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Jacques de Vaucanson: The Father of Simulation

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ABSTRACT

***Background*: Jacques de Vaucanson's accomplishments are remarkable from almost every standpoint. His appreciation of human anatomy allowed him to formalize and discuss at the Royal Academie of Churgeons the first surgery/anatomy trainer.**

***Methods*: Works on the history of automata are replete with descriptions of de Vaucanson's creations. I sought to better understand this intriguing individual and his mechanical accomplishments in light of current interest in surgical simulators and skill enhancement.**

***Results*: de Vaucanson is known to have built at least three highly sophisticated automated robotic devices. His first robot was constructed in 1735: a life-sized flutist that could play 12 melodies. The fingers moved by levers, and a bellow-like device piped air into the robot's mouth. His second robot, another musician, could play 20 melodies. His third automaton became the most famous, a mechanical duck. The duck consisted of a gold-plated copper exterior with more than a thousand moving parts, including a gastrointestinal system. Voltaire would quip that France now had as its glorious mascot a golden creature that was famous for its excrement. Lastly, de Vaucanson created another musical automaton that could play 20 melodies.**

***Conclusions*: de Vaucanson worked with famed surgeon La Cat and in 1741 gave a talk to the Academy of Art on "Constructing an automaton figure which will imitate in its movements animal functions, the circulation of blood, respiration, digestion, the combination of muscles, tendons, nerves, etc." The Academy's minutes recorded "this ingenious machine, which will represent a human anatomy lesson." Add to de Vaucanson's list of accomplishments as devising, albeit not producing, the first anatomic simulator.**

INTRODUCTION

THE ENTIRE INDUSTRIAL REVOLUTION might have been ignited by the son of a glove maker from France. He was born on February 24, 1709, and attended a Jesuit school in Grenoble. His early childhood learning was much influenced by Rene Descartes, and he always had an interest in and a knack for mechanics and sciences. After completing his required classes, he enrolled in the medical school's anatomy classes in Paris.[1]

Jacques de Vaucanson (Fig. 1) and his accomplishments are remarkable from almost every standpoint. As a mechanically inclined youth, he could not have helped but been attracted to the latest trends in scientific/medical education much in vogue in Paris. The midwife Mademoiselle Biheron had developed beautiful wax anatomic models that allowed all aspects of human anatomy to be appreciated by anyone, without, of course, the stigmata of odorous decay and the abject horrors of dissecting corpses.[2]

At these opening moments of the Enlightenment, academic curiosities about science and medicine were on the rise, thanks in part to the widely read philosophies of Descartes and Baruch Spinoza. Descartes was heavily influenced in his speculations about human physiology by his fascination with automated apparatuses that he had seen before being forced to leave France.[3] He insisted that man's body was a duality: mechanical body and spiritual soul. Spinoza took this idea even further by refusing to separate the mind from the body.[4] In this respect, Spinoza presaged modern neurobiology by three centuries.[5] Finally, to round out the heady environment in which the inquisitive

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FIG. 1. Jacques de Vaucanson. "A rival to Prometheus, [Vaucanson] seemed to steal the heavenly fires in his search to give life." Voltaire

mind of de Vaucanson was immersed, the physician/philosopher Julien Offroy de La Mettrie needs consideration. He had just published his *The Natural History of the Soul*, which formally placed his philosophical considerations into the mechanistic camp, like Spinoza.[6] His works were publicly condemned, and he also fled France for more enlightened Netherlands, where he worked with Boerhaave, who became his mentor.[7] But La Mettrie could not be content in his speculations that human bodies are just simple mechanical structures, capable of being studied and understood, and eventually published anonymously *L'Homme machine* (The Man Machine) in 1747.[8] This was too much for even the tolerant Dutch, and he was once again condemned and forced to flee, now to the protection of Frederick the Great of Prussia.

With these ideas as part of the academic atmosphere available to young Jacques, it is no great surprise that his interests in anatomy and penchant for developing and building mechanical devices would rapidly result in truly stunning accomplishment. de Vaucanson said, "*I own freely, that I am surpriz'd myself to see and hear my Automaton play and perform so many and so differently varied Combinations; And I have been more than once ready to despair of succeeding; but Courage and Patience overcame every Thing*."[9] It was his remarkable degree of success that ignited his desire to replicate human anatomy. His appreciation of human anatomy allowed him to formalize and discuss at the Royal Academie of Churgeons the first anatomy trainer.

METHODS

Works on the history of automata are replete with accounts of de Vaucanson's machines.[10,11] There is a great deal of information available about him from articles and books, as well as from the Internet. Our current interest in surgical simulators and surgical skill enhancement gives his accomplishments greater clarity and importance. Historically, as is so often the case, technology makes things new that are in fact old. So too is simulation.[12-15] The minds of investigators of the 18th Century sought innovative methods to overcome the problems of training, skill enhancement, and quality of care with investigations necessary to advance knowledge. The ability of these brilliant researchers is the focus of this historical review of de Vaucanson, who not only utilized his mechanical automata as sources of revenue, but also engaged in research, attempted to elucidate human physiology, sought scientific insight, and vociferously expounded the need for man to rise higher in his state of knowledge.[16]

The term *automaton* implies a mechanical device that performs a specified function automatically. *Automaton*, from the Greek *ατόματοζ*, *automatos*, "acting of one's own will, self-moving bowels," is more often used to describe non-electronic moving machines, especially those that have been made to resemble human or animal actions. Humanoid automata were also referred to as androids (Webster's calls this a machine or automaton in the form of a human being, from Greek *andr* (male) and suffix *–eidos* or species). This is the term that was most appropriate and predates Karel Čapek's more modern term, robots.[17] In fact, the term *simulation* comes from the Latin *simulare*, "to make like, to put on an appearance of," originally meaning a material object representing something.

FLUTE PLAYER

In February 1737, young Jacques demonstrated his first life-sized android at the *Foire* in St. Germain (Fig. 2). By the winter of 1738, he had rented a hall, the grand Salle des quatre Saisons at the Hotel de Longueville, to begin demonstrating his automaton to the public. First-hand accounts of his flutist reveal it to contain an "infinity of wires and steel chain . . . form the movement of the fingers, in the same way as in living man," according to Abbé Desfontaines in a letter. de Vaucanson published a detailed account of this mechanism, which was not a music box, but actually played a real flute. The "Flute Player" could perform 12 pieces of music, including "*The Nightingale*" by Blavet. The automaton could breathe via a series of three bellows, each with a different "blow" pressure; it could form its lips in four directions on the flute, move a tongue-like mechanism within its mouth to adjust air flow, and move its anatomically correct fingers of soft leather on the flute. This first machine was a stunning success. Imagine a 6-foot-high human-like device on a piece of rock, placed squarely on a pedestal about 4 feet in height in 1741.

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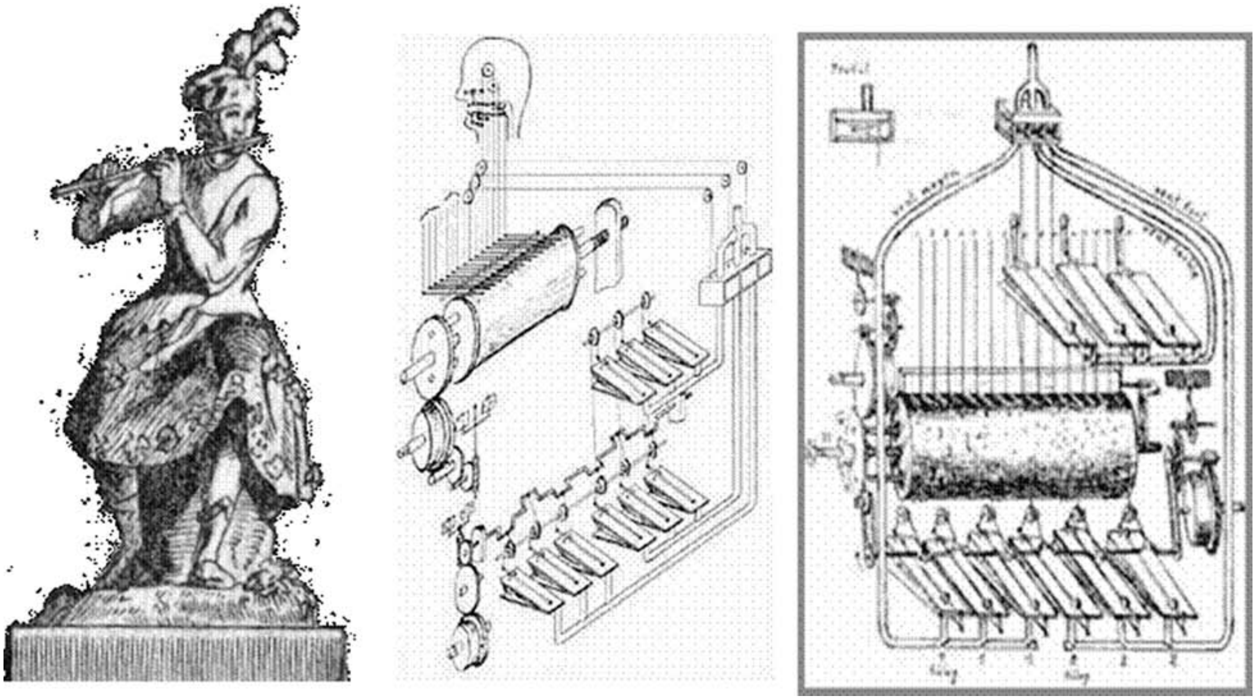

FIG. 2. The "Flutist" by Jacques de Vaucanson, circa 1737.

THE DUCK

Following quickly from one success to another, de Vaucanson introduced his second automaton later that same year, and he would derive the most notoriety for this scatologically correct duck (Fig. 3). The duck had a gold-plated copper exterior and more than a thousand moving parts, including a functional gastrointestinal system synthesized from de Vaucanson's work with rubber. The duck could bend its neck, ingest water and corn meal, swallow, preen itself, flap its wings, and, the grand

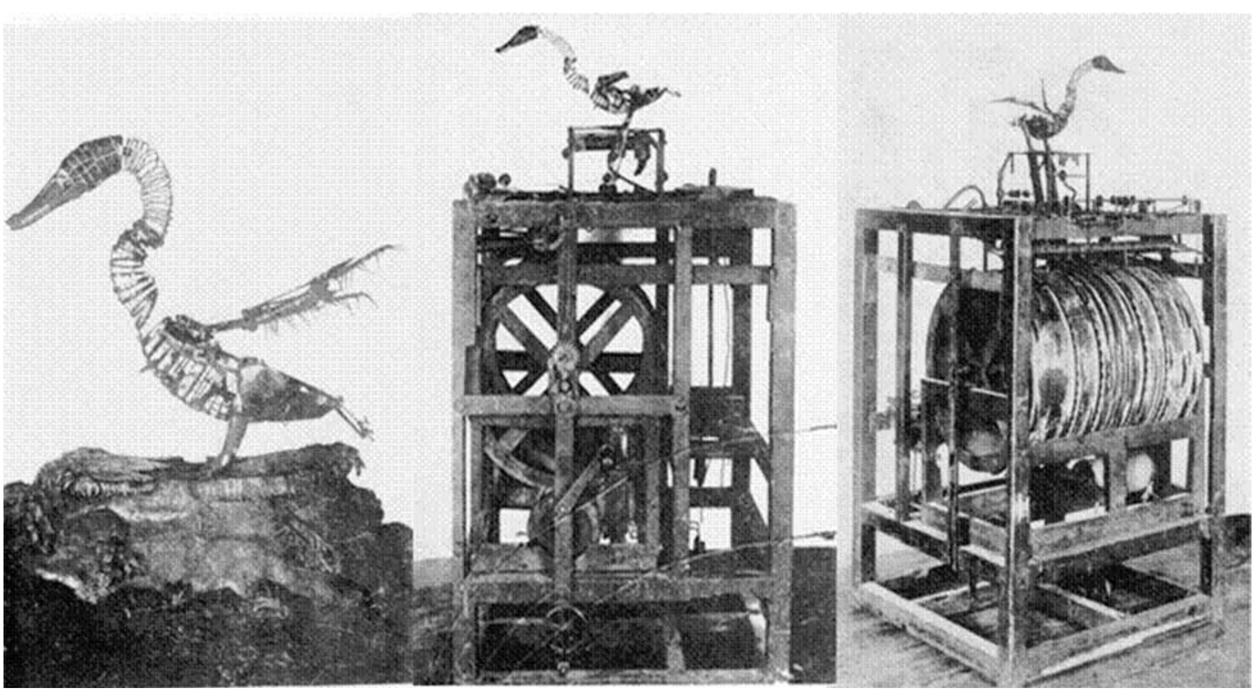

FIG. 3. Vaucanson's duck, circa 1739.

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finale, defecate. The duck immediately became the centerpiece attraction for throngs of visitors from all over Europe. The complexity and function of this machine were extraordinary. One single wing, for instance, contained more than 400 articulated pieces. The mechanisms were quite large to power these devices and thus were housed in the stand below the canard. In pamphlets that were given out by de Vaucanson, he states that the digestive system replicates digestion by "chemical elaboratory," and the process of "solvation, not trituration" was employed to simulate "the matter digested in the stomach being conducted by tubes as in an animal by its bowels into the anus, where there is a sphincter which permits it to be released." And it was all open for viewing by the public!

The price of admission to de Vaucanson's menagerie of automata was a then-hefty fee of 3 livres (about a week's pay), and he became wealthy. The automata attracted significant attention from the philosophical, political, and professional arenas. Voltaire, then hugely successful, became one of his most vocal supporters, stating "*A rival to Prometheus*, [Vaucanson] *seemed to steal the heavenly fires in his search to give life*."[18]

THE FIFE AND TAMBOUR PLAYER

The final addition to his menagerie is also the least known and perhaps the most complex, a "Fife and Tambour Player." The tambour was a type of drum, and the fife was similar to the flute. Combining musical instruments within one android automaton was thought to demonstrate de Vaucanson's unrivalled mastery of sophisticated mechanical recreation (Fig. 4).[1] This humanoid was noted to appear like a life-sized man, dressed in provincial shepherd's clothing and could play 20 different tunes.

THE SIMULATOR

de Vaucanson gained the attention of King Louis XV, who made private showings for the royal family and guests. This in turn, provided de Vaucanson with access to all of the medical and surgical advances from France. He could interact with the highest circles of the physicians in Paris. He competed in the Paris Academy of Sciences and beat Denis Diderot (later of *Encyclopedia* fame) for first prize. In 1741, he presented his "moving anatomy" project to the Académie de Lyon. The minutes of that organization state that de Vaucanson conceived of a "wet machine" that centrally involved the movement of fluids around an anatomically correct humanoid machine. de Vaucanson stated that "*Constructing an automaton figure which will imitate in its movements animal functions, the circulation of blood, respiration, digestion, the combination of muscles, tendons and nerves*, etc." There are no existent drawings or illustrations of this first anatomic simulator, but the Academy's minutes recorded that "*this ingenious machine, which will represent a human anatomy lesson*."

CONCLUSIONS

The 17th and 18th Centuries were likened to the Renaissance for medicine, arising from the Dark Ages. Anatomy and physiology were thought to have great potential, and physician contemporaries of de Vaucanson were François Quesnay and Claude LeCat. Quesnay between 1730 and 1736 created a "moving anatomies" device but never succeeded in a demonstration. The more flamboyant LeCat, an outspoken surgeon at the Hôtel Dieu, presented his surgical simulator in 1744 to the Academy of Rouen, but no records of it survive. On May 13, 1756, an unheralded midwife, Mme. Du Coudray, demonstrated a birthing simulator to the Royal Academy of Surgery, who approved of it in a "very advantageous report."[19] Others even prior to these Parisian demonstrators included Leonardo da Vinci, who is know to have manufactured a glass heart to investigate the physiology of flowing blood within the ventricles, and Reyselius of Württemburg, a physician who was interested in artificially demonstrating circulation, digestion, and ventilation as early as 1677.[20] Anatomic demonstrations themselves arose with attempts by anatomists to create almost hyper-realistic colored wax humanoids by 1775 (Specola collection, University of Florence). In addition, Fragonard by 1766 was making "nat-

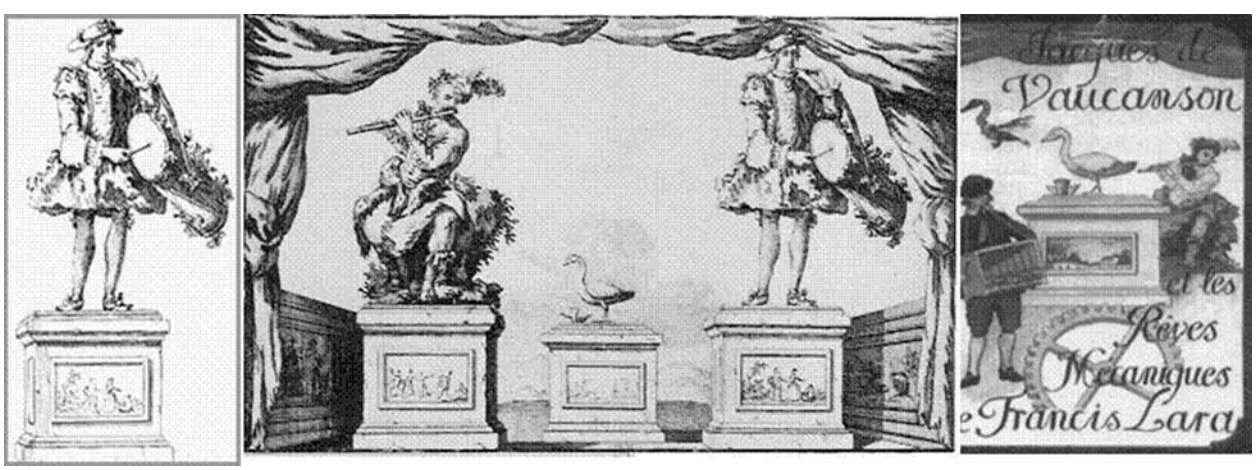

FIG. 4. The "Fife and Tambour Player," circa 1739.

ural anatomical" specimens by injection techniques that hauntingly reflect the now-popular secular anatomic demonstrations of Gunther von Hagens in Body Worlds™.[21] Finally, paper maché anatomic models of Auzoux demonstrated static human anatomy by 1822.[22]

Synchronous with the rise in anatomic investigations and the surgical advances introduced by John Hunter and others, the word *simulation* itself underwent a profound change in meaning during the 18th Century, largely because of the automata of de Vaucanson.[23] Prior to him, the word implied fakery, or to fool someone. After the later half of the 18th Century, simulation implied "to imitate or animate," according to arguments proposed by Jessica Riskins.[24] Current surgical simulation debates face the same crossroads as those of our predecessors with commonly voiced "we don't need simulation, we have plenty of clinical material" chorused by non-believers.[25] But surgery today is not what it was just yesterday. Fifty years ago, there was no vascular or open heart surgery. Twenty years ago, there was no lithotripsy, and transurethral resection of the prostate was the most common urologic procedure. Surgery can no longer stagnate from presumptions antiquated by time and technology. Surgical education must deal with the following new rules that make the "apprentice" model of urologic education antediluvian. Time, both the surgeon's and the resident's, has become an increasingly precious commodity. Certification and the process of acquiring the skills necessary for competency are increasingly being questioned by ourselves, our patients, and our governments.[26] Standards that apply to one profession, such as airline pilot's, can easily be brought forward in comparison with our own. Patient care issues such as "learning curve," "learning curve error," positive surgical margins, and increased risk of injury are commonly heard specters of training programs.

> *We have nothing to fear from these changes, but we need to adapt, change, and revise our surgical training curriculum . . . Monsieur LeCat told us of a plan for an artificial man . . . this automaton will have respiration, circulation, quasi-digestion, secretion and chyle, heart, lungs, liver and bladder, and God forgive us, all that follows from it. Let him have fever, we will bleed him, we will purge him and he will too much resemble man.*[27]

Voltaire would quip that France now had as its glorious mascot, a golden creature that was famous for its excrement.[18] Add to de Vaucanson's list of accomplishments devising the first anatomic simulator and being the first to tackle the expectations that education and skill can in fact be modeled and benefit from new improvements of technology. As Ralph Clayman so poignantly points out, "this is not pie in the sky."[28]

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