to teeth and cornea and kept alive by diffusion of nutrients from nearby blood vessels (Schiller, 1979, 91-2). In 1850, Broca was elected Vice President of the Société. He then began work on muscular disorders, starting in 1847 with club-foot. His 1851 *Description of the muscles in a case of club-foot* refutes the claim that the malformity is the result of lesions of the central nervous system, and instead states that it is due to idiopathic muscle changes resulting in atrophy and eventual loss of muscle fibers. This made him the first to fully report on the pathology of muscular dystrophy (Schiller, 1979, 93-4). One of his later contributions was an explanation of the mechanism of blood clotting (Schiller, 1979, 107). His best-known publication in the late 1850s was *Traité des anévrismes et leur traitement* (*On Aneurysms and their Treatments*), published in 1856. Today, the 931-page oeuvre is still the most comprehensive analysis of aneurysms and their treatment (Schiller, 1979, 106). After its founding by his colleague at the Ecole Pratique, Broca

joined the Société de Biologie, the society to whom he presented his research until he began his studies on hybridity (Schiller, 1979, 112).

By the end of 1853, Broca was a well-known name not only in Paris, but abroad. He experienced contemporaneous success in his personal life. In July of 1857, he married Adèle Augustine Lugol and together they had three children, Pauline (1858), Auguste (1859), and André (1863). They lived in the same house at *1 Rue des Saints-Pères* from 1857 until Broca's death in 1880 (Schiller, 1979, 125, 127).

Influenced by research conducted by American anthropologists Samuel George Morton and his student Josiah Nott, Broca began his studies on human hybridity which he presented before the Société de Biologie in 1858 (Brace, 2005, 148). Once the president of the Société de Biologie insisted for the final time that Broca stop his research, Broca founded the Société d'Anthropologie *de Paris* in 1859 and acted as Secretary/General Secretary until his death. The society was the first "anthropological" society in the world and effectively established its founder as the father of French anthropology (Schiller, 1979, 130-1).

The first year of the society was focused on the study of the hierarchy of races (Schiller, 1979, 137). Across the western world, mid-19th century scholars were tackling the question of monogenism and polygenism, or the unity or plurality of the origin of races. Broca aligned himself with the American polygenists, a viewpoint that pervaded every aspect of his research. One of the more important aspects of his work was the development of anthropometric measurements, for which Broca is credited with making physical anthropology a true science (Schiller, 1979, 150, 163).

Broca's next endeavor, and perhaps his most enduring legacy, was his work on the brain. Rather than focus on brain size as a measure of intelligence, like many of his contemporaries,

namely Samuel George Morton of Philadelphia, Broca suggested that the shape of the brain ought to be considered instead (Schiller, 1979, 174). He studied the brains of individuals with disordered speech and found damage to localized parts of the brain (Schiller, 1979, 183). He discovered that a lesion in the left hemisphere is associated with articulated speech (Schiller, 1979, 192). On May 19, 1861, he presented a paper on aphasia to the Société Anatomique and in 1877 presented his final paper on this topic (Schiller, 1979, 197, 200).

In 1865, Broca was elected president of the Société de Chirurgie de Paris and he continued his work in varying aspects of science including physiognomy and public health (Schiller, 1979, 216, 219). His work gained popularity not only among academics, but within the public due to its focus on the hierarchy of races and French superiority (Schiller, 1979, 274). He took on a new administrative role; beginning in 1872, he published the periodical *Revue d'anthropologie* and by the end of 1876 he opened his School of Anthropology (Schiller, 1979, 275, 278). He became *un homme politique* (politician), running for a seat on the Senate. After one failed attempt, he was elected in January 1880 with the help of the slogan, "France et Science!" (Schiller, 1979, 280). During his campaign, he was subject to intense mudslinging highlighting his most controversial contributions to anthropology and science and entirely avoiding the innocuous content of his career (Schiller, 1979, 281). As a senator, he effortlessly balanced medicine and politics and one of his most impactful pieces of legislation provided public high school education to all girls (Schiller 1979, 285).

In 1880, Broca was struck by a coronary thrombosis, a rare condition in the late-19th century (Schiller, 1979, 286). The condition began to wear him down and on July 7, just one week after his fifty-sixth birthday, he complained of pain in his left shoulder, but went about his day working with students at the hospital. The next day at the Senate, his severe chest pains forced him to return

home where he died later that night (Schiller, 1979, 288). He was buried on Sunday, July 11, 1880 in the Cimetière de Montparnasse. His wife, children, and other family members are today buried in the same grave. Nearly 2,000 people were in attendance, a testament to his lasting impact on the fields of anthropology, anatomy, and biomedicine (Schiller, 1979, 289).

HISTORICAL BACKGROUND

Through the 18th and 19th century, monogenism and polygenism were competing theories concerning the origin of human races. Monogenism was "the doctrine of single origins" which was an interpretation of the Judeo-Christian Biblical origins story that named Adam and Eve as the original pair from which all mankind descended (Brace, 2005, 42). In contrast, polygenism was the doctrine of multiple origins whose interpretation of the Biblical account of human origins stated that Adam and Eve were the ancestors of the Jews, but the gentiles were descended from pre-Adamites, or people that lived before Adam (Brace, 2005, 39). Both theories had their own views on concepts such as race, types, species and hybridity.

The history of these concepts prior to Broca traces through some of the most prominent figures in 18th and 19th century natural history and medicine. The first iteration of the modern species concept was recorded in 1686 by English naturalist John Ray (1627-1705) who defined species as "a stable product of original creation and subsequent propagation" and used hybrid sterility to distinguish them (Douglas, 2015, 2; Brace, 2006, 86). Through the 18th and 19th centuries, the concepts of species, race, and type were used differently by monogenists and polygenists based on the assumed degree to which they admitted the influence of the environment in changing human form over time, and their views on the possibility of human mixture among different types. To some degree, each of the following figures influenced the formation of Broca's polygenist views on species, race, type, and hybridity.

Carl Linnaeus (1707-1778), Swedish botanist and father of modern taxonomy, began to systematically classify living forms in his 1735 publication *Systema Naturae* (Douglas, 2008, 35-6; Brace, 2005, 24-5). He was the first to place *Homo sapiens* in the order Primates, breaking down the distinction between the human and animal world (Brace, 2005, 26). A strict creationist and monogenist, he drew from the work of French physician François Bernier (1620-1688) to understand and systematize human biological variation. Using Bernier's four quadrants of the globe as the basis for his classification, Linnaeus established four varieties of human beings: *Homo sapiens europaeus*; *H. sapiens asiaticus*; *H. sapiens americanus*; and *H. sapiens afer*, corresponding to Europe, Asia, America, and Africa, respectively (Brace, 2005, 27). Linnaeus' *scala naturae*, or "Great Chain of Being," the notion that all beings were placed on a hierarchical scale with God at the top, living forms in the middle, and inorganic materials at the bottom, was integral to his classification of life forms. His categorization of living entities placed Primates as the highest level, with humans at the peak within the order (Brace, 2005, 28). This system of hierarchical classification, coupled with the delineation of human varieties, was key to 19th century anthropology.

German physician Johann Friedrich Blumenbach (1752-1840) spent his entire career as professor of medicine at the University of Göttingen. His doctoral dissertation, *De Generis Humani Varietate Nativa* (1775) was released to the public in 1776. He criticized Linnaeus' four varieties for being "artificial," but expanded upon it to create his own "natural" classification of humankind. He maintained Linnaeus' European, American, and African groups, but split the Asian group into Mongolian and Malayan, thus creating his five races: the Caucasian, or white race; the Mongolian, or yellow race; the Malayan, or brown race; the Ethiopian, or black race; and the American, or red race (Figure 1) (Brace, 2005, 44). There are two explanations for Blumenbach's choice of the word

"Caucasian" to describe the white race. First, he considered the Georgian skull he studied to be the most beautiful, and thus the Caucasus would best represent this beautiful race (Brace, 2005, 44). Second, it was a nod to his Christian beliefs as the Caucasus, specifically Mount Ararat, was the landing place of Noah's ark (Brace, 2005, 44-5). Like many religious persons at the time, Blumenbach was a monogenist and believed that the difference in skin color between the races was a result of degeneration due to external factors, rather than a primordial difference (Douglas, 2008, 38). He preferred a more fluid take on human difference, suggesting the varieties blended into each other to such a degree that his divisions were arbitrary (Brace, 2005, 46). Ironically, Blumenbach's five types served as the building blocks for classifying human difference for the next 200 years (Brace, 2005, 46).

Georges Cuvier (1769-1832), the French naturalist and comparative anatomist best known for his work in vertebrate paleontology was a dominant figure in early 18th century anthropology and natural history (Douglas, 2015, 5). His predominant focus was on race which he defined as "the permanent inherited physical differences which distinguish human groups," (Stocking, 1968, 30). Although his conservative religious background rendered him a monogenist, Cuvier established many of the tenets of 19th century polygenism. He believed in the fixity of species and denounced Lamarckian notions of the role of environment in establishing human difference, favoring a theory of aboriginal variation (Douglas, 2008, 59). He classified humans into three distinct races (Caucasic, or white; Mongolic, or yellow; Ethiopic, or black) based on cranial morphological differences, a practice that continued into the mid-19th century (Douglas, 2008, 41 & 45, Stocking, 1968, 39). In particular, Cuvier utilized Camper's measurement of the facial angle to morphologically differentiate races (Stocking, 1968, 29-30). His stance on human hybridity, as defined in his *Discours sur les révolutions du globe* (1826), also persisted into the next era as he

argued that the species are alterable only by mixing, which nature has taken care to avoid by establishing a "mutual aversion" between separate species (Blanckaert, 2003, 48).

Georges-Louis Leclerc, Comte de Buffon (1707-1788), was a French naturalist who, in his *Histoire naturelle, générale et particulière* (1749), went against Linnean abstraction and asserted the reality of species (*espèce*) which he defined as a concrete category of individuals who are interfertile (Douglas, 2008, 36; Blanckaert, 2003, 44). Extrapolating this definition to humans, Buffon contended that due to their ability to freely reproduce, all human beings belonged to one single species. As a monogenist, he believed that all human diversity was the result of climate-induced degeneration from a primordial form (Blanckaert, 2003, 44-5). Buffon was among the first scholars to engage with the question of human hybridity[1], insisting that no mixed-race individuals (*métis*) are entirely infertile, but rather possess varying degrees of hybridity (Blanckaert, 2003, 45). He developed this idea further through experiments in animal breeding and determined that the degree of fertility of both pure and mixed species was dependent on the similarities (*convenances*) shared by the parent species. Thereby, he redefined species as the number of similarities or dissimilarities (*disconvenances*) which differentiated them (Douglas, 2015, 5). Buffon's legacy for 19th-century monogenism was based on two key concepts: that the human species was entirely interfertile; and that miscegenation improved a species (Douglas, 2015, 5).

In many ways, Buffon's disciple, Julien-Joseph Virey (1775-1846), acted as his foil. Virey distinguished species based on phenotypic characteristics, rather than reproductive capabilities (Douglas, 2008, 50). As a polygenist, he was an advocate of Voltaire and Lord Kames and divided the genus *Homo* into two species, the first including white, yellow, and brown races, the second including black and "'blackish'" races (Bernasconi & Dotson, 2005, vii; Stocking, 1968, 39;

Brace, 2005, 41). He believed in the fixity of species and denied the effects of climate on diversity (Douglas, 2008, 50). Although he agreed with Buffon's take on the fecundity of human hybrids, Virey spun his mentor's focus on interfertility to invalidate the unity of the human species. He argued that since adjacent animal and plant species were capable of producing fertile offspring, thus the creation of new human species was plausible. Whereas Buffon asserted the ameliorative effects of miscegenation, Virey was equivocal in regard to the adequacy of cross-bred individuals (Douglas 2008, 61).

Often considered Broca's greatest inspiration, Samuel George Morton (1799-1851) was a prominent Philadelphia physician and perhaps the most influential polygenist of his time (Brace, 2005, 78; Stocking, 1968, 39). Considered to be the Founder of the American School of Anthropology, Morton adopted Blumenbach's five races but, lamenting that he did not possess a cranium representing each variety, began to compile his immense cranial collection that would come to be known as "The American Golgotha," (Brace, 2005, 81). Meticulously documented and researched, the Morton collection contains skulls from across the globe and became the basis for Morton's major anthropological works, *Crania Americana* (1839) and *Crania Aegyptiaca* (1844). Although his racial categories were adopted from those of Blumenbach, Morton believed in primordial differences between human races (Brace, 2005, 83-4). As he continued to study human variation, he obfuscated his definitions of "race" and "species" such that "any possible distinction between 'race' and species had vanished," (Brace, 2005, 86). Morton began his studies on human hybridity in an attempt to develop a more adequate definition of "race". In his 1846 treatise, *Hybridity in Animals, Considered in Reference to the Question of the Human Species*, Morton refutes the notion of fertile offspring as the touchstone of species, arguing instead that "the mere fact that the several races of mankind produce with each other, a more or less fertile progeny,

constitutes, in itself, no proof of the unity of the human species," (Morton, 1846, 211-2). Morton favored a differential fecundity of hybrids and the "degrees of hybridity" which he developed served as the basis for Broca's expansive study on human hybridity (Douglas, 2008, 66-7).

Among Morton's American supporters was Josiah Clark Nott[2] (1804-1873), a prominent polygenist and physician from Mobile, Alabama. Nott, along with George Gliddon (1809-1857), continued the tradition of the American School of Anthropology after the death of Samuel George Morton in 1851 (Brace, 2005, 93). In their co-edited polygenist manifesto, *Types of Mankind* (1854), they maintained Morton's assertion that different human groups represented separate species (Bernasconi & Dotson, 2005, xiv; Blanckaert, 2003, 56). Their primary goal was to prove the plurality of human species, thus establishing a scientific basis for chattel slavery in the American South (Bernasconi & Dotson, 2005, xvi). Nott recognized that the question of polygenism was entangled with that of hybridity and, drawing from census data, sought to break down the monogenist argument of interfertility "on the basis of weakened progeny" of whites and blacks (Bernasconi & Dotson, 2005, xiv & viii).

Etienne Serres (1786-1868) and Armand de Quatrefages (1810-1892) were among Broca's French contemporaries whose monogeny was in stark contrast with Broca's polygeny (Douglas, 2008, 56). In 1839, Serres was appointed chair of "'anatomy and the natural history of man'" at the *Muséum national d'histoire naturelle* where he lectured on racial classification and sought to improve the anthropological collections at the museum. In 1855, he stepped down as chair, renamed the position to include "'anthropology and the natural history of man'", and appointed Quatrefages as his replacement. By that time, the museum's anthropological collection was the largest in the world and was only expanded upon by Quatrefages who, alongside his assistant E.T. Hamy, published *Crania ethnica* (1882), an oeuvre dedicated to skull types, much like Morton's

Crania Americana and *Crania Aegyptiaca* (Williams, 1985, 340-1). Quatrefages was, in many ways, Broca's chief rival. Just as Broca appropriated the monogenist claim of indefinite fertility of hybrids to support his polygenist agenda, Quatrefages' 1869 anthropology course at the Muséum and his publication *L'espèce humaine* (1877) relied on miscegenation to refute polygenism in favor of a unified human species (Douglas, 2015, 10). Quatrefages explicitly defined the distinction originally made by Buffon, that a métis was the fertile offspring of two distinct races, whereas a hybrid was the infertile offspring of two distinct species (Douglas, 2015, 4). These categories were often conflated by polygenists, namely Broca, who freely used the term hybrid, but distinguished between degrees of fecundity (see, for example, Broca, 1877, 327).

Joseph Arthur, Comte de Gobineau (1816-1882), French aristocrat and social thinker, published in four volumes (1853-55) his *Essai sur l'inégalité des races humaines*, a work which won him the nickname "the father of racism" (Douglas, 2008, 66; Brace, 2005, 119). In Gobineau's ideology, the white, or Aryan, race was the founding race from which all other populations were derived (Brace, 2005, 120). Although he rejected polygenism for its discontinuity with the Catholic story of creation, he believed in the hierarchy and permanence of racial types and was strongly opposed to racial mixing (Brace, 2005, 120-1). To Gobineau, hybrids were always inferior to the pure races of their parents, incapable of reproducing on their own (Gobineau, 1855, 397-8; Douglas, 2008, 66). He believed that miscegenation was a precursor to degeneration and sterility, both of which signified the end of civilization (Blanckaert, 2009, 94). Though popular in Europe, Gobineau's work gained its largest following in America where the issue of slavery was approaching its apex (Brace, 2005, 121).

Though their conflicting views of human origins put polygenism and monogenism in direct opposition, many of the nuances of each argument could be adopted by either side. Both theories

were compatible with different views on the fixity of human types, the role of the environment in changing human form, and the possibility of compatible hybrids.

HISTORY OF MEASURING HUMAN FORM

As the desire to understand human variation grew, anatomists developed methods of measurement to systematize it. The earliest attempts to quantify human difference can be traced to the 4th century BCE, when Aristotle used the facial angle as an indicator of intelligence (Haller, 1971, 9). Aristotle did not record systematic measurements of this feature, which was left to 18th century Dutch painter and anatomist Petrus Camper (1722-1789). The facial angle, as defined by Camper, is the angle made between the line tangent to the forehead and through the upper lip (the facial line) and the line from the base of the nose to the ear canal (Figure 2) (Brace, 2005, 33). The ancient Greeks gave their statues a superhuman facial angle measuring 100 degrees, setting an exaggerated standard for human perfection (Haller, 1971, 9). Camper revitalized this practice in 1784 after Linnaeus called for a method "by which to distinguish between Man and Ape," (Haller, 1971, 9; Brace, 2005, 33). Camper measured the skulls of Europeans, Africans, central Asians, a monkey and an orangutan and came to conclusions that were readily accepted by the scientific realm (Brace, 2005, 33; Haller, 1971, 9).

Camper determined that the human facial angle ranged from 70 to 80 degrees; "everything above eighty degrees belonged to the realm of art, everything below seventy degrees to the animal kingdom," (Brace, 2005, 33). He also claimed that the facial angle of the African skull bore a considerable resemblance to the orangutan and such strong low-face prognathism was associated with stupidity (Brace, 2005, 33; Haller, 1971, 9-11). Camper's facial angle was the first attempt to demonstrate explicit morphological differences between the races and establish that cranial measurements could determine intelligence and morality (Stocking, 1968, 29-30). His

measurements were to quantify Linnaeus' Great Chain of Being in which 'the further a race departed from the ideal form represented by Greek statuary, the lower it must rank on the scale of humanity," (Brace, 2005, 33; Meijer, 1991, 6). Despite his own monogenist beliefs, by 1860, Camper's facial angle became a commonly used method of distinguishing and ranking human species (Meijer, 1991, 5; Haller, 1971, 11).

As the field of craniometry formed, studying the brain became popularized. Some anatomists who dabbled in phrenology[3] transitioned to measuring cranial capacity. The first to do so was German anatomy and physiology professor Friedrich Tiedemann (1781-1861) (Brace, 2005, 75).[4] Tiedemann, who viewed the brain as "the noblest part of the body," published in 1836 *On the Brain of the Negro, compared with that of the European and the Orang-Outang*,[5] his study of the brain sizes of Blumenbach's five races (Tiedemann, 1836, 498; Brace, 2005, 75). He procured his information in two ways. First, he simply weighed the brains (Tiedemann, 1836, 500). He then measured cranial capacity by weighing the empty skull, filling it with millet-seed through the foramen magnum, re-weighing the filled skull, and subtracting the empty weight from the filled weight (Tiedemann, 1836, 504). After conducting both experiments, Tiedemann found that the skulls of the "Ethiopian race" are generally no smaller than those of other races and condemned the naturalists[6] who argued otherwise (Tiedemann, 1836, 511).

Ironically, Samuel George Morton, Tiedemann's contemporary, used the same method of measuring cranial capacity to rank the five races based on brain size (Gould, 1981, 51; Morton 1839). He initially used white mustard seed, instead of Tiedemann's millet, to measure cranial capacity by filling the cranium with sifted seed and then pouring the seed back into a graduated cylinder to measure the cranial volume in cubic inches. He soon discovered that the seeds did not pack well, when he was unable to replicate his results, so he switched to ⅛" diameter, BB-sized

lead shots and received consistent measurements with an error of no more than one cubic inch for any given skull (Gould, 1981, 53). Morton published the resultant measures of hundreds of crania (as well as the facial angle for the same specimens) in three major works, *Crania Americana* (1839), *Crania Aegyptiaca* (1844), and his *Catalogue of skulls of man and the inferior animals* (1849). From his measurements, Morton developed a hierarchy of Blumenbach's five races and twenty-two subgroups based on his measurements of brain size, setting the stage for Broca to develop his own methods of quantifying racial difference (Gould, 1981, 53-4).

In 1842, Swedish anatomist Anders Retzius (1796-1860) developed the cranial index, a new technique of craniometric measurement, which he defined in his 1843 book *Om Formen paa Nordboernes Cranier* (Carson, 2007, 102; Andreassen, 2015, 38). The index was the ratio between the width and length of the head, effectively measuring the relative size of the anterior lobes of the brain. From these measurements, Retzius divided crania into two types: dolichocephalic (long-headed) and brachycephalic (round-headed) (Carson, 2007, 102). He contended that his ancestors, the Nordic peoples, were descended from the dolichocephalic Bronze Age Europeans, whereas all non-whites were descended from brachycephalic Stone Age Europeans (Andreassen, 2015, 39). The cranial index garnered the most attention when Retzius argued that the Swedes and other long-headed blonde-haired Aryans were intellectually and morally superior to all other Europeans because of their highly developed anterior lobes (Carson, 2007, 102). In fact, one of Broca's first forays into anthropometry was revisiting the cranial index in a study of Basque skulls (Carson 2007, 102; Schiller, 1979).

BROCA AND HYBRIDITY

For Broca, the question of the plurality of species was inseparable from the question of human hybridity. He called his *Mémoires sur l'hybridité* (1877), the republication of his major

work on hybridity, a "*plaidoyer polygéniste*", or a polygenist appeal (Broca, 1877, 321). He did not want to deeply explore the conflict between monogenism and polygenism, he simply wanted to put monogenist reasoning in contestation with the facts and thus prove that their doctrine of the unity of the human species was hypothetical, arbitrary, and uncorroborated (Broca, 1877, 408). Broca believed that the human species had already undergone all possible changes and constantly cites the continuity between modern Egyptians and their depictions on ancient Egyptian monuments, following Morton (1844), as evidence that distinct types have existed since time immemorial (Broca, 1877, 334, 346-7). Broca splits the opposing monogenist view into two camps: those that adhere to the Biblical time scale and those who believe in deeper time (Broca, 1877, 348). He starts his attack with the first group who believes that the black race is a result of the curse of Noah on his second son, Ham (Broca, 1877, 348). Hearkening back to his Christian upbringing, Broca recounts the story, noting that the curse only mandates servitude and says nothing about skin color. He shames the monogenists that used this story to justify slavery, a practice that Broca did not support (Broca, 1877, 349-50).

The second group of monogenists suggests that climate is the cause of phenotypic variation (Broca, 1877, 349). Broca argues that the time-frame accepted by these Christian monogenists requires racial differentiation to occur post-flood, that is, within 300-400 years. He argues that Europeans have been in tropical climates for similar amounts of time and have not begun to transform into Africans (Broca, 1877, 351). He begins to refute this claim with skin-tone, which he finds to be the most striking difference between races (Broca, 1877, 353). If the monogenists were right in stating that latitude is responsible for these differences, one would expect to see a single, consistent cline of skin color variation. Broca disproves this theory with numerous Native American and African populations whose skin colors are not distributed in a light-to-dark/north-

to-south pattern (Broca, 1877, 362-4). He then introduces hair texture as a marker of distinct species (Broca, 1877, 372). Broca posits that the monogenists, who argue again for the effects of climate, must recant because not all dark-skinned people have what they refer to as woolly hair (Broca, 1877, 380).

To regain legitimacy, the monogenists developed a new, more scientific argument for the unity of the genus *Homo*. They state, "All the human races descend from one common origin and belong to the same species because they are all capable of producing fecund cross-breeds with one another," (Broca, 1877, 408, translated by the author). Broca was unconvinced, and sought to discover whether this definition of species was real, or invented by the monogenists to support their agenda (Broca, 1877, 322). It is this question that he tackles in his major work on hybridity, *Recherches sur l'hybridité animale en général et sur l'hybridité humaine en particulier considérées dans leurs rapports avec la question de la pluralité des espèces humaines* (1858-1860).

Broca defines hybridity as "the crossing of species", but posits that this definition is only appropriate if a species can be defined based on precise anatomic characteristics and are thought of as immutable, a feat which has not yet been accomplished (Broca, 1877, 411). Thus, he believes that making "hybridity the touchstone of species and species the touchstone of hybridity", as Buffon did, is "turning in a vicious circle" (Broca, 1877, 411, translated by the author). Broca does not seek to claim that hybridity has no relation to the question of species, but rather argues that it is evidence against, not in favor of, this definition. According to Broca, when two individuals are incapable of producing offspring or produce offspring with limited fertility, they clearly belong to two distinct species. But when they produce offspring that are freely fertile with each other, this does not necessarily prove that they are of the same species, but rather that their genitals are compatible (Broca, 1877, 411). Broca gives this compatibility the name *homœogénésie*, which he

defines as “a similitude in reproductive function” of which there are various degrees (Broca, 1877, 418). With the introduction of this term, Broca begins to present his rules on hybridity.

Broca contends that the most important condition to produce hybrid offspring is comparable gestation periods (in mammals) and incubation periods (in birds) (Broca, 1877, 425). Only when this condition is met can progeny be produced. When a male from species A can produce offspring with a female from species B and a male from species B can produce offspring with a female from species A, this is an example of *bilateral hybridity*. When a male from species A can produce offspring with a female from species B, but a male from species B cannot do so with a female from species A, this is called *unilateral hybridity*. Broca attests that the more dissimilar the species, the less the degree of *homœogénésie*, but it is no more possible for proximate species to produce offspring than it is for distant ones (Broca, 1877, 421). Thus, the only way to fully understand hybridity and *homœogénésie* is to abandon *a priori* reasoning for *a posteriori* methods and methodically study the formation of hybrids (Broca, 1877, 426).

For Broca, “*homœogénésie* is directly proportional to the degree of perfection of the hybrids” (Broca, 1877, 426; translated by the author). He defines a perfect hybrid as one that is either equal to or better than one or both parent races. It can perpetuate its own race, as well as breed with the parent races to produce offspring (Broca, 1877, 426-7). On the other hand, an imperfect hybrid is one that is always inferior to the parent species, incapable of reproducing, and, borrowing from Nott’s views on hybridity, the most imperfect hybrid is weaker than the parent species (Broca, 1877, 427). Based on this scale, Broca defines the highest form of *homœogénésie* as “*homogénéité complète*” (complete homogeneity) and the lowest form as “*hétérogénésie*” (heterogenesis), or “absolute sterility” (Broca, 1877, 428). Broca places all hybrids somewhere between these two limits (Broca, 1877, 428).

According to Broca, the lowest form of hybridity, which he hesitates to define as a degree on the basis that it is "hypothetical", is *l'hybridité abortive* (abortive hybridity), which is when the crossing of two species results in a miscarriage or stillbirth. Broca calls this the "transition between *hétérogénésie* and *homœogénésie*" because progeny is produced, but does not come to term (Broca, 1877, 428). Broca establishes and outlines four degrees of hybridity (Figure 3), which he adapted from those of Samuel George Morton (1850, 9) (Figure 4) (Broca, 1877, 433-4). He explains the differences between his four degrees of hybridity and Morton's and describes why he chose to change Morton's classifications in the way he did (Broca, 1877, 432-3). Broca's and Morton's first degrees of hybridity are identical, Broca simply gave Morton's a proper name (agenesic). Broca split Morton's second degree into dysgenesic and paragenesic hybridity because he found that their pattern of fertility was distinct enough to justify separate classifications. Morton's third and fourth degrees correspond to Broca's eugenesic hybridity. He finds Morton's division into two groups "entirely insufficient", arguing that this distinction was "evidently no more than a sacrifice to the demands of the moment"[7] and that "the fourth degree of hybridity is entirely imaginary" (Broca, 1877, 433-4; translated by the author).

Broca divides his four degrees into two distinct classes: *l'hybridité inférieure* (inferior hybridity), which includes the first two degrees (agenesic and dysgenesic); and *l'hybridité supérieure* (superior hybridity), which includes the last two degrees (paragenesic and eugenesic) (Broca, 1877, 434). Broca attests that the two types of inferior hybridity have no influence on the parent species, whereas the two types of superior hybridity can modify a species by creating new races, thus falsifying the doctrine of the permanence of species (Broca, 1877, 434).

Though Broca attests that paragenesic hybrids are able to generate new races, he admits that the creation of a permanent type has yet to be supported by evidence. Instead, what is observed

is a *croisement de retour* (back crossing), when the hybrid offspring of the first generation mates with one of the parent species and produces a hybrid offspring of the second generation that is two parts parent species, and one part hybrid. If the crossings continue to follow the same pattern, the offspring will eventually revert to the parent species with which it has been crossed (Figure 5) (Broca, 1877, 437, 454). On the contrary, eugenesic hybridity can create new races (Broca, 1877, 445). To demonstrate this fact, Broca cites numerous examples of eugenesic animal hybrids, such as dogs and wolves, sheep and goats, one-humped and two-humped camels, and llama, alpaca, and vicuña hybrids, all of which can reproduce freely, but are clearly members of distinct species (Broca, 1877, 453, 448, 457, 460-1). To understand and describe these hybrids, Broca mentions a number of observational methods, including counting the ribs of half-breed buffaloes to see whether they take after the mother or father species and whether there is a difference in rib-count in first or second generation hybrids (Broca, 1877, 443-4). He also cites the abbot Molina who, in his *Histoire naturelle du Chili* (1782), describes the differences in wool texture of the cross-breeds of goats and sheep (Broca, 1877, 448).

It is worth noting that for most of these examples, Broca cites the experiments of other naturalists, most often his fellow Frenchman, Comte de Buffon. Broca's first, and most impactful, hands-on experience with hybrids was with crossing hares and rabbits, giving rise to a hybrid which Broca named *léporides* (leporids[8]) (Broca, 1877, 475, 468). Broca asserts that the hare and rabbit are clearly distinct species, going so far as to say that "it seems superfluous to prove" it (Broca, 1877, 468; translated by the author). They differ in their social behaviors (hares are solitary, rabbits are social), their habitat (hares live out in the open, whereas rabbits live in the bushes, hares have larger ears and longer back legs, thicker skin, and coarser hair (Broca, 1877, 468-70). Broca states:

> The difference in their forms, in their coat, in their flesh, in their smell, in their fecundity, in their intelligence, in their habits, cannot be attributed to accidental influences: it is the work of nature, and no one would ever dream to find two species so distinct that could come from a common origin (Broca, 1877, 470; translated by the author).

Despite being natural enemies, the hares and rabbits have an identical gestation (thirty days), and thus can be bred in captivity (Broca, 1877, 469, 425). In the 18th century, Buffon attempted this crossing to no avail, but the first successful crossing of a hare with a rabbit was recorded by the naturalist abbot Carlo Amoretti whose experiments suggested paragenesic hybridity between the two species (Broca, 1877, 471-2). Broca was not the only of his 19th century contemporaries to consider the hybrids of hares and rabbits; Samuel Morton, the biggest influence on his hybridity studies, was presented the hides of an unknown species of the genus *Lepus* by John Bachman, who claimed that they were a new hybrid species, an assertion that Morton accepted (Broca, 1877, 474).

Broca first became involved with the leporids in October 1857 when his friend, M. Léonce Bergis, presented him two female hybrids of the first generation (half hare, half rabbit) and one male hybrid of the second generation (three-quarters hare, one quarter rabbit) which he had brought from Angoulême where a man by the name of M. Alfred Roux had been breeding them since 1850. Each of the females had five young, each of which was five-eighths hare and three-eighths rabbit. M. Bergis gave Broca one of these young hybrids, which he brought back to Paris where it was raised in the Jardin des Plantes by Broca's colleague, M. Vulpian (Broca, 1877, 475). After establishing the existence of the leporids, Broca wanted to better understand their fertility, so he went to Angoulême that same month (October 1857) to meet with M. Roux (Broca, 1877, 475-6). Upon arrival, he found that the hybrids had reproduced to the sixth or seventh generation and he could immediately see varying degrees of hybridity amongst them and three or four types intermediate to the parent species. Broca states that at this moment he could not help but think of the public festivals in Havana "where men of all colors, from white to black, mix and collide,"

(Broca, 1877, 476; translated by the author). M. Roux continued his breeding experiment and by March 1859, he had reached the tenth generation of leporids. M. Roux had succeeded in creating a new race that was not only, in Broca's opinion, stronger and more beautiful than either parent species, but he had created a eugenesic hybrid race that was able to proliferate on its own, proving that distinct species are able to produce fertile offspring, thus invalidating the assertion that hybridity can serve as the touchstone of species (Broca, 1877, 476, 485).

Broca presents his leporid before the Société de Biologie in 1858 and was promptly told to discontinue his study because it presented a threat to Biblical creationism and "was in contradiction with the law of species" (Brace, 2005, 148; Broca, 1877, 323). Broca was shocked and became skeptical of the monogenist definition of species. In his memoir he says, "What I did not know is that the definition of species based on interfertility had become a dogma and that everything, up until my evidence, had to bend before it; for is there anything more evident than the species-level difference between the hare and the rabbit?" (Broca, 1877, 324, translated by the author). Broca realized he either had to abandon his study and give up on the possibility of studying the hybridity of the human genus, or found a new society where he was free to study whatever he pleased. Therefore, in 1859, he founded the Société d'Anthropologie *de Paris* whose main purpose was "the scientific study of the human races" (Broca, 1877, 325; Société d'Anthropologie de Paris, 1864, v). Hybridity was the foundation upon which his society, and French anthropology as a discipline, was built and after presenting his first major work, *Recherches sur l'ethnologie de la France*[9] (1859) before the Société, his primary focus became the study of human hybridity (Brace, 2005, 149; Broca, 1877, 516).

Des phénomènes d'hybridité dans le genre humain the third and final part of Broca's *Mémoires sur l'hybridité* (1877) was published in two parts from 1859 to 1860 and translated into

English as *On the Phenomenon of Hybridity in the Genus* Homo for the Anthropological Society of London in 1864. Having completed his studies on eugenesic hybridity in animal species, Broca's goal is to show that the human races are subject his four degrees of hybridity and to use this differential fertility to prove the plurality of human origins. To understand Broca's argument, one must first understand what he means by "race". To differentiate between two races, Broca says that "a single character, however slight, is sufficient, provided it be hereditary and sufficiently fixed," (Broca, 1864, 7). There are, thus, an immense number of human races, but they tend to naturally separate into groups, or "types", based on broadly shared characteristics (Broca, 1864, 7-8). Broca defines type as "the ensemble of the characters common to each group" and bases his "types" on Blumenbach's five races (Broca, 1864, 8). He insists that types are nothing more than abstractions and although an individual may belong to a certain type, no individual will ever personify the type to which it belongs (Broca, 1864, 8). Ironically, given his penchant for conflating terms such as hybrid and métis, Broca criticizes those polygenists who conflate race with type because if they argue, for example, that a light-haired German and a dark-haired Celt belong to the same race, then there is nothing stopping monogenists from arguing that a Celt and a Berber belong to the same race (Broca, 1877, 503). Finally, Broca stresses the care one must take when using the word "species" which refers to "both the idea of a special confirmation and a special origin" (Broca, 1864, 11). Many polygenists refrain from using the term "species" because they believe in the plurality of human origins, thus rendering it impossible of determining every primitive stock and its characteristics (Broca, 1864, 11). Other polygenists, whom Broca has deemed "pentagenists" use Blumenbach's five races to constitute five distinct, primitive stock, whereas monogenists argue that these five races all emerged from the same primitive stock (Broca,

1864, 12). Broca ascribes to the polygenist approach and uses race, rather than species, to refer to the different human groups (Broca, 1877, 508).

At the start of his treatise, Broca cites Gobineau who, in his *Essai sur l'inégalité des races humaines* (1855) attests that the crossing of human races "constantly produces disastrous effects and physical or moral degradation is sooner or later the inevitable result," (Broca, 1877, 493). Broca admits that he does not share this view and goes against those who believe that no mixed race is capable of self-preservation (Broca, 1877, 493). He argues instead that, much like the animal species he studied, human races reproduce with varying degrees of *homœogénésie*, and thus some crossings are entirely eugenesic, others occupy an intermediate paragenesic or dysgenesic space, and others are potentially agenesic (Broca, 1877, 508).

Drawing from the teachings of his teacher and companion, Pierre Nicolas Gerdy, Broca contends that most races, including the French, have arisen from the eugenesic crossing of two or more races (Broca, 1877, 509). He does not extend this degree of *homœogénésie* to all races of men, however, and only mentions Caucasian races in this section on eugenesic hybridity (Broca, 1877, 517). Citing other naturalists and anthropologist, he discusses a unilateral hybridity between Negro[10] and Caucasian races. Broca attests that the union of a Negro man with a Caucasian woman is often sterile, whereas the union of a Caucasian man with a Negro woman is entirely fertile (Broca, 1877, 521). The mulatto offspring of these unions are extremely fertile when mixed with either one of the parent races, constituting paragenesic hybridity like that which Broca observed between animal species (Broca, 1877, 523). Broca remains objective in his exploration of human hybridity and is hesitant to accept explanations for why certain mixed races are unable to proliferate, either because there is not enough evidence or because he does not believe that the authors he cites consider all potential influences on or barriers to fertility[11]. He also finds that, just

as in animals, proximate races of humans do not necessarily produce more fertile offspring than more distant races, but, instead, citing M. Omalius d'Halloy, President of the Belgian Senate, claims that the most distant races (the Europeans and the Tasmanians) produce weak and sterile offspring bilaterally, thus representing agenesic human hybridity (Broca, 1877, 537, 542). Broca takes a more pragmatic approach to this claim, arguing that he does not have enough information to explicitly argue that the Australian mulattos are inferior hybrids, so he calls upon all physicians and travelers to go to Australia and observe the patterns of racial mixing (Broca, 1877, 555). Broca sums up his study on human hybridity in an eight-point list of observations (Figure 6). It is important to note that Broca presents very few of these assertions as facts, but rather expresses a need for more data and more observation to fully form his opinions (Broca, 1864, 60).

Broca concludes his memoir by stating that the human group is one genus made up of multiple species (Broca, 1877, 556). By proving that not all human intermixtures are eugenesic, he feels he has overturned the monogenist doctrine which argues, based on the belief animals that produce eugenesic offspring are of the same species, that human crossings are entirely eugenesic and thus humans belong to a single species (Broca, 1877, 559, 561). It may come as a shock that Broca ends his long treatise on hybridity, whose polygenist agenda often labels it a racist manifesto, by stating, "It might be said that the polygenist doctrine assigns to the inferior races of humanity a more honourable place than in the opposite doctrine. To be inferior to another man either in intelligence, vigour, or beauty, is not a humiliating condition," (Broca, 1864, 71). As he begins to expand his methods of experimentation, it becomes evident that Broca's only goal is to prove there is a primordial difference between the human races.

BROCA AND ANTHROPOMETRY

Before becoming a physician and anthropologist, Paul Broca initially studied for a bachelor's degree in mathematics (Schiller, 1979, 14). He is quoted saying, "A number is always better than an assertion: it leaves a more durable imprint on the memory," (Blanckaert, 2009, 122, translated by the author). This background and appreciation for quantitative data underlies much of his approach to anthropology and explains why he developed such comprehensive anthropometric measurements after his first foray into craniometry.

As a medical student, Broca wrote to his father, "Currently, I am studying the skull. I do not find osteology very amusing. Besides being a drudgery, it offers the disadvantage of being so easily forgotten. But I must get through it," (Broca, 1886, 30, translated by the author). Ironically, he would go on to become one of the most important craniologists of 19th century anthropology. Just over a year later, he wrote his mother of his growing taste for natural history and anatomy, claiming to like them "just as he once liked mathematics, because they gave him results that satisfied his mind," (Broca, 1886, 131-2, translated by the author). By combining his objectivity with his studies of anthropology, Broca became especially interested in analyzing anatomical and morphological variation, most importantly the facial angle, the brain, and craniology, but also other physical characteristics such as size, skin tone, and body hair (Broca, 1871, 7). For traits such as eye color, skin color, and hair texture, which are not measurable in the traditional sense, Broca created scales on which to place individuals and satisfy his need for systematization (Figures 7, 8) (Broca, 1865, 137). It was only after he finished publication of his treatise on human hybridity that Broca began to experiment with measuring skulls and bodies. Whereas in controlled experiments, Broca was able to categorize animal hybrids as intermediates between the parent species in terms of color and hair growth pattern, this was harder to accomplish with human crossings and he had to develop more exact ways of identifying hybrids (Broca, 1877, 491).

As a neurosurgeon, it is no surprise that Broca's first experience with anthropometry was measuring the size and the form of the brain. In 1861, he published *Sur le volume et la forme du cerveau suivant les individus et suivant les races*, in which he sought to answer whether intelligence is linked to the form of the brain, rather than size (Broca, 1861a, 3). Following Morton's method of measuring cranial capacity in cubic inches, Broca plugged all openings of the skull, but the foramen magnum, and filled the cranium with equal sized grains, achieving sufficiently precise measurements (Broca, 1861a, 46). Broca did find correlations between intelligence and cranial capacity, but he concluded that brain form was just as, if not more, important as cranial volume (Broca, 1861a, 50-1).

Broca's next experiment in craniometry was reworking the cranial index in an attempt to prove wrong Retzius' assertion that Basque skulls were brachycephalic (Carson, 2007, 102; Broca, 1862a, 1). Broca claims that the Basque are an autochthonous race predating the arrival of the Celts (Broca, 1862a, 2). After studying and measuring 60 skulls, Broca's results did not match up with Retzius' theory. He found very few brachycephalic skulls and the average cranial index was 77.67 (Broca, 1862a, 3). Broca criticizes Retzius for his lack of numerical data, which he believes have only relative value and could have been the reason the Basque were deemed brachycephalic (Broca, 1862a, 4). Broca reminds the reader that he had redefined the cranial index into pure dolichocephaly (under 75), sub-dolichocephaly (75-77.77), mesaticephaly (77.77-80), sub-brachycephaly (80-85), and pure brachycephaly (above 85). Based on these distinctions, none of the Basque skulls that he measured was truly brachycephalic, as the highest cephalic index only measured 83.24 (Figure 9) (Broca, 1862a, 6).

Broca not only expanded upon previously existing craniometric measurements, but he began to develop his own measurements, as well as various instruments to aid in anthropometry

(Broca, 1861b). Broca was the first to name singular points on the cranial vault, the same which are used today for craniometric data (Broca, 1862b). According to Broca, "the ordinary anatomic methods of measurement are entirely insufficient and in order to fruitfully compare species, races, and individuals, one must resort to using special instruments," (Broca, 1861b, 42, translated by the author). One such instrument was the *craniographe* (craniograph) which Broca developed to measure the auricular angles in order to map the curve of the skull and the placement of the auditory canals (Broca, 1861b, 44). Evidently, Broca had a very specific purpose in mind when developing this tool, but he also used it to obtain three other measurements which he equated with inferior or superior races: facial prognathism, anterior projection, and posterior projection (Broca 1861b, 60).

Shortly after developing the craniograph, Broca published *Sur les projections de la tête et sur un nouveau procédé de céphalométrie et d'anthropométrie* (1862c). In this work, rather than simply taking measurements, Broca is attempting to quantitatively define inferior and superior races and to do so, he borrows both Camper's facial angle and Gratiolet's three groups: frontal races (Europeans), parietal races (Mongolians), and occipital races (Negroes) (Broca, 1862c, 79; Broca, 1861a, 5l; Gould, 1981, 97). Preferring to call the measurement "anterior facial projection", rather than facial angle, Broca was measuring prognathism, which he associated with inferiority (Broca, 1862c, 86). Most likely due to his background in neuroscience, Broca quickly abandoned cranial capacity as a measure for intelligence in favor of the "'relative development of the parts of the brain'", where larger anterior portions are associated with intelligence, whereas larger posterior portions are associated with inferiority (Schiller, 1979, 151; Gould, 1981, 97-8). He thus focused on measuring the relative sizes of the anterior and posterior portions of the skulls of Europeans and Negros (Figure 10). He noticed that to make a Negro skull from a European, one must not

only increase the degree of facial prognathism, but also decrease the projection of the anterior lobe and increase the projection of the posterior lobe (Broca, 1862c, 92).

As he continued to study morphological differences between human races, Broca moved from taking just cranial measurements to measuring the rest of the body. His first instance of using postcranial data to compare races was in 1858 in the first part of the *Recherches sur l'hybridité animale.* . . He describes Negros as an intermediate form between apes and humans. He cites numerous anatomical measurements including pronounced facial prognathism, small facial angle and cranial capacity, and their relative forearm-to-arm lengths (Broca, 1877, 397). He took these measurements from skeletons in September 1858 and published them four years later in *Sur les proportions relatives du bras, de l'avant-bras et de la clavicule chez les nègres et chez les Européens* (1862) (Broca, 1862d, 164). Broca cites Charles White who determined that the forearm of the Negro is proportionally longer than that of the European (Broca, 1862d, 163). Broca's first set of measurements found that, on average, the radius of the Negro is longer than that of the European, both in males and in females (Figure 11) (Broca, 1862d, 165). Broca uses the marked differences in arm-to-forearm length to argue for primordial human difference by claiming that climate, which many believe is the reason for racial diversity, could not have played a role in altering these characteristics (Broca, 1862d, 168). He then chooses to determine whether an elongated radius is a sign of inferiority. Using Hottentots, Eskimos, and Australians as examples of inferior races, he finds that the radius of the Australian measures roughly the same as that of the shortest European and that they all measure shorter than that of the shortest Negro (Broca, 1862d, 169). Thus, Broca is unable to name an elongated radius as an inferior trait (Broca, 1862d, 169-70). Broca then moves to measurements of the clavicle, which are longer in both European and Negro women than they are in their respective male counterparts (Figure 12). Broca also observes

that the clavicles of Negros are longer than those of Europeans, demonstrating a larger racial difference than sexual difference in clavicle length (Broca, 1862d, 171).

In 1867, Broca, having been met with controversy for not taking his measurements from living individuals, publishes S*ur les proportions relatives des membres supérieurs et des membres inférieurs chez les Nègres et le Européens*, a work compiling every possible measurement from every skeleton in the Museum where Broca conducted the study for his 1862 publication (Broca, 1867, 641-2). He limits himself to discussing the arm, forearm, and clavicle in order to respond to his critics (Broca, 1867, 642). Though he is criticized for using skeletons rather than living people, Broca contends that only on a skeleton does one know the true superior and inferior limits of the long bones, allowing for more accurate measurements (Broca, 1867, 645). Broca measures the length of the upper limb in comparison to the length of the lower limb and, surprisingly, the highest median length measurement belongs to a European male (Figure 13). Broca asserts that the young male Negro individual whose long arm measurement raised the Negro average probably experienced arrested development in his lower limbs (Broca, 1867. 647). Broca explains that his results do not at all conform to the popular opinion of blacks being intermediate between the anthropoid apes and Europeans. Since the apes have much longer arms in comparison to their legs, this in humans is considered an inferior trait, but do Broca's measurements demonstrate the opposite? (Broca, 1867, 648) Broca then compares the length of the humerus to the length of the leg (Figure 14). The humerus length of Negros is considerably less than that of Europeans, which is not a shock if one considers that in black individuals, the radius is longer compared to the humerus than it is in European individuals. The radius of the Venus of Hottentot, a member of the Khoi people of South Africa, a race which is considered inferior to most, measures 41.20, higher than the average for male Europeans (Broca, 1867, 649).

Broca continues by comparing the length of the humerus to the length of the femur (Figure 15). Again, his measurements show that the Europeans have longer humerii across sexes and the Hottentot race measures more closely to the European than to the Negro type. Broca adds that in the anthropoid apes, the humerus is oftentimes equal in length or longer than the femur. In these measurements, he notes that the Negro differs more from the apes than does the European (Broca, 1867, 650). Broca concludes that the Negro is characterized by a short humerus when compared with the radius, with the lower leg, and with the femur. He then tries to determine whether this is the reason for the short upper limb measurements he has obtained from the Negro skeletons and expects to find that the radius is relatively the same length when compared to the lower limb (Figure 16). This is not the case, however, and Broca finds that the radius is longer in Negros than it is in Europeans, but they still have shorter upper limbs in comparison to their lower limbs (Broca, 1867, 651).

Broca summarizes his results in five points: 1) based on the comparative arm-to-leg length, the Negro is further from the apes than is the European; 2) based on the length of the humerus compared to that of the femur, the Negro is again further from the apes than is the European; 3) based on the length of the humerus compared to the radius, the Negro is closer to the apes; 4) the extreme length of the radius in comparison to the humerus depends, in some degree, on the shortness of the humerus and the radius of the Negro is longer than that of the European compared to the lower limb; and 5) the upper limb of the Negro both approaches the European type (radial length) and the simian type (humeral length) (Broca, 1867, 652-3). Broca accepts that in studying the skeleton one often finds mosaic characteristics, despite being a superior or inferior race. He mentions again that the Hottentot, which is well-understood to be inferior to the Negro, often

resembled the European type in its measurements. For Broca, this is clear evidence in support of the polygenist belief in the plurality of human origins (Broca, 1867, 653).

Surprisingly, Broca, unlike Morton, does not engage in anthropometry with a clear racist framework. In fact, he has stated, in reference to his measurements:

> Incidentally, we are not looking to establish the superiority or inferiority of this or that part of the genus Homo; we are only looking to see if Ethiopians and Caucasians could have the same origin and if the considerable differences seen in the cranial morphology of both types could be explained by anything but the diversity of human origins. The volume of the brain is nothing more than a question of curiosity for us. (Broca, 1858, 405).

This is in direct opposition with claims made by scholars, such as Stephen Jay Gould, who explicitly accused Broca of using "numbers not to generate new theories but to illustrate a priori conclusions," (Gould, 1981, 74). If this were true, Broca would have never published his 1867 anthropometric piece for it completely contradicted every pre-existing accepted notion of the inferiority of Hottentots and the intermediate placement of Negros between Europeans and the anthropoid apes. I argue instead that Broca was using numbers to generate new theories on human hybrids.

When conducting these anthropometric studies, Broca takes special note of hybrid individuals. For example, in his early facial projection measurements, he wonders where to classify intermediary types (Broca, 1862c, 87). Additionally, he measures the radii and humerii of a mulatto and mulatress when doing his preliminary anthropometric measurements of Negro and European arm bones in 1858. He finds that the individuals do not represent an intermediate form, but that the Negro characteristics have persisted, making Broca wonder whether upper limb length is one of the characteristics transmitted matrilineally, the first time he makes mention of such a theory of inherited traits (Broca, 1862d, 167). Broca measures the clavicle of the mulatress as well and gets a measurement longer than the median clavicle length of a pure race female Negro, more evidence that the mixed-race individual is not taking on an intermediate form, but adhering more

to the black race, which is probably that of her mother (Broca, 1862d, 171). He redoes these measurements in 1867 along with the other skeletons but does not discuss them in detail (Broca, 1867, 649). Interestingly, though Broca borrowed both his four degrees on hybridity and his method of measuring cranial capacity, from Samuel George Morton, Morton himself deliberately excluded hybrids from his craniometric samples as did his students, Nott and Gliddon, when they took over the American School of Anthropology after his death (Morton, 1849, ix; Nott & Gliddon, 1854, 371). Hybrids only become theoretically interesting with Broca and he is the first to attempt to quantify these hybrids, developing anthropometry to do so and dedicating twelve pages in his anthropological field guide to studying hybrids (Blanckaert, 2003, 61).

Broca's *Instructions générales pour les recherches et observations anthropologiques (anatomie et physiologie)* (1865/1879) is a compilation of all of Broca's observations of human physiology and measurements of the human body. It is unique in that it outlines how to study living people, rather than skeletal remains. In the twelve pages dedicated to hybrids, Broca establishes a guide to identify, measure, and evaluate racial métis. He poses a number of observations and tips for describing hybrids and then poses the question:

> Do métis of the first degree resemble one race more than the other, or do they present a more intermediate type? Describe the characteristics of this métis and document the on the individual observation sheets; one should not be limited to noting skin color, hair type, and facial morphology; one should practice measurements of the head, the trunk, and the limbs that are indicated in our table (Broca, 1865, 113).

Broca explicitly defines the link between the development of his anthropometric measurements and his desire to quantitatively measure and describe hybrids. It is worth noting that in his 1919 pieces on Anthropometry, Aleš Hrdlička, founder of the American Journal of Physical Anthropology and the first curator of physical anthropology at the Smithsonian Institution National Museum of Natural History, who mentions Broca as the "father of anthropometry", also mentions how to, if possible, recognize and identify mixed-race individuals. It is interesting, however, that

just forty years after the publication of the second edition of Broca's *Instructions générales pour les recherches anthropologiques à faire sur le vivant* (1879) that the progeny of members of different races are again being excluded from measurements (Hrdlička 1919, 187). Perhaps Broca's untimely death in 1880 is to blame for the sudden halt in studying hybrids (Schiller, 1979, 288). Though hybridity, both in animals and plants, had been studied for centuries before him, Broca was the most involved and attached to these studies and was the first to deliberately fashion categories of hybrids and develop measurements for their study.

MAKING UP PEOPLE

Ian Hacking is a Canadian philosopher of science who served as chair of Philosophy and History of Scientific Concepts at the Collège de France from 2001 to 2006, becoming the first Anglophone elected to a permanent chair in the Collège's history (Collège de France; Miller, 2006, 1480).

Both in his inaugural lecture at the Collège de France and in several papers, Hacking makes reference to a philosophical project aimed at the analysis of practices used in classifying people, how these classifications affect said people, and how these people then change their classifications (Hacking, 2006, 23). He maintains that people, and particularly scientists, sort people into finite groups based on particular characteristics with the goal of controlling, organizing, or simply understanding the groups of people under classification (Hacking, 2006, 23). For Hacking, though, the process is not unidirectional, since these classifications are interactive: the people we classify are "moving targets because our investigations interact with them, and change them" (Hacking, 2002, 11; Hacking, 2006, 23). This is what he calls the "looping effect", when the categories we impose on individuals change the ways in which they act, thus rendering the categories false,

requiring a historical perspective on the construction and application of classificatory concepts (Hacking, 2006, 23; Hacking, 2002, 11).

To understand the classifications of people and the looping effect, one must look to the philosophical debate between nominalism and realism. Nominalists are particularists and deny the reality of kinds of things and categories made to organize these kinds. Instead, they suggest that only the names applied to things are what groups of things have in common. Using stars as an example, an extreme nominalist would say that the only thing stars have in common is their name. On the contrary, a realist would argue that there is something inherent to all stars, some single characteristic or set of characteristics that are sufficient and necessary criteria for inclusion in to the class of "stars," justifiably situating them in that category (Hacking, 1986, 164). It is not hard to argue on the side of realism when dealing with some classifications of people, such as male or female, short or tall, fat or thin. But nominalism has its merits, especially when dealing with borderline cases such as hermaphrodites or people of average or middle height or weight (Hacking, 1986, 164-5). When discussing the categorization of people, Hacking adopts a position he calls dynamic nominalism, eschewing static nominalism and realism in preference of the claim that "a kind of person came into being at the same time as the kind itself was being invented" (Hacking, 2002, 10-11; Hacking, 1986, 165, 170). Hacking admits that this idea traces back to other thinkers, such as Friedrich Nietzsche (Hacking, 2006, 24). In his inaugural lecture at the Collège de France, Hacking quotes an aphorism from Nietzsche's *The Gay Science*: "Unspeakably more depends on *what things are called* than on what they are . . . creating new names and assessments and apparent truths is eventually enough to create new 'things,'" (Nietzsche, 1974 [1887] quoted in Hacking, 2002, 7). To Nietzsche, the act of classifying abstractions and giving them names creates real entities that did not exist before.

Classification is fundamental to the natural sciences and, according to Hacking, there has been a push in the human sciences, such as anthropology and medicine, to treat people as "objects of scientific inquiry" and classify them in the same way (Hacking, 2002, 11; Hacking, 2006, 23). He says, "Sometimes, our sciences create kinds of people that in a certain sense did not exist before. I call this 'making up people'," (Hacking, 2006, 23). To explain what he means by this, Hacking cites numerous clinical examples, one of which is multiple personality disorder, which experienced a sudden burst in diagnoses during the 1980s (Hacking, 2006, 25). Hacking presents two sentences:

> A. There were no multiple personalities in 1955; there were many in 1985.
>
> B. In 1955 this was not a way to be a person, people did not experience themselves in this way, they did not interact with their friends, their families, their employers, their counsellors, in this way; but in 1985 this was a way to be a person, to experience oneself, to live in society (Hacking, 2006, 25).

For Hacking, both A and B are true. Although some would disagree with the validity of A, whether due to a preference for the name Dissociative Identity Disorder, or simply because they do not believe the disorder exists, Hacking argues that everyone would agree with B. B is an example of making up people (Hacking, 2006, 25).

Hacking refers to multiple personality, or Dissociative Identity Disorder as a "transient mental illness", transient meaning of "existing only at a certain time and place" (Hacking. 2006, 3). These ideas of transience and historical context were deeply explored by French physician and philosopher of science, Georges Canguilhem (1904-1995) who theorized on the formation of a concept and the idea of historical epistemology, or the idea that "philosophical problems are inseparable from their historical milieu" (Méthot, 2013, 112). For Canguilhem, these "philosophical problems" include "genuine (scientific) concepts", which he defines as "dynamic and complex entities comprising three components: a phenomenon, a denomination, and a

definition" (Méthot, 2013, 112, 119; Schmidgen, 2014, 245). He contends that there is a strong relation between experimentation and the formation of concepts "that gestures towards the wider social and cultural contexts in which those processes operate" (Méthot, 2013, 120).

Hacking refers to multiple personality, or Dissociative Identity Disorder as a "transient mental illness", transient meaning of "existing only at a certain time and place" (Hacking. 2006, 3). These ideas of transience and historical context were deeply explored by French physician and philosopher of science, Georges Canguilhem (1904-1995) who theorized on the formation of a concept and the idea of historical epistemology, or the "a posteriori reconstitution of forms of knowledge in a given domain" (Méthot, 2013, 112-3). Canguilhem contends that there is a strong relation between experimentation and the formation of concepts and that in biology especially, "the core issue is perhaps not so much 'using experimental concepts' but rather 'experimentally constituting authentic biological concepts' (Méthot, 2013, 119).

Broca's and M. Roux's experiments crossing hares and rabbits to produce leporids were an attempt to establish the concept of animal hybridity. After M. Roux's breeding experiment was complete, Broca claimed that "the scientific experiment still leaves something to desire" (Broca, 1877, 476, translated by the author). He thus began to observe M. Roux's leporids of varying degrees in an attempt to systematically differentiate them from the parent species based on their physical appearance. He took note of their size, fur color and texture, ear length, and length of their hind limbs (Broca, 1877, 479-81). Eventually, Broca introduces several other measurements, such as nostril size, size of the head and eyes, and both absolute and relative (to the hind limbs) length of the forelimbs (Broca, 1877, 480-1).

Broca uses these observations as a launchpad for his study of human racial mixing. He admits that conducting similar breeding experiments on humans is both physically and morally

impossible, so one must observe the hybrids that emerge from the natural crossing of human races (Broca, 1877, 491). In the twelve pages dedicated to identifying hybrids in *Instructions générales pour les recherches anthropologique à faire sur le vivant (anatomie et physiologie)* (1865), Broca demands that hybrids be studied based on hair and skin color, hair texture, head size, body size, and limb lengths, the same qualities that he studied in the leporid hybrids (Broca, 1865, 113).

By applying his methods of studying animal hybrids and to the human domain, Broca demonstrates Canguilhem's notion of the "'filiation of concepts'" or "the historical process by which concepts emerge out of scientific ideologies and are captured by a theory or succession of theories" (Kritzman & Reilly, 2006, 469). The scientific ideology from which Broca's concept of hybridity emerges is the polygenesis of the human species, which he claims to have proven by demonstrating that distinct species can produce fully fertile young. The theories that Broca develops from his experimentation with hybrid leporids and his studies of human hybrids allow him to formulate new biological concepts, such as his four degrees of hybridity, which, according to Canguilhem, "are the result of newly opened spaces of experimentation and foster at the same time the developments of new forms of practice" (Méthot, 2013, 119). By experimenting with leporids, Broca introduced, and took advantage of, the possibility of studying human racial mixing, thus creating the concept of an identifiable human hybrid that can be systematically distinguished from the parent races through various measurements and physical observations.

Together, Canguilhem's and Hacking's ideas propose various methods by which concepts are created. By arguing that experimentation is the method by which concepts are formed, Canguilhem introduces one of the ways in which people are made up (Méthot 2013, 119).

Hacking presents a five-part framework for "making up people": "(e) the experts or professionals who generate (d) the knowledge, judge its validity, and use it in their practice. They

work within (c) institutions that guarantee their legitimacy, authenticity and status as experts. They study, try to help, or advise on the control of (b) the people who are (a) classified as of a given kind" (Hacking, 2006, 24). Operating within this five-part framework are several "engines of discovery" – that is, technoscientific imperatives -- that Hacking (2006, 1) suggests are used by the human sciences as "engines for making up people". Some of these engines are:

1. Count!
2. Quantify!
3. Create Norms!
4. Correlate!
5. Medicalise!
6. Biologise!
7. Geneticise! (Hacking, 2006, 6)

These engines are used to develop part (d) of Hacking's framework and can be associated with the experimentation that Canguilhem argues is key in the formation of a concept (Hacking 2006, 1; Méthot, 2013, 119).

With his studies on human hybrids, Broca was, in effect, "making up people". Extrapolating Hacking's five-part framework to Broca's 19th century work, we have (e) the expert, Dr. Pierre Paul Broca who introduced (a) the classification, the term "hybrid" which is used to describe (b) the people, which are mixed-race persons. The word was used to denote the crossing of individuals of different races as early as 1843 by Josiah Clark Nott, but it first appeared in the Oxford English Dictionary in 1861, the year following Broca's final publication in his series on hybridity, *Des phénomènes d'hybridité dans le genre humain* (1860) (Young, 1995, 6). The OED states, "A few examples of this word occur early in 17th cent.; but it was scarcely in use till the 19th" (OED). Before 1861, a human hybrid did not exist. The word of choice was "mongrel", "mixing", or "métis" (Young, 1995, 6; Douglas, 2015, Broca, 1858, 433). But Broca, who was known to conflate species and race, also conflated the terms mongrel, mixing, and métis with hybrid, thereby creating an entirely new way of naming and understanding human difference

(Broca, 1858, 433). The word hybrid's "appearance between 1843 and 1861, therefore marks the rise of the belief that there could be such a thing as a human hybrid" (Young, 1995, 6). This new scientific classification gave rise to a new social classification, which created the possibility for scientific *and* social changes that would affect and be affected by the mixed-race individuals who were the target of the classification.

Continuing with Hacking's framework, (c) the major institution in Broca's making up hybrids is the Société d'Anthropologie, which he founded with the sole purpose of continuing his work on hybridity after his preliminary papers were rejected and his research was halted by the Société de Biologie in 1858 (Schiller, 1975, 129, 130-1). Aside from his illustrious Société, in 1867, Broca created an anthropological laboratory dedicated to (d) the knowledge, or the science of anthropometry (Carson, 2007, 100). In producing fine distinctions among human hybrids, Broca needed more precise measures:

> As anthropologists moved from the classification of primary to secondary races, the number of morphological peculiarities necessary to separate races increased, and these were more and more subject to quantification. Color alone would usually distinguish Negro from Caucasian; but to separate Nordic and Mediterranean one must observe - and measure - not only pigmentation, but stature and headform as well" (Stocking, 1968, 56).

As he shifted his focus from intelligence to the more complex question of hybridity, Broca developed and applied these precise measurements – not just of the head, but of the entire body -- to not only distinguish between the races, but to scientifically analyze the products of their crossings.

Broca was the first to systematically quantify the human body, not just the cranium, and he developed these methods to better understand hybrids, a concept that depended upon as well as buttressed his fundamental belief in the plurality of human origins. No matter Broca's personal beliefs on racial equality[12] his scientific re-inscription of profound human racial difference introduced methods and concepts which extended racist science[13]. Although Broca's phrase

"eugenesic," and indeed his entire hybrid classificatory system, has been largely forgotten, it is notable that Francis Galton's word "eugenic" has a shared etymology. Galton coined this word in 1883, in his *Inquiries into Human Faculty and Its Development*, defining it as:

> the science of improving stock, which is by no means confined to questions of judicious mating, but which, especially in the case of man, takes cognizance of all influences that tend in however remote a degree to give to the more suitable races or strains of blood a better chance of prevailing speedily over the less suitable than they otherwise would have had" (Galton, 1883, 25).

Galton did not cite Broca in this work (although he did read him, e.g. Eaton 2013, 148), but the parallels between *eugenic* and *eugenesic* are striking. A few pages after the definition of "eugenic," Galton (1883, 40-41) laments the want of anthropometric laboratories and registers: "When shall we have anthropometric laboratories, where a man may, when he pleases, get himself and his children weighed, measured, and rightly photographed, and have their bodily faculties tested by the best methods known to modern science?" By 1865, Broca had developed these registers and opened such a laboratory in Paris by 1867, but it was not until 1883, three years after his death, that his measurements and methods were appropriated to support a racist agenda (Carson, 2007, 100).

CONCLUSION

In the historical background sections of this work, various 18th and 19th century views on human origins and variation were discussed in relation to Broca's own polygenist way of thinking. Then, the earliest attempts to measure human difference were mentioned as a preface to Broca's own experience with craniometry. The bulk of the paper focused on Broca's attempt to prove polygenism through his study on hybridity for which he developed his anthropometric measurements. The final section related Broca's attempts to identify hybrids to Georges Canguilhem's ideas on concept formation and Ian Hacking's "making up people", arguing that Broca developed anthropometric measurements to systematically categorize human hybrids, thus

"making up" a human hybrid, a concept that did not exist before. Although studies of hybridity did not continue after his death, Broca's word "eugenesic" was appropriated by Francis Galton to coin the term "eugenics" and Broca's anthropometric methods were used by others in racist science.

Although in secondary literature Broca is often portrayed as a racist who uses his measurements to prove *a priori* expectations, perusal of the primary literature shows that he was perhaps the purest scientist of the 19th century. He developed precise measurements in order to quantify human difference, but did not explicitly enlist them to establish a hierarchy of human races. Instead, he sought only to prove the theory of polygenesis.

In many ways, Broca was the most influential figure on the field of anthropology as it exists today. His treatise on hybridity formed the basis of French anthropology and led to the foundation of the Société d'Anthropologie de Paris, the first society devoted to the science of anthropology, which Broca defined as "the study of the human group, considered in its entirety, in detail, and in reference to its relation to the rest of nature" (Stocking, 1968, 40; Broca, 1871, 1). His contributions to the field transcend his own country as his version of anthropology served as a model for biological anthropology as a discipline in Germany, England, and the United States (Brace, 2005, 149).

Arguably, Broca's most important contribution to physical anthropology was the development of anthropometric measurements of not only the skull, but the entire human body. Today, these measurements are commonplace and are used in studies of not only anthropology, but human biology and evolution, biomedicine, and forensics. Although the methods themselves are not racist, it is important to recognize their historical context and that they are predicated on a

polygenist way of thinking and developed in response to an existing, 19th century claim of a primordial difference between the human races.

ENDNOTES

1. Buffon did not use the term "hybrid" -- according to his logic, hybrids, in their traditional definition, do not exist (Douglas, 2015, 4).

2. Josiah Nott was also among Gobineau's followers, stating "I have seldom perused a work which has afforded me such pleasure and instruction as the one of Count Gobineau, *'Sur l'Inégalité des Races Humaines,'* and regard most of his conclusions as incontrovertible," (Nott, 1856, 463).

3. Phrenology, a popular 19th century pseudo-science begun by Viennese physician Franz Joseph Gall (1758-1828), was the study of the size and shape of a person's skull, used to determine a person's character and mental abilities. It was based on the notion that certain mental traits are associated with certain parts of the brain, for which the cranium can be used as a proxy (Brace, 2005, 66). The divisions between early craniology and phrenology were not always clear: Scottish phrenologist George Combe (1788-1858) popularized phrenology in America, and Morton allowed him to write an appendix to his *Crania Americana* (1839).

4. Although Tiedemann was not fully aligned with phrenology, he did proceed from certain of its tenets:

   "There is undoubtedly a very close connection between the absolute size of the brain and the intellectual powers and functions of the mind. This is evident from the remarkable smallness of the brain in cases of congenital idiotismus, few much exceeding in weight the brain of a new-born child. Gall, Spurzheim, Haslam, Esquirol, and others, have already observed this, which is also confirmed by my own researches. The brain of very talented men is remarkable, on the other hand, for its size" (Tiedemann 1836, 502-3).]

5. This was his own, abbreviated English translation of his German book *Das Hirn des Negers mit dem des Europäers und Orang-Outangs verglichen* (1837).

6. He specifically names Petrus Camper, anatomist Samuel Thomas von Sömmerring (1755-1830), naturalist Georges Cuvier (1769-1832), surgeon and naturalist Sir William Lawrence (1783-1867), and Julien-Joseph Virey (1775-1846). He directly attacks Camper's facial line and angle as "unsatisfactory in determining the capacity of the skull, the size of the brain, and the degree of intellectual powers," (Tiedemann, 1836, 511).

7. Broca contends that Morton made this distinction to differentiate between individuals that clearly belong to different species (e.g. dogs and wolves, goats and sheep) and those whose origin is not agreed upon by all naturalists (e.g. principal races of dogs, horse, and humans) (Broca, 1877, 433).

8. The French word "*léporide*" refers specifically to the métis produced by crossing a hare and a rabbit and does not have an English equivalent. The English word "leporids" usually refers to members of the family *Leporidae,* including rabbis and hares, and translates into French as

"*léporidé*". For the purposes of this paper, I will use the English "leporid" to refer to Broca's term "*léporide*".

9. Broca's *Recherches sur l'ethnologie de la France* (1859) was his first attempt at describing the effects of racial mixing on a population. He stated that mixed individuals are easily distinguished from their mother races (17) and usually take on intermediate characteristics (Broca, 1859, 18). Based on the diversity in France, he attested that French people presents all the characteristics of a mixed race (Broca, 1859, 19).

10. Wherever relevant, direct translations of Broca's categorical terminology will be used because they were his delineators of populations. Many of these terms are today considered to be derogatory. They do not, in any way, reflect the opinions of the author, nor does she advocate their use.

11. Broca is hesitant to accept Nott's explanation for the differential fecundity of mulattoes at different latitudes before getting an alternative explanation (Broca, 1877, 527-8).

12. "Incidentally, we are not looking to establish the superiority or inferiority of this or that part of the genus *Homo*; we are only looking to see if Ethiopians and Caucasians could have the same origin and if the considerable differences seen in the cranial morphology of both types could be explained by anything but the diversity of human origins" (Broca, 1877, 405, translated by the author).

13. "From another point of view, it might be said that the polygenist doctrine assigns to the inferior races of humanity a more honourable place than in the opposite doctrine. To be inferior to another man either in intelligence, vigour, or beauty, is not a humiliating condition. On the contrary one might be ashamed to have undergone a physical or moral degradation, to have descended the scale of beings, and to have lost rank in creation" (Broca, 1864, 71).

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Figure 1: Blumenbach's Five Races Represented with Crania.

Plate IV of Blumenbach 1865
Blumenbach's five races represented by crania, from left to right: Mongolian (Tungun), American (Caribbean), Caucasian (young female Georgian), Malay (Tahitian), Ethiopian.

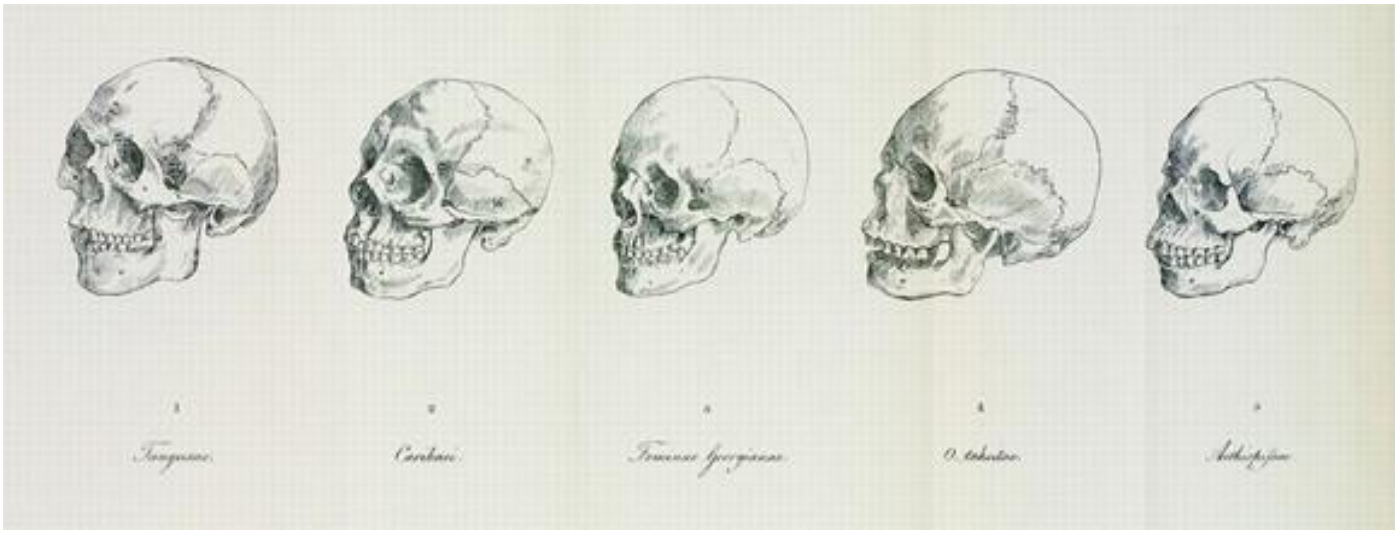


Figure 2: Camper's use of the facial line.

Camper, P. 1792. *Über den natürlichen Unterschied der Gesichtszüge*. Berlin: Vossischen Buchhandlung.

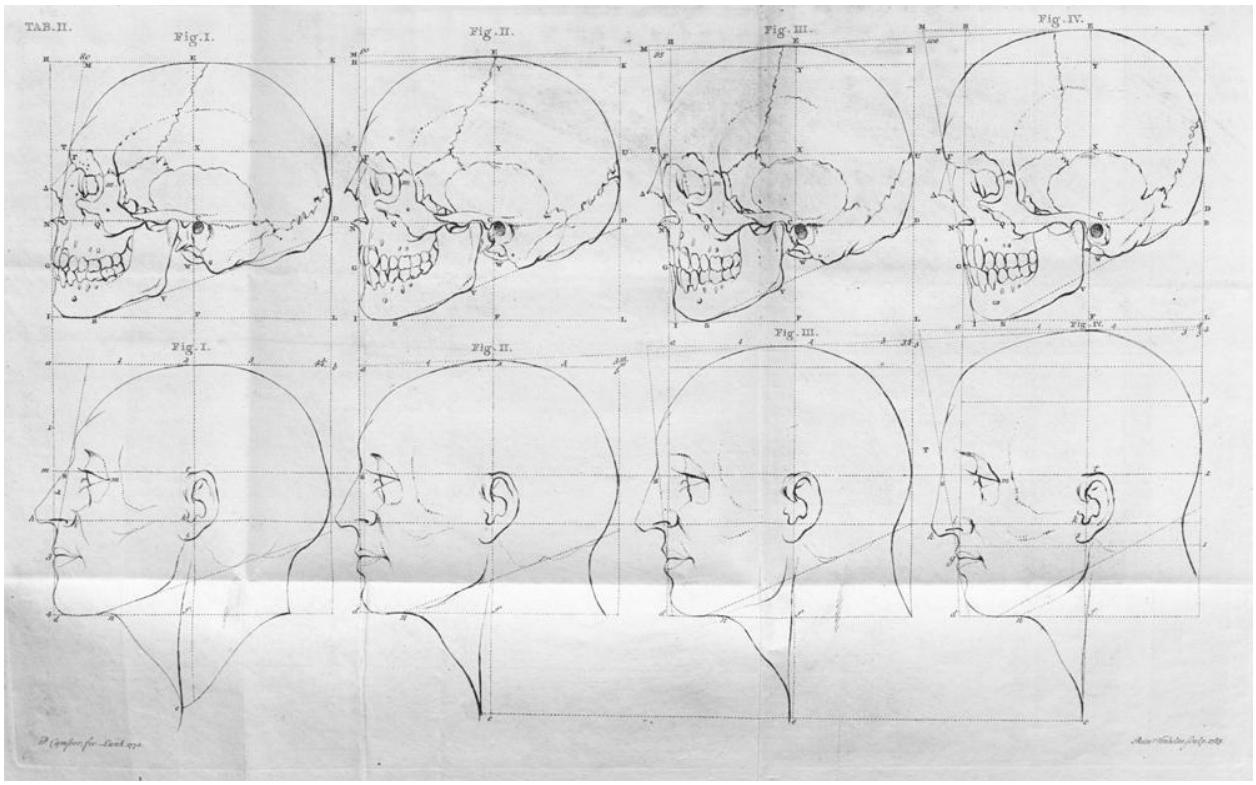


Figure 3: Broca's four degrees of hybridity.

Broca, P. 1864. *On the Phenomena of Hybridity in the Genus* Homo. Blake, CC, ed. London: Longman, Green, Longman, & Roberts.

GLOSSARIAL NOTE.

The significations of the following words, habitually used by Dr. Broca, are appended :—

AGENESIC. Mongrels of the first generation, entirely unfertile, either between each other, or with the two parent species, and consequently being unable to produce either direct descendants or mongrels of the second generation.

DYSGENESIC. Mongrels of the first generation, nearly altogether sterile.

a. Unfertile with each other, therefore with no direct descendants.

b. They sometimes, but rarely and with difficulty, breed with one or the other parent species. The mongrels of the second generation, produced by this interbreeding, are infertile.

PARAGENESIC. Mongrels of the first generation having a partial fecundity.

a. They are hardly fertile or infertile *inter se*, and when they produce direct descendants, these have merely a decreasing fertility, tending to necessary extinction at the end of some generations.

b. They breed easily with one at least of the two parent species. The mongrels of the second generation, issued from this second breeding, are themselves and their descendants fertile *inter se*, and with the mongrels of the first generation, with the nearest allied pure species, and with the intermediate mongrels arising from these various crossings.

EUGENESIC. Mongrels of the first generation entirely fertile.

a. They are fertile *inter se*, and their direct descendants are equally so.

b. They breed easily and indiscriminately with the two parent species; the mongrels of the second generation, in their turn are, themselves and their descendants, indefinitely fertile, both *inter se* or with the mongrels of all kinds which result from the mixture of the two parent species.

Figure 4: Morton's four degrees of hybridity.

Morton, SG. 1850. *Additional Observations on Hybridity in Animals and on some Collateral Subjects; Being a Reply to the Objections of the Rev. John Bachman, D.D.* Charleston: Walker & James.

Hybridity.

Hybridity, whether in plants or animals, has been singularly neglected by naturalists. It has generally been regarded as a *unit:* whereas, its facts are as susceptible of classification as any other series of physiological phenomena. Hence, I have, on a former occasion, proposed *four degrees* of hybridity, which I will briefly recapitulate in this place.

The 1st degree is that in which the hybrids never reproduce; in other words, where the mixed progeny begins and ends with the first cross.

The 2d degree is that in which the hybrids are incapable of re-producing, *inter se*, but multiply by union with the parent stock.

The 3d degree is that in which animals of unquestionably distinct species produce a progeny which is prolific, *inter se.*

The 4th degree is that which takes place between closely proximate species—among mankind, for example, and among those domestic animals most essential to their wants and happiness.

Figure 5: Graphic of Broca's *croisements de retour* (back crossings).

Broca, P. 1865. *Instructions générales pour les recherches et observations anthropologiques (anatomie et physiologie)*. Paris: Victor Masson et Fils.

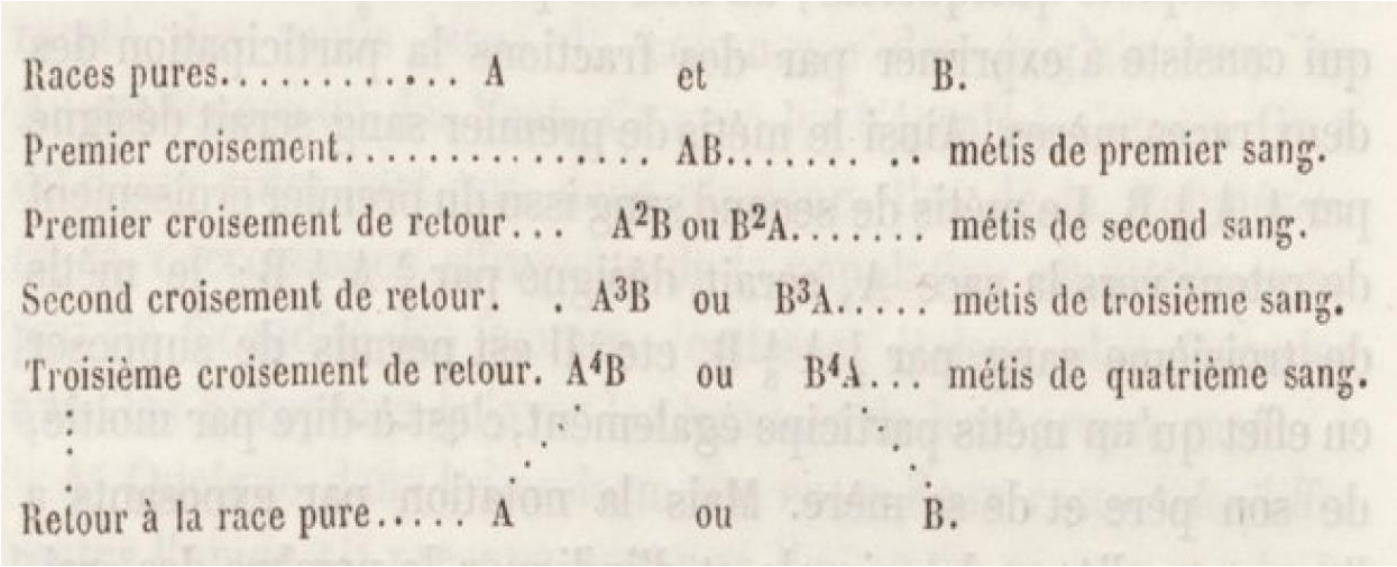


Figure 6: Broca's eight observations on human hybridity.

Broca, P. 1864. *On the Phenomena of Hybridity in the Genus* Homo. Blake, CC, ed. London: Longman, Green, Longman, & Roberts.

1. That certain intermixtures are perfectly eugenesic.

2. That other intermixtures are in their results notably inferior to those of eugenesic hybridity.

3. That Mulattoes of the first degree, issued from the union of the Germanic (Anglo-Saxon) race with the African Negroes, appear inferior in fecundity and longevity to individuals of the pure races.

4. That it is at least doubtful, whether these Mulattoes, in their alliances between themselves, are capable of indefinitely perpetuating their race, and that they are less prolific in their direct alliances than in their re-crossing with the parent stocks, as is observed in paragenesic hybridity.

5. That alliances between the Germanic race (Anglo-Saxon) with the Melanesian races (Australians and Tasmanians) are but little prolific.

6. That the Mulattoes sprung from such intercourse are too rare to have enabled us to obtain exact particulars as to their viability and fecundity.

7. That several degrees of hybridity, which have been observed in the cross-breeds of animals of different species, seem also to occur in the various crossings of men of different races.

8. That the lowest degree of human hybridity in which the homœogenesis is so feeble as to render the fecundity of the first crossing uncertain, is exhibited in the most disparate crossings between one of the most elevated and the two lowest races of humanity.

Figure 7: *Scale of eye colors.*

Broca, P. 1865. *Instructions générales pour les recherches et observations anthropologiques (anatomie et physiologie)*. Paris: Victor Masson et Fils.

From: J. 2010. Paul Broca - Eye and Skin color charts. Chaudron [Internet]. Available from: http://chaudron.blogspot.com/2010/02/paul-broca-eye-and-skin-color-charts.html

Figure 8: *Skin colors and hair system.*

Broca, P. 1865. *Instructions générales pour les recherches et observations anthropologiques (anatomie et physiologie)*. Paris: Victor Masson et Fils.

From: J. 2010. Paul Broca - Eye and Skin color charts. Chaudron [Internet]. Available from: http://chaudron.blogspot.com/2010/02/paul-broca-eye-and-skin-color-charts.html

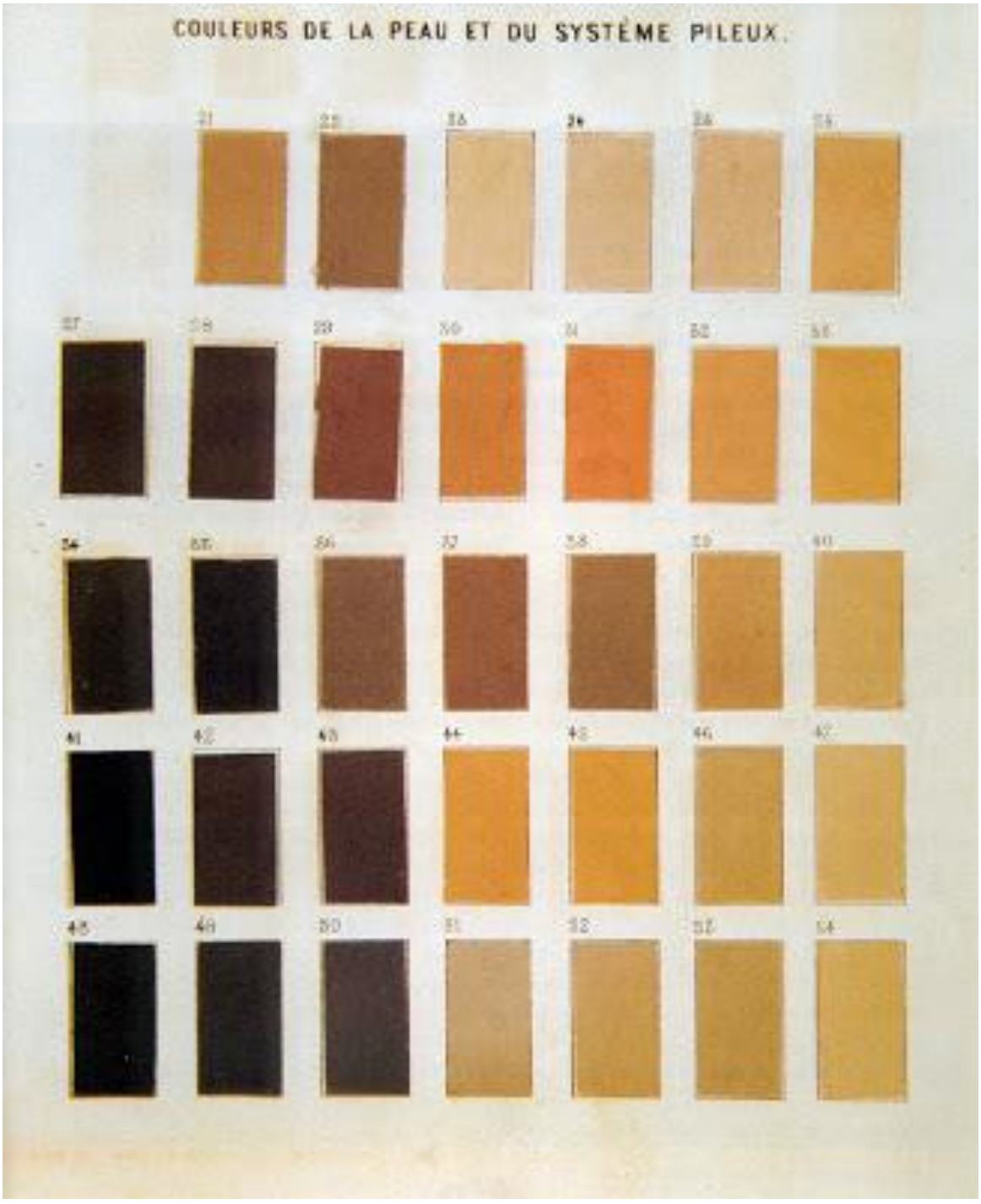


Figure 9: Broca's refinement of Retzius' cephalic index.

Broca, P. 1862a. Sur les caractères des crânes basques de Zaraus (Guipuzcoa). In: Broca, P. 1874. Mémoires d'anthropologie. Paris: C. Reinwald et Co. 2: 1-32.

INDICE CÉPHALIQUE.	NOMBRE DES CRANES de chaque catégorie, en centièmes.					TOUT Paris.	BAS-QUES.
	CITÉ.	INNO-CENTS.	SÉPUL-TURES parti-culières.	FOSSE com-mune.	MORGUE.		
Au-dessous de 75.	14.4	17.1	12.2	14.3	5.9	14.3	15.0
De 75 à 77.77.....	23.2	21.4	17.8	14.3	5.9	19.8	33.3
De 77.78 à 80.....	28.8	20.5	26.7	22.9	29.4	25.2	31.7
De 80.01 à 83.24..	16.8	20 5	23.3	28.5	35.3	21.4	20.0
au-dessus de 83.24.	16.8	20.5	20.0	20.0	23.5	19.3	0.0
Nombre de crânes.	100.0	100.0	100.0	100.0	100.0	100.0	100.0

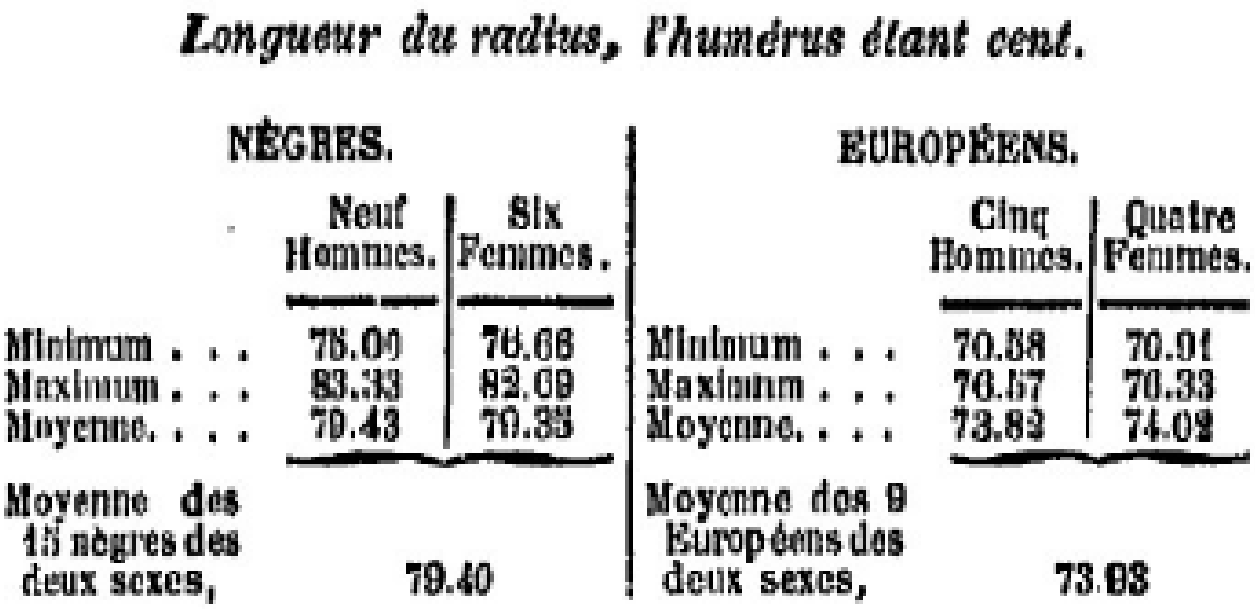
Figure 10: Measurements of the anterior and posterior projections of the crania of Europeans and Negros.

Broca P. 1862c. Sur les projections de la tête et sur un nouveau procédé de céphalométrie et d'anthropométrie. In: Broca, P. 1871. *Mémoires d'anthropologie*. Paris: C. Reinwald et Co. 1: 79-105.

	1° EN MILLIMÈTRES.			2° EN MILLIÈMES.		
	EUROPÉENS.	NÈGRES.	DIFFÉRENCE.	EUROPÉENS.	NÈGRES.	DIFFÉRENCE.
Projection antérieure.... faciale..	12,385	27,676	+15,291	64,80	137,58	+72,78
Projection antérieure.... crânienne	78,351	72,628	— 5,723	409,95	361,04	—48,91
Projection crânienne postérieure.....	100,385	100,857	+ 0,472	525,24	501,37	—23,87
Total..... ...	191,121	201,161	+10,040	1000	1000	

Figure 11: *Length of the radius, the humerus being 100*. Relative length of the radius to the humerus in male and female Negros and Europeans.

Broca, P. 1862d. Sur les proportions relatives du bras, de l'avant-bras et de la clavicule chez les nègres et chez les Européens. *Bullétins de la Société d'anthropologie* 3:162-172.

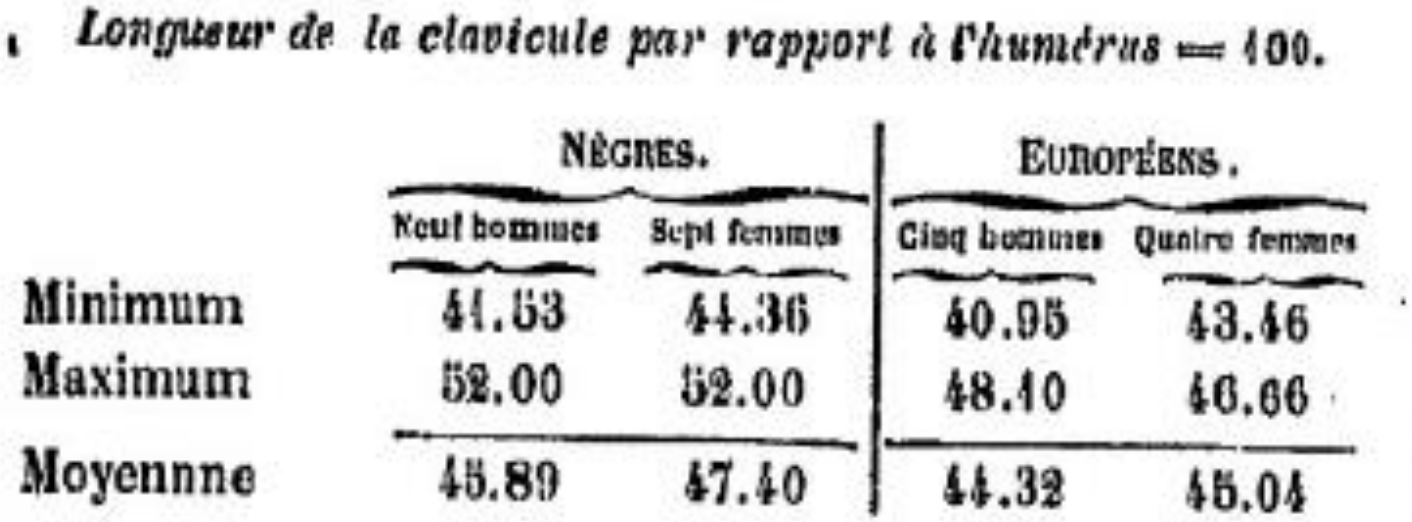


Longueur du radius, l'humérus étant cent.

	NÈGRES.		EUROPÉENS.		
	Neuf Hommes.	Six Femmes.		Cinq Hommes.	Quatre Femmes.
Minimum . . .	76.09	76.66	Minimum . . .	70.58	70.91
Maximum . . .	83.33	82.69	Maximum . . .	76.57	76.33
Moyenne. . . .	79.43	79.35	Moyenne. . . .	73.83	74.02
Moyenne des 15 nègres des deux sexes,	79.40		Moyenne des 9 Européens des deux sexes,	73.93	

Figure 12: *Length of the clavicle in relation to the humerus – 100*. In male and female Negros and Europeans.

Broca, P. 1862d. Sur les proportions relatives du bras, de l'avant-bras et de la clavicule chez les nègres et chez les Européens. *Bullétins de la Société d'anthropologie* 3:162-172.



Longueur de la clavicule par rapport à l'humérus = 100.

	Nègres.		Européens.	
	Neuf hommes	Sept femmes	Cinq hommes	Quatre femmes
Minimum	41.53	44.36	40.95	43.46
Maximum	52.00	52.00	48.10	46.66
Moyennne	45.89	47.40	44.32	45.04

Figure 13: *Length of the upper limb, the lower limb represented by 100*. In male and female Negros and Europeans.

Broca, P. 1867. Sur les proportions relatives des membres supérieurs et des membres inférieurs chez les Nègres et le Européens. Bullétins de la Société d'anthropologie 2: 641-653.

LONGUEUR DU MEMBRE SUPÉRIEUR, LE MEMBRE INFÉRIEUR ÉTANT REPRÉSENTÉ PAR 100.

	Nombres.	Maximum.	Minimum.	Moyennes.
Nègres.....	10	73.04	65.70	68.30
Négresses.....	6	70.20	65.96	68.15
Nègres des deux sexes.	16	73.04	65.70	68.27
Européens.....	8	70.54	68.97	70.04
Européennes.....	6	71.42	66.37	69.33
Europ. des deux sexes.	14	71.42	66.37	69.73

Figure 14: *Length of the humerus, the lower limb represented by 100.* In male and female Negros and Europeans.

Broca, P. 1867. Sur les proportions relatives des membres supérieurs et des membres inférieurs chez les Nègres et le Européens. Bullétins de la Société d'anthropologie 2: 641-653.

LONGUEUR DE L'HUMÉRUS, LE MEMBRE INFÉRIEUR ÉTANT REPRÉSENTÉ PAR 100.

	Nombres.	Maximum.	Minimum.	Moyennes.
Nègres.....	10	39.84	35.93	38.03
Négresses.....	6	39.73	37.14	38.51
Nègres des deux sexes.	16	39.84	35.93	38.20
Européens.....	8	41.26	39.04	40.35
Européennes.....	6	41.20	38.83	39.79
Europ. des deux sexes.	14	41.26	38.83	40.11

Figure 15: *Length of the humerus, the femur represented by 100*. In male and female Negros and Europeans.

Broca, P. 1867. Sur les proportions relatives des membres supérieurs et des membres inférieurs chez les Nègres et le Européens. Bullétins de la Société d'anthropologie 2: 641-653.

LONGUEUR DE L'HUMÉRUS, LE FÉMUR ÉTANT REPRÉSENTÉ PAR 100.

	Nombres.	Maximum.	Minimum.	Moyennes.
Nègres.....	10	72.79	66.23	69.03
Négresses.	6	72.28	66.13	68.88
Nègres des deux sexes.	16	72.79	66.13	68.97
Européens.....	8	74.51	69.37	72.46
Européennes,.....	6	75.37	68.00	71.87
Europ. des deux sexes.	14	75.37	68.00	72.20

Figure 16: *Length of the radius, the lower limb represented by 100*. In male and female Negros and Europeans.

Broca, P. 1867. Sur les proportions relatives des membres supérieurs et des membres inférieurs chez les Nègres et le Européens. Bullétins de la Société d'anthropologie 2: 641-653.

LONGUEUR DU RADIUS, LE MEMBRE INFÉRIEUR ÉTANT REPRÉSENTÉ PAR 100.

	Nombres.	Maximum.	Minimum.	Moyennes.
Nègres.....	10	33.20	28.23	30.36
Négresses.....	6	30.71	29.68	30.14
Nègres des deux sexes.	16	33.20	28.23	30.28
Européens.....	8	30.35	29.12	29.75
Européennes.....	6	30.22	27.53	29.28
Europ. des deux sexes.	14	30.35	27.53	29.54