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DIGITAL RECONSTRUCTION reveals how Washington probably looked at 19 years of age.

By Jeffrey H. Schwartz

Putting a face on the first President

Solving a surprisingly long-standing mystery, a forensic anthropologist reconstructs what George Washington looked like as a young man

among the few things I remember from grade school about George Washington is that as a youth he chopped down a cherry tree and then confessed the deed to his father, and as an adult, he wore wooden dentures. Recently I learned quite a bit more about Washington. It turns out he never chopped down a cherry tree. He didn't wear wooden dentures either. But those were the least of the surprises.

An unexpected invitation to reconstruct the first president as he looked in his younger years—before the famous portraits and statue—sent me on a hunt that revealed a very different Washington from the unapproachable, thin-lipped elder statesman on the dollar bill. My foray into American history started when James C. Rees, executive director of Mount Vernon, Washington's estate, asked me whether I could re-create the way Washington, who was born in 1732 and died in 1799, had looked at three important points in his life. Rees wanted these life-size figures for Mount Vernon's new education center, which will open in the fall of 2006.

The 19-year-old Washington would be depicted in 1751, during his early career as an adventurer and surveyor. The 45-year-old would be shown in 1777, when he and his troops were bivouacked during the dreadful winter at Valley Forge, waiting for a chance to attack the British, who had occupied the city of Philadelphia. These two figures would complement a third portrayal, the 57-year-old Washington being sworn in on April 30, 1789, as the first president, a role he chose instead of the alternative he had been offered: becoming king.

As a physical anthropologist, I have studied early hominid bones and reconstructed specimens of our predecessors. My work as a forensic anthropologist for the Allegheny County, Pennsylvania, coroner's office has augmented this experience. But nothing prepared me for the curious challenges involved in figuring out what Washington actually looked like. One of the first things I learned was that I would not be allowed to study his skeleton, which would remain buried. No bones? How could I begin to imagine doing a forensic reconstruction without bones? But the challenge was too intriguing to decline.

The Clues

AMONG THE MATERIALS I did have to work with were a full-length white marble statue, a bust and a life mask, all by French court sculptor Jean-Antoine Houdon, who had begun his depictions during a visit to Mount Vernon in 1785, when Washington was 53 years old. A handful of portraits from his middle and later years added to the available clues—mainly those by Gilbert Stuart, Charles Wilson Peale and his son Rembrandt Peale, and John Trumbull. Several sets of dentures and a scattering of clothing, also from the later part of his life, could furnish other valuable evidence.

What I needed was some way to combine and manipulate these clues. If I could three-dimensionally scan Houdon's life mask, bust and statue, for example, I could compare them for accuracy of detail. If I could three-dimensionally scan surviving dentures, I could insert them into the digital head to determine the curvature of the jaws. Then I could try to estimate how much bone Washington had lost from his jaws by the time he was 53 (probably a close approximation to his jaws at age 57) and replace it as I worked my way through making him progressively younger.

As soon as I realized I would need to operate in the three-dimensional digital realm, I thought of PRISM, the Partnership for Research in Spatial Modeling, at Arizona State University. I had visited its laboratory when I gave a talk at the university, and I remembered seeing the results of collaborations involving sculptors, physical anthropologists, engineers and computer scientists. Although other labs were also expert in 3-D digital imaging, PRISM already had a track record of working with physical anthropologists, which meant that we shared a common scientific language. I presented the project to Anshuman Razdan, then PRISM's director, who to my delight agreed to help with the imaging.

I decided to start with Houdon's depictions of the 53-year-old Washington. I began with Houdon in part because the sculptor is legendary for his meticulous technique. According to contemporary accounts, he had used calipers to measure the president from head to toe. Unfortunately, Houdon's studio and all his notes were destroyed during the French Revolution,

No bones? How could I begin to imagine doing a forensic reconstruction without bones?

but many experts are nonetheless convinced of the physical accuracy of the bust and statue, which Washington had specifically asked the sculptor not to make larger than life, as was the custom for representing people of importance.

To determine the degree of accuracy, Razdan and his colleagues scanned the bust and the life mask and compared them digitally, finding them to be almost identical. The two differ at most by a statistically insignificant 0.3 millimeter. Surely this proved that the statue and the bust were accurate representations of Washington's face. But something bothered me about the astonishing congruence between the life mask and the bust's face. Documents at Mount Vernon indicate that Houdon had made the bust days before the life mask, which suggests the two would have differed more, because the bust would have been done freehand. Yet the eyes, nose, asymmetrical skewed chin, positions of the exposed earlobes, and creases in the forehead were identical in the life mask and bust. Finally, after months of puzzling, I concluded that Houdon had not created the face in the bust freehand. After he added the eyes to the life mask (they had to be covered when the mold of the face was taken), he then made a mold of the mask and pressed terra cotta into it to achieve the bust's face. I had to take it on faith that the rest of the head was based on Houdon's caliper measurements.

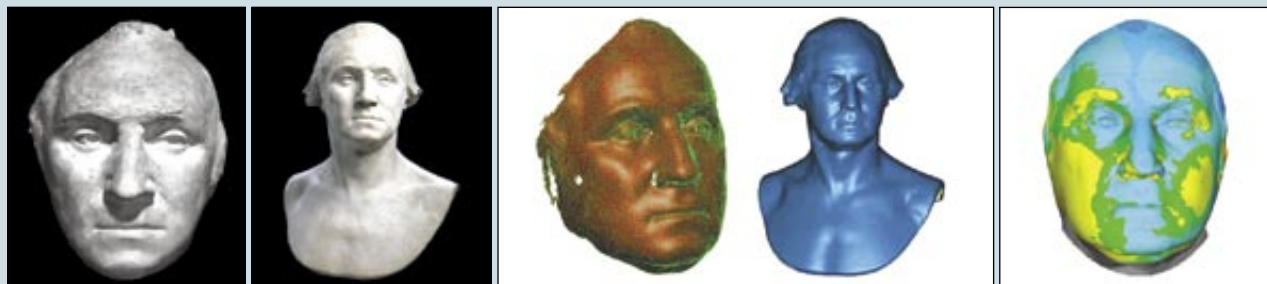
While we were sorting out the information gleaned from the digital scans, I met with Ellen G. Miles, curator of painting and sculpture at the Smithsonian National Portrait Gallery, to begin my education in the accuracy, and thus usefulness, of Washington portraits. From the beginning, she warned that one must be skeptical not only of portraits copied from originals painted by artists for whom Washington posed but of the originals themselves. Take, for instance, Stuart's portrait from the late 1790s, which is one of the few full-length 18th-century paintings of Washington. The face is recognizably Washington's—Stuart probably copied it from his portrait that now hangs in the Boston Athenaeum, the mirror image of which is on the dollar bill—but the hands at least are most likely Stuart's, and the body was fashioned after as many as three models who stood in for Washington.

Trumbull's 1792 portrait, in contrast, may more accurately portray Washington's body from the neck down than from the neck up. An even more impressive example of artistic interpretation turned up when Miles compared portraits that Peale and his 17-year-old son Rembrandt painted simultaneously in 1795, when Washington, then in his 60s, sat for the two of them together. The elder Peale painted a slightly pudgy, compassionate-looking, even rosy-cheeked person: his longtime friend and comrade. The son portrayed a deeply wrinkled, very old, haggard-looking man. Thus, we have at least

Overview/Reconstructing GW

- The author, a physical anthropologist, was asked to make the first forensic reconstruction of George Washington. Part of a new education center at Mount Vernon, the project calls for full-length figures of the first president at the ages of 19, 45 and 57.
- The skeletal remains could not be used to furnish clues. A statue, portraits, a life mask, dentures and clothing—all from the later years of Washington's life—constituted the available evidence.
- A special three-dimensional computer program allowed the author and his colleagues to combine and manipulate these clues to arrive at the three lifelike reproductions.

FIRST STEPS IN THE RECONSTRUCTION



*Life mask at age 53,
by Houdon*

*Bust at age 53,
by Houdon*

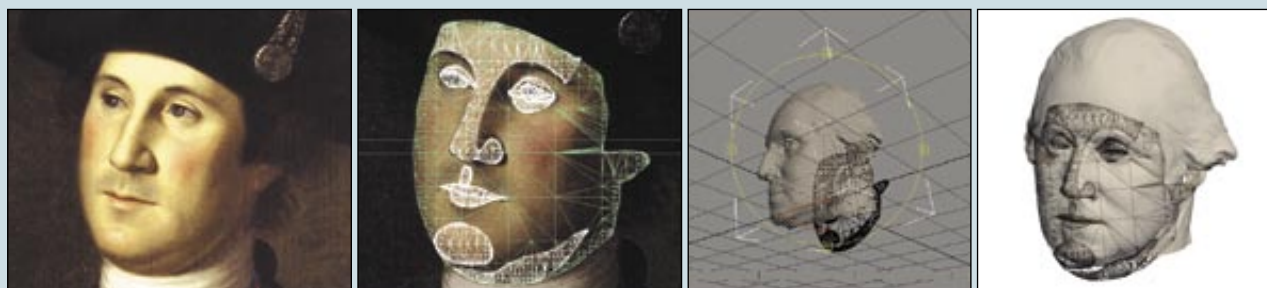
Scan of life mask

Scan of bust

Comparison

The starting point for the reconstruction was sculptor Jean-Antoine Houdon's life mask and bust, made in 1785, when Washington was 53. To determine whether the bust could be used with confidence as a representation of what Washington looked like, the author and his

colleagues made three-dimensional computer scans of the mask and the bust and compared them digitally. The result: an insignificant difference of 0.3 millimeter. Yellow denotes areas of contrast: the crucial eye, nose and mouth regions are virtually identical.



*Portrait at age 40,
by C. W. Peale*

Scan of portrait

*Importing scan of
portrait over bust*

*Comparison of
portrait and bust*

For help in working back to the younger Washington, they scanned the earliest existing representation, Charles Wilson Peale's 1772 portrait, painted when the leader was 40. Comparison of this scan and that of the bust revealed that the distance from nose to chin was longer in the painting. The author reasoned that although by the time

Washington was 53 he had lost most of his teeth, in his early 40s he probably still had some front teeth, which would have made a difference to the shape of his face. The observed difference gave the author some guidance for how to work backward from the bust and mask to the earlier years.

four "likenesses" of Washington in his 60s, each differing distinctly from the others.

If the portraits were confusing, the dentures were even more so. I quickly learned, of course, that contrary to myth Washington did not wear wooden dentures. In the 1700s the most common material used to form the plates in which teeth (human or animal) were anchored was ivory, often from hippopotamus tusks. Over time, ivory develops hairline cracks along its surface, between the mineralized prisms it is made of. Years of eating, drinking and smoking stain these cracks darker than the enamel prisms. Apparently someone mistook the pattern of staining for the grain of wood, and a legend was born.

What is true is that Washington had lost most of his teeth by the time Houdon visited Mount Vernon. In fact, his first tooth was extracted when he was in his early 20s; by the time he was 53, he may have had only two lower teeth remaining. We do not know the cause of his dental distress, but he may have had progressive periodontal disease, exacerbated by his self-proclaimed addiction to eating walnuts, which he cracked with his teeth. When one loses a tooth, the bone in which the roots were anchored is resorbed, diminishing the height of the jaw in that region. If one loses enough teeth, the jaws—espe-

cially the lower—become severely altered in size and shape. This process meant that I had to try to determine the state of Washington's jaws and oral cavity as a 53-year-old before I could think about adding tooth and bone and reshaping the jaws to re-create the 19- and 45-year-olds.

First, I had to track down any surviving dentures that Washington might have worn around this time in his life. It turned out that he had been buried with his last set of dentures. I was able to examine a lower plate made by dentist Joseph Greenwood in 1789, which is at the New York Academy of Medicine, as well as a lower of what had once been a complete set that Greenwood made in 1795, after Washington had lost his last tooth, and that had been in the Smithsonian but is now in the National Museum of Dentistry. The upper had disappeared during a theft from a Smithsonian storeroom. The only complete set I could locate was an initially mysterious pair in the collection at Mount Vernon.

These were found in one of Martha Washington's footlockers many decades after her death. She did not have false teeth, so they presumably belonged to her husband. Nobody knew who had made them or when, although I was able to figure out that they must have been fabricated between 1789 and 1795.

Scholars had determined that the plates were constructed of lead and that the teeth in the upper plate included horse or donkey upper incisors and cow lower incisors and that those in the lower jaw were human teeth, plus one artificial structure supposedly carved from a nut. To my surprise, I saw that some of the teeth in the lower plate were human upper teeth. Even more astonishing was my discovery that the dentures had been essentially unusable. The surfaces of the lead plates were not hollowed out to cup toothless gums; they were flat. Moreover, the springs that held the plates together and pressed them against the gums arced to the rear, not to the sides—their tension would thus have acted to push the dentures out when Washington opened his mouth. The only purpose these dentures could have served was filling space in Washington's oral cavity, perhaps when he was sitting for a portrait. They did, however, tell me something about the size and shape of the president's jaw.

Guided by the dimensions of the false teeth, I began to piece together a model of the inside of Washington's mouth. Later I would worry about melding this information with Houdon's life mask and bust.

Putting the Head Together

WITH MATTHEW TOCHERI, then working at PRISM, I took measurements from the bust that reflected the width of the lower jaw (mandible) where it connects with the base of the skull. Coincidentally, Brenda Baker, an anthropologist at Arizona State, had a small skeletal collection of British soldiers from the French and Indian War. One had a mandible almost as large as Washington's, which we scanned, inserted digitally into the bust's face and scaled up slightly to the correct size. We then aged the mandible by digitally whittling away bone and all the teeth except for the left lower second premolar. We inserted the Mount Vernon dentures digitally on top of the mandible, as they would have sat in Washington's mouth, and adjusted the bone's curve and the location and height of the premolar to fit. We fine-tuned these aspects by scanning a perfect replica of the 1789 Greenwood lower denture into the computer and superimposing it on what we already had. Because the chin of the soldier's mandible and Washington's were not a perfect match, we digitally reshaped the former to produce Washington's broad, obliquely slanted chin line. Using a pro-

The only complete set of dentures I could locate was an initially mysterious pair at Mount Vernon.

gram that PRISM's Jeremy Hansen wrote for this project, we changed the angle at the back of the mandible to reflect both what I could identify on the life mask as the jawline and the remodeling of bone that would have occurred during almost three decades of tooth loss.

Reconstructing the shape of Washington's upper jaw was not as straightforward, because we lacked the stolen upper half of the 1795 Greenwood dentures. The National Museum of Dentistry, however, had a replica of the once-complete original, and I figured that we could scan it as well as the original lower. But when I compared the replica visually with the original lower, I could see noticeable differences: the replica had been cleaned up to look prettier than the fairly gruesome original. Fortunately, the replica and original had been photographed together, so we could scan the replica, and because we knew its size, we could calculate the size of the original. Thus, we were able to produce a three-dimensional upper denture; we modified the soldier's upper jaw to fit into it and adjusted this bony structure to fit, in turn, in the bust's face.

To incorporate this information into the face of a 45-year-old, and ultimately a 19-year-old, I turned to Charles Wilson Peale's portraits of Washington at 40 and 47. After I spent hours staring at them, it struck me that the distance from the nose to chin was longer than that in either the bust or the portraits of Washington at older ages. To confirm this, we compared digitized two-dimensional scans of faces in these paintings with the three-dimensional digital face of the bust. The scans revealed a real difference, and it made sense. Teeth in the back of the mouth are often lost first—the somewhat longer lower facial height of the 40- and 47-year-old Washingtons was quite likely the result of the presence of front teeth and associated bone.

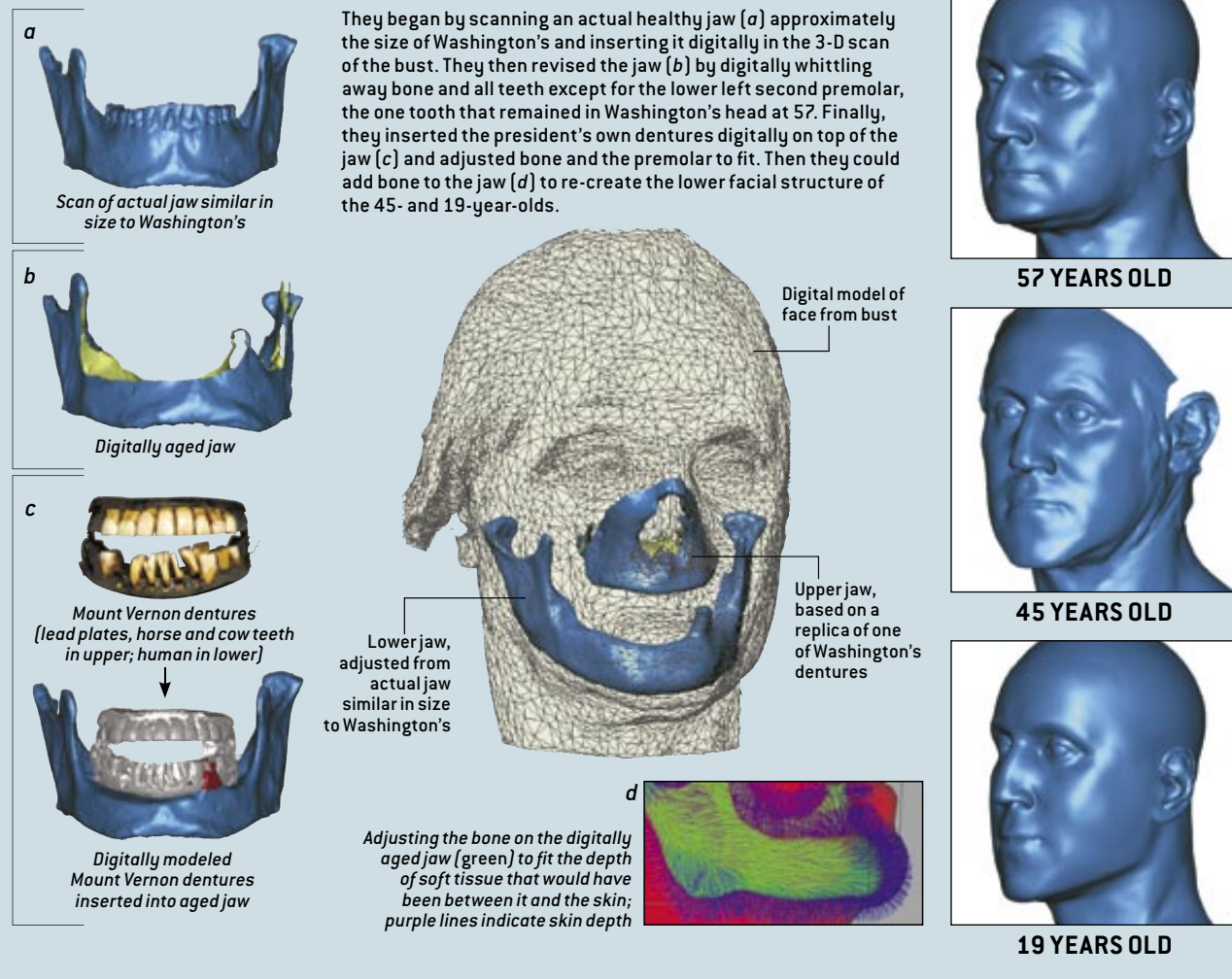
With the portraits as a guide, Hansen used his program to transform the digital face of the 53-year-old to the length of the younger face. Because I also noticed that the chins of the 40- and 47-year-old Washingtons were more symmetrical than in either the life mask or portraits at older ages, we adjusted the chin accordingly. We then imported the soldier's modified jaws into what was now a 40-ish face, adjusted them to fit and checked the image against established data on the thickness of skin. Because the 45-year-old would have had more bone along his mandible than the 53-year-old, the angle at the back had to be better delineated. We finally had the lower face of the 45-year-old. I then used it as the model for the 19-year-old, defining the jaw angle even more in the younger version. For the rest of the face, I softened or removed wrinkles and creases, added some fat to the cheeks (which is lost with age), and shortened the nose and earlobes (because the cartilage in them grows throughout life).

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FINISHING THE FACE

Washington's dental history provided important clues to completing the reconstructions of his head at ages 45 and 19. Tooth loss leads to bone loss, diminishing the height of the jaw and severely altering its size and shape. Once the

reconstruction team established the shape of the jaw at 53, they could then add tooth and bone to reshape the jaws so that they took on the structure they had in Washington's younger days.



Creating the three faces did not mark the end of the process. The skin under the chin and on the neck had to be tightened for the 45-year-old and much more so for the 19-year-old. The heads were ready. Now we had to reconstruct the bodies. Then we could digitally join them.

Constructing the Body

BOTH THE STATUE AND THE PAINTINGS portrayed a form somewhat different from what we expect to see in a 20th- or 21st-century male physique. I discovered that in keeping with an 18th-century custom common among English families of status, Washington's body had been corseted until about the age of five. I have not been able to find an example or even description of such a corset, but it would have differed from that used on girls and women to pull in the waist, because the effect altered the male body to look like a ballet dancer's. The shoul-

ders were pulled back, puffing out the chest and flattening the area across the shoulder blades, as well as down, creating a long slope from the neck on each side; the natural inward curvature of the lower back was further accentuated, which then pushed the belly out. (As I also learned, Washington had been a fabulous ballroom dancer. In fact, he kept meticulous notes on each type of dance.) Once the growth trajectory of the body had been changed in the boy, the new shape would have persisted throughout life, which is why portraits of 18th-century English gentlemen, including the signers of the Declaration of Independence, have a distinctly different look to them than portraits of important men of later centuries.

Washington's unusual height for his day—probably 6' 2" (but not 6' 3.5", as sometimes cited; this is most likely the length of his coffin)—has been given as a reason for his uncommon ability not only as a dancer but also as a horseman.

RE-CREATING THE BODY

America's founding father at 19 was tall, muscular and lean. When the figure, which is shown here at its full length for the first time, is installed at Mount Vernon in the fall of 2006, it will be clothed in the apparel Washington would have worn as frontier surveyor. His auburn hair will be tied back in a ponytail.

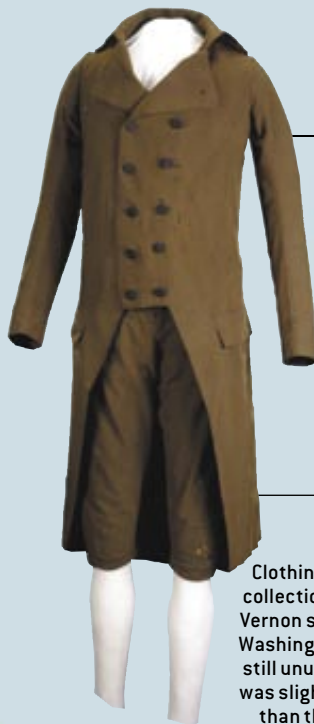


Washington's height comes most reliably from Houdon's 1785 statue (*left*), which shows the president as at least 6' 2". The portraits are less reliable; Stuart's famous full-length painting (*right*), for example, contains bits of Washington and bits of other models



Attaching the head to the body required painstaking digital "stitching": the edges of the two parts are made up of many small triangles rather than being a smooth cut, so that joining them was like putting together a delicate jigsaw puzzle

Washington's body had been corseted until about the age of five, pulling back the shoulders, puffing out the chest and creating a long slope from the neck down to the shoulders



Clothing from the collection at Mount Vernon showed that Washington, though still unusually thin, was slightly heavier than the statue portrays him



Trumbull's 1797 painting gives further evidence of Washington's long legs, which, it was said, he could wrap around the belly of his horse (Washington is on a dark horse at the middle right)



45 YEARS OLD (astride a horse)



57 YEARS OLD



19 YEARS OLD

In keeping with an 18th-century custom, Washington's body had been corseted until about the age of five.

He was described as wrapping his long legs tightly around his horse's belly as he outrode his comrades. As I found, Washington could do that not only because he had long legs but also because many of the breeds of horses kept in the 18th century were smaller than most of those developed during the 19th century. Another reason—based, it turns out, on only one much-repeated incorrect description—is that Washington was supposed to have been very broad across the hips, which, in turn, explained why he was able to sit so well in the saddle.

To find more concrete information about Washington's physique, I asked the curators at Mount Vernon for an array of items he might have worn; the style of clothing at the time was formfitting, especially around the torso, hips and legs. But I had to whittle my wish list down quickly. No hats, shoes, boots or gloves existed—items that would have provided details on the size and shape of head, hands and feet. Collections at Mount Vernon and other museums, however, contained clothing from the 1770s through the 1790s (his middle to late years) that could be verified as having been worn by Washington and not altered after his death to fit relatives. Aided by the expert eye of Linda Baumgarten, curator of textiles at Colonial Williamsburg, I then obtained linear and volumetric measurements on Washington's clothing and compared them with the Houdon statue.

These comparisons proved critical when I studied the statue, which stands in the state capitol building in Richmond, Va. As I approached it for the first time, I immediately saw that Washington appeared much thinner, particularly around the hips, than descriptions and portraits portrayed him. With PRISM's Gene Cooper and Scott Van Note, I compared the lengths of the arms and legs and the width between the shoulders of the statue with the measurements from the clothing. They were almost identical, although the clothing indicated a somewhat bulkier individual than the statue represented. Not tremendously bulkier, but a few centimeters one way or another does make a difference. We digitally adjusted the shape of the statue accordingly. From there, I could reconstruct the bodies of the 19-, 45- and 57-year-olds, guided by general knowledge about how bodies change with age and by some information specific to the man himself.

Historical documents suggesting that Washington was lanky in his older years—no doubt because of bouts of serious illness and difficulty eating—corroborated the measurements from the clothing, so I thought it reasonable to use the adjusted body of the statue for the 57-year-old figure. The 45-year-old body required a different approach. The elder Peale's portraits of Washington at 40 and 47 show the general as heavier around the belly and hips than later portraits and the clothing indicate. But why would he be heavier, I wondered, especially because, by the age of 47, he had endured the hardships of war, includ-

ing the winter at Valley Forge. His dental pain during those years was so unremitting that he may have changed his diet to softer foods that were probably higher in fat content. (Washington was in such agony during the battle of Trenton in 1776—he was 44—that his physician commissioned a blacksmith to forge a set of pliers so he could remove the offending tooth.) Thus, I made the 45-year-old body bulkier, especially around the middle. As for the 19-year-old, even if he had come close to his full adult height, he would not have been hormonally mature. He would have been fit as a result of carrying his surveying equipment uphill and down, but he would have been thin and sinewy, and this is how I portray him.

Finally, we could put the heads on the bodies. To do this, we had to digitally stitch together scans of each head and body. The scans produce data points that are connected to form triangles, so it was like piecing together a jigsaw puzzle of thousands of small polygons. We then sent the digital data to Kreyler and Associates in northern California to use in milling the heads of the three different Washingtons from dense plastic foam.

These traveled across the country to Studio EIS in New York City, where molds were made so the heads could be formed in clay. They will eventually be attached—on the basis of our digital “jigsaw”—to bodies made at the studio. The bodies will be constructed of dense foam covered with plaster and padded where necessary to simulate the softness of a real body. I worked with sculptor Stuart Williamson, a consultant at EIS, to give each face a unique expression before the clay itself was molded to create wax reproductions. Sue Day, an artist also working as a consultant at the studio, has painted these wax faces to look extremely lifelike, down to the pale skin with ruddy cheeks and grayish-blue eyes that Gilbert Stuart described for Washington. Reddish hair will be implanted in the younger two and tied back in the wiglike fashion of the time; the 57-year-old will have grayish hair to simulate the powdered look he would have had for the inauguration scene.

In the end, I hope each of the three representations of the father of this country will impart something of the dynamic and human side of a person who, despite his historical importance, remains a colorless figure to most Americans. Beyond this, another lasting result of the project is that through novel collaborations and applications of different research domains, my collaborators and I have made inroads into fusing science, art and history in ways that were hardly imaginable even a few years ago. SA

MORE TO EXPLORE

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