Electric Body Manipulation as Performance Art: A Historical Perspective

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ABSTRACT

The authors trace the history of electric performance art. They begin with the roots of this art form in 18th-century experiments with "animal electricity" and "artificial electricity," which were often performed as public demonstrations in royal courts and anatomical theaters. Next, the authors sketch the development of increasingly powerful techniques for the generation of electric current and their applications in destructive body manipulation, culminating in the electric chair. Finally, they discuss the development of electric muscle-control technology, from its 18th-century beginnings through Duchenne de Boulogne's photo sessions to the current work of Stelarc and Arthur Elsenaar.

Electric performance art can be defined as the theatrical display of electrically manipulated human bodies. In this article, we trace the historical development of this genre, from its roots in the scientific/technological innovations of the 18th century to today's most advanced computer-based muscle-control pieces.

The body manipulations employed in electric performance art are of three different types, all of which are equally valid and interesting. They each involve essentially different conceptualizations of the human body and its relationship to the electromagnetic realm, and deserve separate discussions.

First, we discuss pieces that treat the human body as a mere material object and demonstrate its electrical properties: its ability to carry an electrical charge and to conduct an electrical current.

Secondly, we review pieces that deal with the vulnerability of the human body, with the boundaries of its integrity. If an electrical current is too strong, it will effectively destroy the body's functional structure. Observing this phenomenon has a very powerful, disturbing effect on most people. At the same time, there are important practical applications that we also discuss.

Finally, we assume an information-theoretical, cybernetic standpoint and view the human body as a kinematic system whose motions can be steered by means of electrical *control signals*. This point of view was already implicit in Galvani's 18th-century experiments with frogs' legs—but it is particularly relevant today because it opens up the possibility of employing the human body as a display device for algorithms that run on digital computers.

THE HUMAN BODY AS A PHYSICAL OBJECT

The Electrified Human Body

When the ancient Greeks discovered the power of amber to attract small particles, they called this phenomenon "electricity"; and for many centuries the word did not mean much more than that. Many important electrical phenomena were first investigated in the 18th century. The pioneering work in this period was done in London by Stephen Gray, who in 1729 announced his discovery that the electric power to attract small particles can be transferred from one object to another by simply placing these objects close together. This is what we now know as "electrical induction." To investigate this phenomenon, Gray carried out an extensive series of experiments involving different materials. In March 1730, for instance, he demonstrated that an electric charge, created in a glass tube by rubbing it with velvet, could be transferred to a soap bubble, which could then attract silver leaf over a vertical distance of 2 inches [1]. This experiment was recently duplicated by the Dutch performance artist Dick Raaijmakers [2].

Almost immediately, Gray began to investigate the electrical properties of the human body in public performances. The first piece of this sort premiered in London, on 8 April 1730. Its protagonist was an 8-year-old boy, suspended in mid-air on silk threads. The boy was subjected to a fairly complex electrical situation: A positively charged glass tube was held close to the boy's feet, inducing a negative charge in them; because the boy was electrically isolated from his environment, this created an opposite (positive) charge in his other extremities. In the demonstration, only his face and his hands were exposed; these were then seen to induce charges on small particles of brass leaf and to attract these particles through the air. This experiment was duplicated in France by Charles Fran ois de Cisternay du Fay and in Germany by Christian Augustus Hausen, who employed a girl rather than a boy in his demonstration [3] (Fig. 1).

Several variations on this piece were soon developed by Gray and others. The person to be electrified need not be suspended, of course, but may be positioned on a pedestal made out of nonconductive material; usually a cake of resin was used for this purpose. And the body's electrification may be demonstrated in various different ways—for instance, by the mutual repulsion between similarly charged objects, which causes the hair of an electrified person to stand straight up [4] (Fig. 2).

These performances employ the human body as a prop—as a static, passive object. They demonstrate basic physical properties that human tissues share with many other organic and inorganic materials. It is of course a deeply meaningful experience for a person to watch the body of a fellow human displayed in such a fashion. The suspension pieces are the

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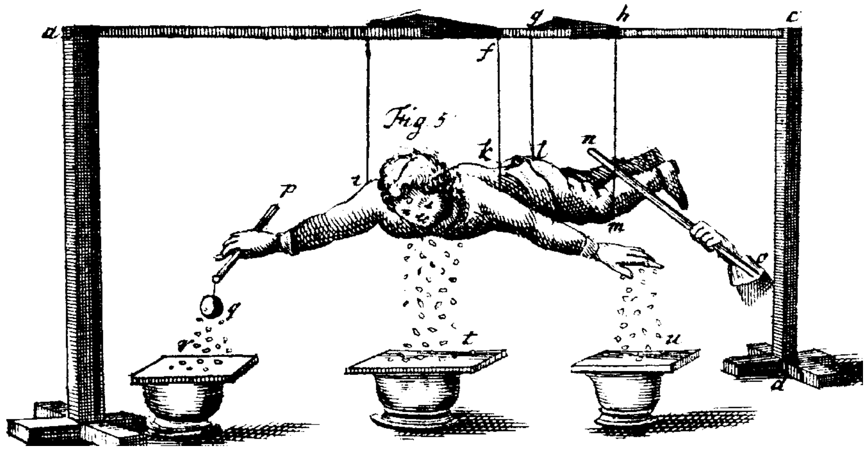
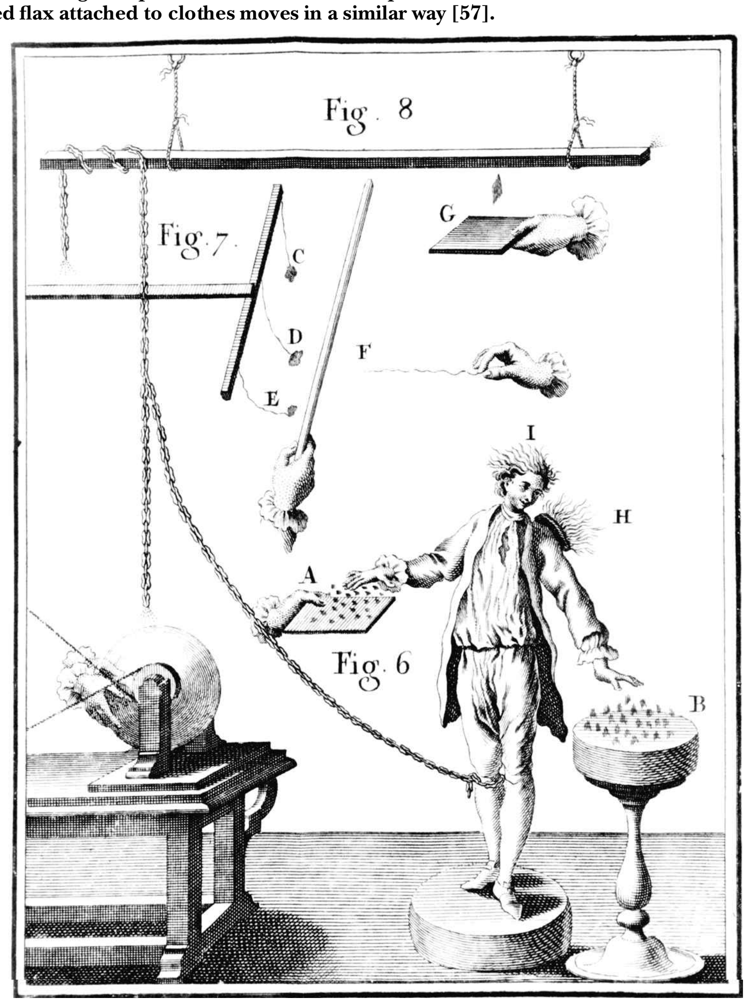


Fig. 1. Stephen Gray, static electricity demonstration, London, 8 April 1730. The electrified human body: An electrically charged boy attracts small particles of brass leaf through electrical induction [56].

most powerful ones in this respect: They show the body in a helpless, passive state. That is why the exhibition of suspended human bodies has always been an important motif in performance art and continues to be practiced to this day. Well-known examples in the ancient world are the crucifixions of criminals in several provinces of the Roman Empire, the most famous being the execution of Jesus Christ in Jerusalem, in about 33 C.E.

Stephen Gray's suspensions thus alluded, in a rather implicit way, to masochism and martyrdom. Explicit religious denotations appeared in the next wave of electric demonstrations, in Germany around 1740. The "beatification" pieces of Georg Mathias Bose continued Gray's involvement with the electrified human body, while employing a different method to visualize the body's electric field. Bose would gradually electrify a person in a darkened room; when the person's surface voltage would get high enough, it would ionize the surrounding air, creating a bluish glow around the person. In the words of an eyewitness: "Finally his entire body was bathed in light and surrounded in the manner sometimes used to depict the glory of a saint by encircling him in rays of light" [5].

Fig. 2. This plate shows some of the effects of static electricity on an electrically isolated person standing on a piece of resin: small metal particles are attracted; hair stands on end; combed flax attached to clothes moves in a similar way [57].



By providing the charged person with pointed metal headgear, the light rays could be concentrated on the head, resulting in an artificial halo. In Bose's own words: "A Chair being suspended by Ropes of Silk, made perfectly dry, a Man placed therein is render'd so much electrical . . . that, in the dark, a continual Radiance, or *Corona* of Light, appears encircling his Head, in the manner Saints are painted" [6].

The Human Body as a Conductor

In 1732, Stephen Gray launched a series of variations on his original piece, introducing a second theme: the capacity of the human body to function as a *conductor,* allowing an electrical charge to be transferred between two points. Gray now employed two boys holding hands, or two boys connected by a 4-foot metal ruler, or two boys connected by a metal wire. In this setup, inducing an electrical charge in one boy creates an electrostatic force in the other. The pieces thus show that the electricity passes from one boy to the other, offering a subtle parody on the idea of "interpersonal communication" [7].

Again, Georg Mathias Bose was the one to turn allusions into blatant signifiers. His piece *Venus Electrificata,* a.k.a. "the electric kiss," is a truly interactive salon performance. An attractive female person is secretly electrified; newly arriving guests are hit by strong electric sparks when they touch or kiss her [8].

Electric Venus is obviously a performance piece, set up for the entertainment of the onlookers. But from the point of view of the person receiving the "electric kiss" it is first of all an instance of what we may call "immediate art": an art experience that does not involve the perception of an external object through the senses; instead, the end-user's afferent nerves are directly stimulated by means of electric current.

The spark of the electric kiss was barely visible. But when the voltages used are high enough, electric discharges can be produced that look like strokes of lightning. The equipment that makes this possible was developed by Nikola Tesla at the end of the 19th century. Tesla's demonstrations are still in the repertoire of many science museums today [9]. They have also been incorporated into recent performance pieces by Barry Schwartz [10].

An important step in this development was made in 1745, when the first electrical condenser device was invented independently by Ewald Georg von Kleist in Germany, and by Pieter van Musschenbroek at the electrical engineering department of Leyden University in the Netherlands; it was called the "Leyden jar" as a result of the P.R. of one of van Musschenbroek's most enthusiastic betatesters, the French abbot Jean Antoine Nollet [11].

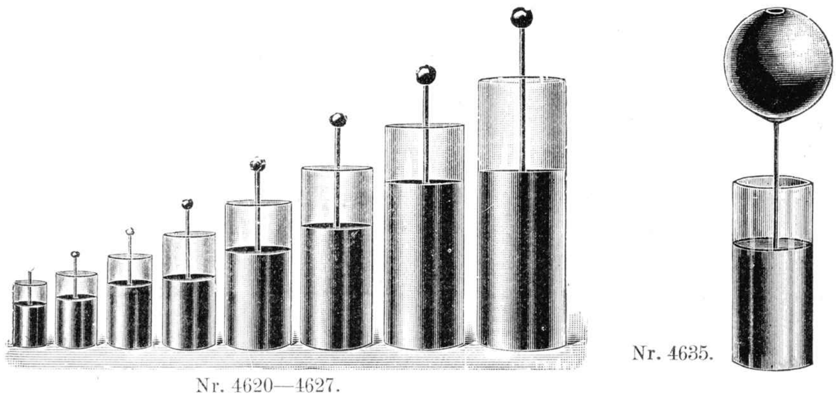
The Leyden jar is a glass bottle coated on the outside with metal foil and filled with water. It is essentially a pair of parallel conductors (metal foil and water), separated by a nonconductor (the glass) (Fig. 3). It can store (and release) much larger charges than could the glass rods used in Gray's early performances. When the two conductors are connected with each other, the bottle discharges, and the connection (briefly) carries a fairly large current. When the connection is made through the human body, the current may be strong enough to produce a visible effect: an involuntary convulsive contraction of the muscles in the affected body parts.

This phenomenon was noted in the first reports on the Leyden jar. Von Kleist himself received a shock that set his arm and shoulders in motion; Johann Heinrich Winkler felt a convulsion in his whole body, in particular in his lips and jaws; and Johann Carl Wilcke fell unconscious on the floor [12].

The Leyden jar created the technological preconditions for electric performance art in the modern sense of the word: pieces in which electric currents are used to affect the operation of the human body. In particular, they created the possibility of transposing Gray's conductivity pieces to a more dramatic form. Performances involving several persons connected together became very popular. The Abbé Nollet, for instance, directed several pieces of this sort. One of them, performed for the king of France, involved a chain of 180 guards, who were all made to jump into the air at the same time when they were used to close the circuit with a Leyden jar. Another piece employed an entire community of Carthusian monks, who were connected by iron wires over a distance of more than 1.5 km. Remember that Gray's chamber pieces focused on observing the motions of very small metal particles—with Nollet's work we have clearly moved to a very different scale of "social sculpture" [13].

Some of the connotations of this kind of work were made explicit in a piece directed in 1772 by Joseph-Aignan Sigaud de la Fond for the duke of Chartres, involving a chain of 20 persons. This piece may seem more modest than Nollet's grandiose performances, but it had a more specific point. The chain contained three castrati, in order to test whether bodily fluids with a sexual function might be essential for the electrical conductivity of the human body; this turned out not to be the case [14].

Fig. 3. The Leyden jar, invented in 1745, was the first electrical condenser device. Its improved storage capacity made it possible to produce much larger charges than before. This gave rise to new electrical performance pieces, which became very popular in the European courts [58].



Transgressing the Body's Limits: Destructive Testing

The electric shocks enabled by the Leyden jar were in fact strong enough to violate the integrity of the body and cause minor or major damage. This was first discovered accidentally by brave scientists experimenting on their own bodies in the solitude of their laboratories. Johann Heinrich Winkler, for instance, reported a shock that caused his nose to bleed [15].

Animal Electrocutions

Almost immediately, experiments were carried out to investigate this property of the electric current in a systematic way. Once more, the prolific Abbé Nollet was one of the first to do so. He realized that the amount of damage inflicted on a body would very likely be inversely proportional to the size of that body. A current causing a bleeding nose in a human might have much more serious consequences for a smaller animal. With his well-known sense of theater, Nollet decided to go for the killer application. He set out to investigate whether the Leyden jar could be used to terminate the life of suitably chosen higher animals. He soon succeeded in killing a sparrow by means of a Leyden jar discharge. He observed that it appeared as if the bird had been struck by lightning; on dissection it was found that most of its blood vessels had burst [16].

At the same time, Daniel Gralath, in Danzig, began small-scale experiments in which he killed beetles. In order to create stronger shocks, he then invented the condenser battery: he linked several Leyden jars in a series and used this setup to kill birds [17]. Gralath failed in his attempt to electrocute a goose, but Benjamin Franklin, in Philadelphia, managed to dispose of guinea fowls and a turkey [18]. The enlightened English minister Joseph Priestley raised the death count further while writing the first history of the newly developing science of electricity; he found it useful to do some additional experiments of his own, and in the process sacrificed the lives of a rat, a shrew, a dog and some cats [19].

We all know where this would lead. The deadly experiments with animals presage the deliberate electrocution of humans. But with 18th-century technology, this was not yet feasible; effective experimentation with animals larger than cats or chickens would have required impractically large batteries of Leyden jars.

The Electric Chair

In the course of the 19th century, the situation changed dramatically. Michael Faraday discovered in 1831 that mechanical motion could be transformed into electric current by means of electromagnetic induction. On the basis of this principle, the first electric power generator (a rather inefficient one) was built by Hyppolite Pixii in 1832. It took almost half a century of further inventions before large-scale power generators, driven by steam engines or waterfalls, became practically feasible [20].

The world's first power plant for public use was built in 1882 by the Edison Electric Illuminating Company of New York on Pearl Street in New York City. Initially it generated the electric current for 1,284 lamps in 59 houses [21]. This was the beginning of Edison's power-generation and distribution empire, based on the use of direct current (DC). Soon afterwards, the techniques for using alternating current (AC) were developed. AC has a significant advantage, because it can be more efficiently distributed over long distances. Edison stuck with DC, however, and ended up in fierce competition with George Westinghouse, who was using AC. (Nikola Tesla, one of the inventors of AC technology, was working for Westinghouse after a falling out with Edison.) This business battle was the context for a new wave of electrocution performances beginning at the end of the nineteenth century [22].

The new electric power infrastructure was already claiming victims in the early 1880s, as people sometimes made accidental contact with high-voltage lines. In 1881, the dentistry professor Alfred P. Southwick of Buffalo, NY, witnessed such an accident. He noticed that death occurred instantly, and realized that electricity might be the answer to a difficult but pressing societal question: how to administer the death penalty in a clean, quick and painless way. (The established method for capital punishment in New York State, death by hanging, was increasingly experienced as undignified and barbaric [23].) To investigate this idea, Southwick revived the 18th-century research tradition that we discussed above: he exposed several animals to various doses of electric current, in order to determine under which conditions they would die [24].

Having ascertained the feasibility of deliberate and controlled electrocution, Southwick proceeded to lobby for its introduction as the legal method for capital punishment in the state of New York. His efforts were successful. In the autumn of 1888 the state legislature passed the Electrical Execution Law [25].

At the same time, another noteworthy series of animal electrocutions was being carried out on the premises of Edison's research laboratory in West Orange, NJ. These experiments, initiated and directed by the freelance electrical engineering consultant Harold P. Brown, were primarily intended to demonstrate the dangerous nature of alternating current. In the course of 1888, Brown killed 50 dogs and cats with AC; he concluded this series with a calf and a horse [26]. Brown would explain his results by pointing out that AC currents create a rigid contraction of all muscles, including heart and lungs; a modest dose of AC is therefore sufficient to cause immediate unconsciousness and rapid death. Brown maintained that for this reason AC was completely unsuitable for most applications, but ideal for administering the death penalty [27].

The first execution under the Electrical Execution Law took place on 6 August 1890, and it was indeed carried out by means of AC equipment. Harold Brown had been appointed as the official "New York State Expert on Electrical Execution," and he had taken pains to procure some second-hand Westinghouse dynamos for this purpose. The axe murderer William Kemmler was killed at Auburn Prison (Auburn, NY), in the presence of 25 witnesses, including 14 physicians and some journalists. The event, however, did not unfold as smoothly as had been hoped. The voltage was too low, and the electrode placement not optimal. A second dose of electric current was needed before Kemmler finally succumbed, with his blood vessels exploding and his skin burning [28]. What was supposed to be an unusually clean procedure ended up looking like a drawn-out torture session. The result was a big publicity scandal [29]. The medical expert reviewing the execution considered the experiment completely successful, however, arguing that the victim had become unconscious as soon as the current was applied [30].

Kemmler's death was the first in a long and open-ended list of official electrocutions of humans. But from a purely technical point of view, interesting challenges were still to be found in the animal kingdom. The ultimate electrocution demo took place on 4 January 1903, when Edison killed an elephant. The Coney Island–based elephant Topsy was in fact a dangerous animal: She had killed three innocent people. Her execution was recorded on film (Fig. 4).

Fig. 4. Thomas A. Edison, stills from the film *The Electrocution of Topsy*, Coney Island, 4 January 1903.

Edison's scare campaign could not change the course of history, and AC won the battle for the electricity infrastructure. Nevertheless, the electric chair did become an important and well-recognized instrument of justice in many parts of the United States [31].

Electrocutions had (and have) all the properties of large-scale festive spectacles, with one exception: The set of people who witness the actual event is kept extremely limited. Death-penalty executions used to be important social events almost everywhere in the world, but in the course of the 19th century this began to change. In some U.S. states, the death penalty was abolished altogether, while in others the executions were removed from the public sphere. In 1835 (long before the electric chair!), the state of New York was one of the first to adopt a policy of concealed executions, in order to prevent the unruly behavior of the excited crowds that public executions would often attract [32]. In today's mass media society, the situation has changed once more, of course. Jazz critic Nat Hentoff has argued convincingly that in television, we now have an ideal medium for making death penalty executions public events again:

> A once familiar argument against public executions was that they would be accompanied by rowdy crowds, sleazy entrepreneurs selling souvenirs, drunken brawls, and other assaults on our customary harmony and civility. But with television, that fear is obsolete. We would be watching in our homes, not in crowds.
>
> Through our taxes, we all pay for the electrocution or the lethal injection or the gas chamber or other instruments of finality. Why, then, can't we see what we pay for? Why can't we—including children—see the ultimate majesty of American justice in its most Wild West form? Watching a man turn into a thing will convince kids that if they don't mind their parents, they'll fry.
>
> If—as politicians believe—there is a ravenous hunger among the people for official killing of those who kill, why not fully satisfy that hunger by showing on television the last twitching moments of the justly condemned? Should we not be able to hear the prisoner's final desperate, cracked breaths? [33]

Home electricity conquered the world, and the means to inflict electric body-damage has become available to everyone. The artist Chris Burden has performed several pieces that toy with the lethal power of electric current. Some of these pieces (*110* and *220* [1971]) merely set up possibilities for dangerous accidents. In *Doorway to Heaven* (1973), Burden comes close to putting some actual current through his body. His report runs as follows: "At 6 p.m. I stood in the doorway of my studio facing the Venice boardwalk. A few spectators watched as I pushed two live electric wires into my chest. The wires crossed and exploded, burning me but saving me from electrocution" [34].

To end this section about electric death on a more pleasant note, we should also mention the opposite application: the resuscitation of apparently dead human bodies by applying moderate shocks to various vital muscles. This possibility was first suggested by Charles Kite in London in 1778, and has been very popular ever since [35].

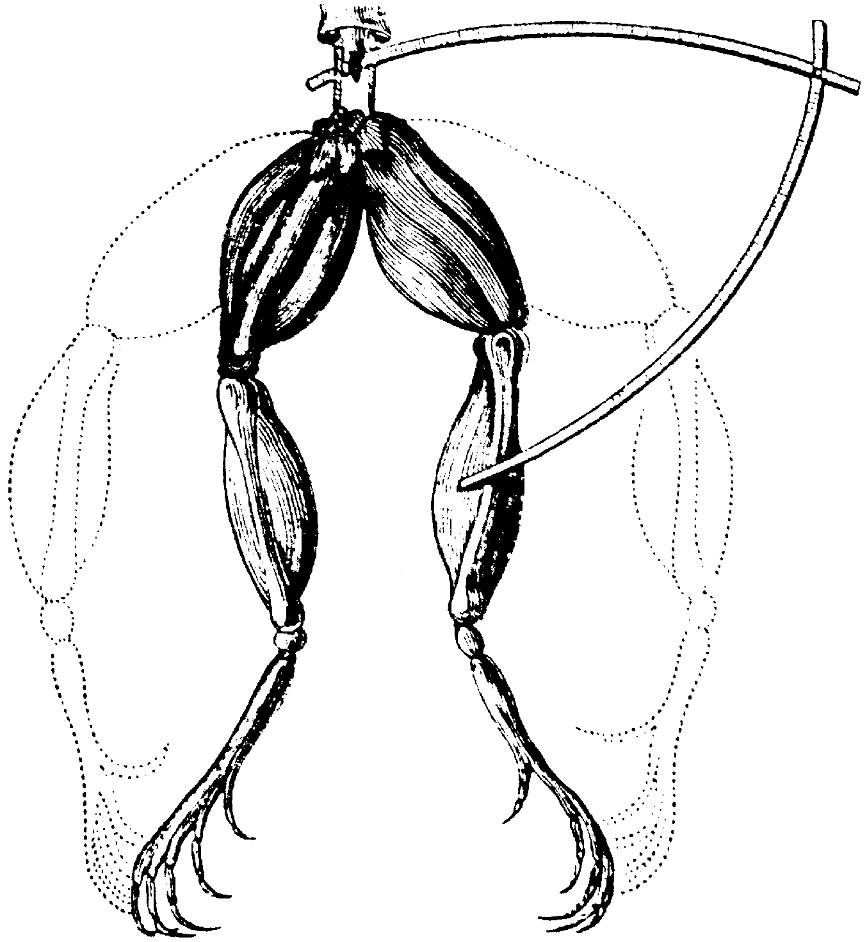


Fig. 5. Luigi Galvani discovered that a frog's leg will contract if the circuit between the leg's muscle and the frog's spinal cord is closed by means of a connection involving different metals [59].

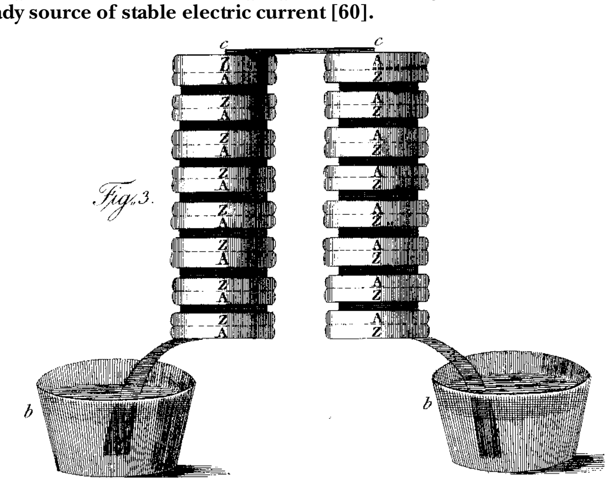
The Body as an Electrical System: Muscle Control Signals

Let us now turn back and review the possibilities of the more refined and nondestructive control of human bodies. Work in this area began immediately after the invention of the Leyden jar in 1745, and right away there were some important successes.

Triggering Individual Muscles

In 1747, Jean Jallabert in Geneva discovered that individual muscles could be

Fig. 6. The electrochemical battery was invented by Alessandro Volta after Luigi Galvani's research group discovered the electric properties of metal junctions. This "Voltaic cell" was the first steady source of stable electric current [60].



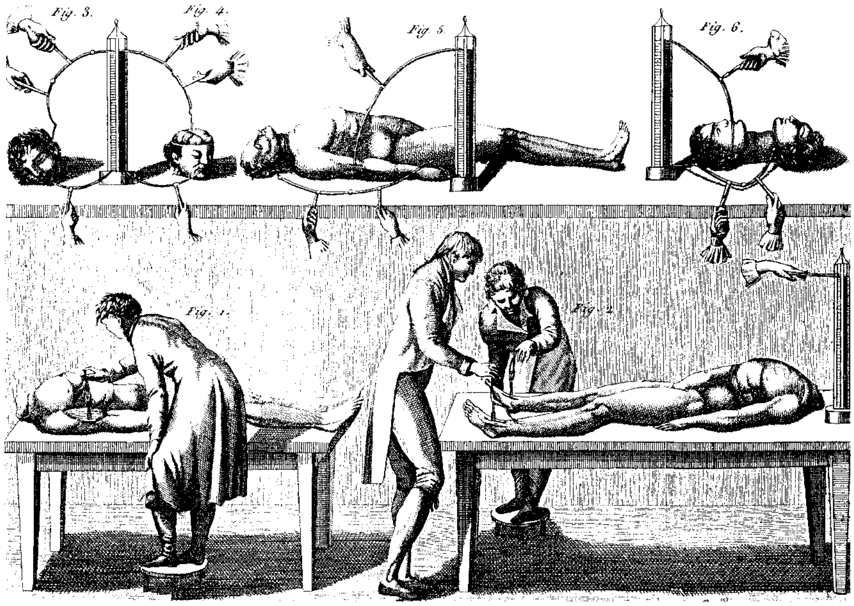


Fig. 7. Giovanni Aldini, Demonstration of "Animal Electricity" in the Human Body, Paris, ca. 1800. This piece was part of a long series of experiments with the heads and trunks of decapitated animals and beheaded criminals, investigating the electric properties of their muscles [61].

Fig. 8. Artificial emotional expressions on the face of a model, induced by Guillaume B.A. Duchenne de Boulogne. Duchenne first practiced the technique of Transcutaneous Electrical Nerve Stimulation, which is still used in electric performance art today. This photograph shows an example of Duchenne's efforts toward "artificial theater": staged situations with expressionless actors whose faces were "turned on" by means of electrical currents [62]. (Photo: Adrian Tournachon)

stimulated by electric shocks from a Leyden jar. He created muscle contractions in a patient's arm that had been paralyzed for 14 years; electrical treatment led to complete recovery of the arm's functionality within three months. Jallabert also created involuntary contractions in the muscles of his own (healthy) arm [36].

In 1756, Marc'Antonio Caldani and Felice Fontana in Bologna began their work on electrical stimulation of animal muscles. They succeeded in applying the more old-fashioned technique of electrified rods to induce muscular contractions in all parts of living frogs, as well as dead ones, and they found that electrical stimulation caused the intestines of a cat to display very unusual movements.

Caldani and Fontana then went on to demonstrate that the nerves conduct electricity to the muscle. The contraction of a muscle group can thus be externally triggered by electrically stimulating the nerve that normally carries the signals from the brain to the muscle. Caldani and Fontana cut the femoral nerves of a frog at a point close to that of their exit from the spinal column and spread them out in four curves on a board; apart from that, the frog was left fully functional. When an electrified rod was brought close to the nerves, movement of the lower limbs occurred [37].

Similarly prepared frogs were also used by Luigi Galvani in the 1780s, in his rather complete survey of techniques for generating muscle contractions in animals [38]. Galvani's big discovery was to generate contractions by simply closing the circuit between the nerve and the muscle by means of a metal connection. He thought that this demonstrated the intrinsic charge of the muscle ("animal electricity"), though what he had in fact discovered was the electric potential of metal junctions (Fig. 5). (Alessandro Volta realized this soon after Galvani's publication and proceeded to exploit this phenomenon in the "Voltaic cell") [39] (Fig. 6).

Galvani also triggered muscle contractions by means of nearby electric sparks ("artificial electricity"). He found that the effect was stronger if the nerves were extended with long metal wires. This is probably the first instance of muscle stimulation through radio control. The third source that Galvani explored was "atmospheric electricity": contractions evoked by strokes of lightning, or by charges picked up from thunderclouds by means of high metal poles. Galvani's work became very well known; his experiments were duplicated by large numbers of physicists, biologists, physicians and amateurs [40].

To ascertain that his conclusions applied to warm-blooded animals, Galvani successfully experimented with live chickens and sheep. Christoph Heinrich Pfaff established that "animals from all classes" were susceptible to electric muscle stimulation: mammals, birds, amphibians, fish, insects and worms. Plants, however, seemed not to react at all [41].

This research line was continued around 1800 by Galvani's nephew, Giovanni Aldini, who performed a long series of impressive demonstrations with decapitated animals. He stimulated the heads and trunks of cows, horses, sheep and dogs. An eyewitness reported:

> Aldini, after having cut off the head of a dog, makes the current of a strong battery go through it: the mere contact triggers really terrible convulsions. The jaws open, the teeth chatter, the eyes roll in their sockets; and if reason did not stop the fired imagination, one would almost believe that the animal is suffering and alive again [42].

To what extent these phenomena would also occur in humans was of course of particular interest. Galvani had therefore continued his investigations with freshly amputated human arms and legs obtained from the local hospital [43]. In Paris, this kind of research was facilitated by the French Revolution. Some fortunate researchers received official permission to conduct galvanic experiments with the corpses of those who died under the guillotine: "One minute before three, the axe fell on the Place de Grêve, and at 3.15 I already had the head in my hands and Mr. Nysten the body" [44].

But much of this research remained centered in Italy. In 1802, for instance, there were extensive presentations involving beheaded bodies in the anatomical theater of the University of Turin [45] (Fig. 7). Aldini took his show on the road and gave very successful demonstrations in London with the body of a recently hanged criminal. An electrical current between the mouth and an ear created "terrible convulsions" in the mouth, and caused the left eye to open [46].

In the early 19th century, considerable progress was made in France concerning the techniques for precisely controlling muscles in living humans. Bernard Raymond Fabré-Palaprat and Jean Baptiste Sarlandière pioneered the use of thin metal needles (derived from Chinese acupuncture) to administer galvanic current to quite specific points inside the human body. Fran ois Magendie showed that needles could be inserted in nerve cells without causing damage [47].

Fig. 9. Duchenne investigated in great detail how to access the different muscles of the human face. This photograph displays an artificial grin on the face of his favorite model [63]. (Photo: Adrian Tournachon)

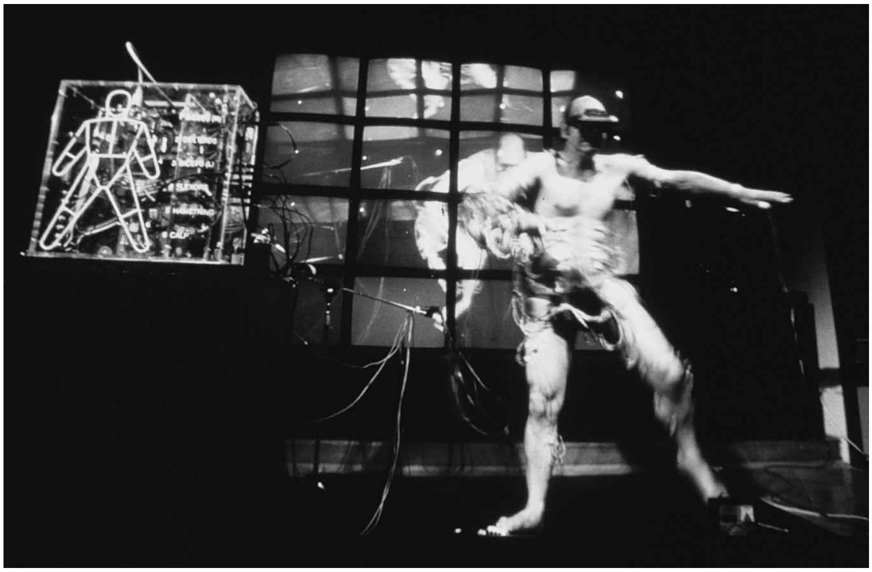
Duchenne de Boulogne

The crucial step towards modern muscle stimulation technology was made by Guillaume Benjamin Armand Duchenne de Boulogne. He pointed out various problems with the "electropuncture" method and showed that very often there is a convenient alternative. Many individual muscles can be triggered by putting voltages across electrodes on the skin, if these electrodes are positioned sufficiently carefully; also, the voltages applied must be calibrated very precisely. This is the technique known as Transcutaneous Electrical Nerve Stimulation, which is still used today by artists such as Stelarc and Arthur Elsenaar (co-author of this article). Duchenne gave rather precise indications about the locations at which various muscles can be accessed. He also made a detailed study of the human facial muscles, their excitation points and their emotional significance [48].

Much of Duchenne's work was concerned with innovative medical applications of electricity, in particular with the treatment of various kinds of paralysis. At the same time, he pioneered the scientific use of the recently invented art of photography. He published photographs of the various expressions that he could evoke on human faces—"straight" ones as well as photographs of staged situations with props and actors (Fig. 8).

One series of photographs about facial expression was deliberately made with "an old toothless man, with a thin face, whose features, without being absolutely ugly, approached ordinary triviality and whose facial expression was in perfect agreement with his inoffensive character and his limited intelligence" (Fig. 9). Duchenne explained: "I preferred this coarse face to one of noble, beautiful features . . . because I wanted to prove that, despite defects of shape and lack of plas-

Fig. 10. Stelarc, *Split Body: Voltage-In/Voltage-Out*, Galeria Kapelica, Ljubljana, 1996. One of the many pieces in which the Australian performance artist Stelarc enabled the audience to control the muscles of a substantial part of his body. On the left, this photo shows the touch-screen interface that was used for this purpose. (Photo: I. Andjelic, © Stelarc)



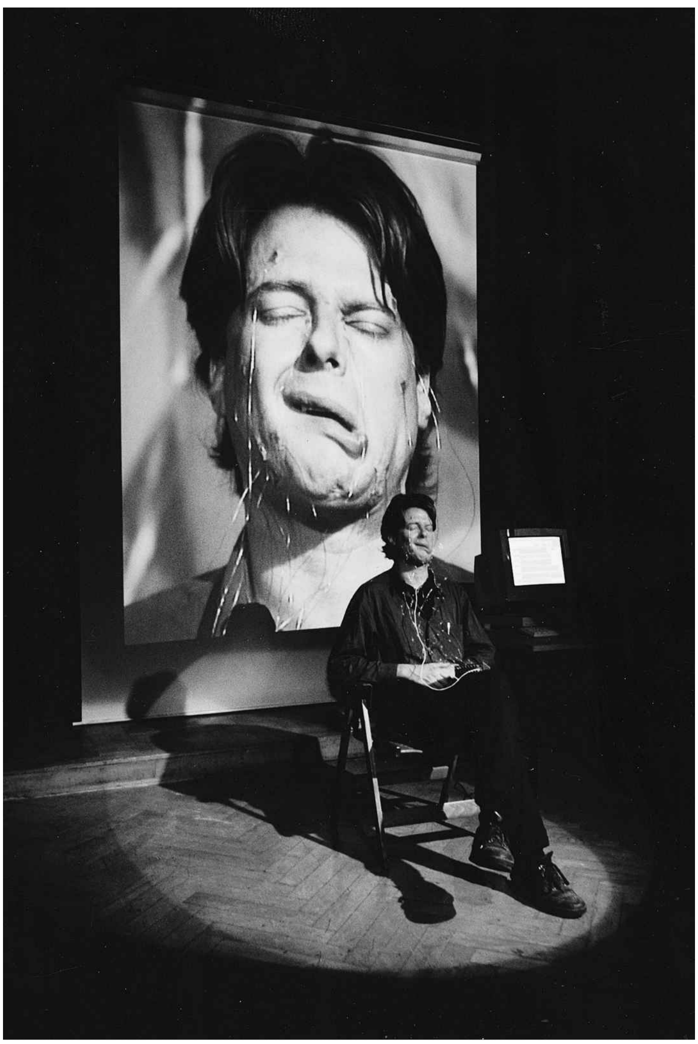


Fig. 11. Huge Harry, *Towards a Digital Computer with a Human Face*, Galeria Kapelica, Ljubljana, 2000. In this lecture, computer voice "Huge Harry" explains how the human facial muscles may be externally controlled through electrical stimulation. He employs the face of Arthur Elsenaar as a live "display device." (Photo © J. Jasperse)

tic beauty, every human face can become spiritually beautiful through the accurate rendering of emotions" [49]. In fact, this subject also suffered from an anesthetic condition of the face, which made him a better passive receptacle for the display of artificially simulated expressions. For the same reason, Duchenne also repeated these "artificial expression" experiments with a dead body and with a head severed from its trunk [50].

Twentieth-Century Performance Art

Duchenne's ideas and techniques were the basis of 20th-century physiotherapy techniques and armchair-workout devices. This paramedical technology, in its turn, constituted the point of departure for the muscle-control devices employed in contemporary electric performance art. Several pieces by Stelarc and by Elsenaar involve Duchenne-style muscle-stimulation devices hooked up to a computer interfacing the artist's muscles with an automatic control regime or with the whims of a (local or remote) audience. Compared to their 19th-century predecessors, these pieces focus less on static postures or expressions, and more on motion patterns and behavioral processes. In other words, they moved from the sphere of visual art into the sphere of theater.

Since his attempt to jump through a glass pane in 1976, Australian artist Stelarc has put forward a large variety of different performance pieces. In many of these, Stelarc employs his own body as a passive physical object, subject to the forces of gravity or to electrical manipulation. At the same time, the physical parameters of his body (including its muscle activities) are amplified and externalized in various ways: as sounds, visual projections or movements of robots or prostheses. He pioneered, for instance, the use of a "Third Hand": an additional robotic hand attached to one of his arms, which is moved by electric signals that are picked up by electrodes from other parts of his body [51].

Stelarc introduced external muscle control in his work in the *Event for Video Shadow, Automatic Arm and Third Hand* at the Caulfield Art Complex in Melbourne in August 1988. In this fairly complex event, Stelarc's left arm was operated automatically and continuously by two muscle stimulators—curling the fingers, closing the hand and jerking the arm upwards. At the same time, six body signals and his third hand were acoustically amplified. Also, a "fragmented and synthesized" video shadow of Stelarc's body was

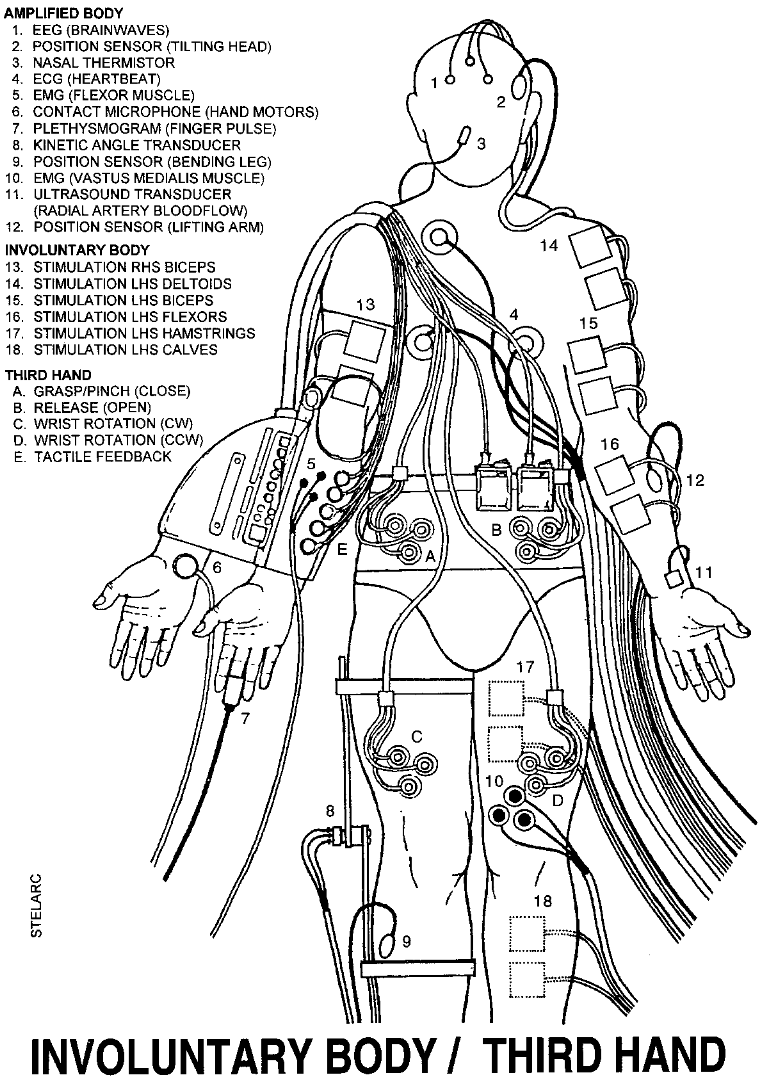
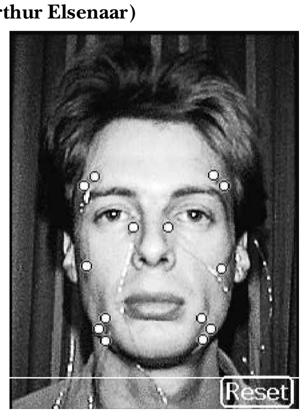


Fig. 12. Stelarc, *Involuntary Body/Third Hand* (performed in Padua, 1995; Auckland, 1996; Vienna, 1998). Diagram indicating which muscles are controlled externally and which muscles are employed to control the "Third Hand" prosthesis. In the *Fractal Flesh* event (Luxemburg, Paris, Helsinki, Amsterdam, 1995), the input controlling the "Involuntary Body" came from a remote audience through the Internet. (© Stelarc)

Fig. 13. Arthur Elsenaar, *rEmote,* live Internet performance, Groningen, Amsterdam, Delft, Toronto, 1995. This photograph shows the placement of electrodes on Arthur Elsenaar's face. By clicking on the marked spots via a Web interface, the Internet audience could trigger Elsenaar's facial muscles. (© Arthur Elsenaar)



projected, obtained through live manipulation of the output of four video cameras. In the subsequent "Split Body" performances (first shown in 1994 in various locations in Australia), the automated part of Stelarc's body (also including one of his legs) is programmed by the audience through a touch-screen interface in the gallery space [52] (Fig. 10).

Duchenne's investigation of the muscle system of the human face is being continued in our own work at the Institute of Artificial Art Amsterdam, at the Department of ArtiFacial Expression. Elsenaar built a muscle-interface device around a microprocessor system that allows fast, precisely synchronized and finely tuned simultaneous control of 16 different facial muscle groups using a virtually continuous scale of 128 levels of contraction strength. This device can be controlled by a host computer through MIDI.

Using this equipment, we have confirmed and extended Duchenne's findings about the ways in which humans use particular configurations of muscle contractions to signal particular states of their operating systems. Since 1994, these results have been regularly reported in various lectures with live demos by Huge Harry [53] (Fig. 11).

Internet Interactivity

In the fall of 1995, the time was ripe to explore the possibility of remotely controlled body movements with large-scale audience participation via the Internet. In November, Stelarc presented the *Fractal Flesh* event. During this event, Stelarc's body was located in Luxemburg, while audiences in Paris, Helsinki and Amsterdam could view and control his muscles through a web interface. At the same time, Stelarc could activate his robotic Third Hand and also trigger the upload of images to a web site [54] (Fig. 12).

In December 1995, Arthur Elsenaar presented the interactive Internet performance *rEmote*, a.k.a. *Compose Your Emoticon:* Elsenaar's live face in Groningen was connected through a Web interface with audiences in Amsterdam, Delft and Toronto, who could trigger his facial muscles so as to put together whatever facial expressions they liked to see (Fig. 13).

Algorithmic Control

In Stelarc's more recent pieces, he has moved to muscle-control regimes that are largely unpredictable and not influenced at all by any conscious human ideas. In

Fig. 14. Arthur Elsenaar and Remko Scha, *The Varieties of Human Facial Expression (12 Bit Version)*, 1997. A computer program enumerates all facial expressions that can be realized with a particular electrode configuration on Arthur Elsenaar's face. (Stills from a videotape: © J. Jasperse)

the *Ping Body* performance, which premiered in 1996 in Sydney, Stelarc's involuntary gestures turn into a representation of a part of the Internet. In this piece, a program sends signals over the Internet to more than 30 domains around the world and measures how many milliseconds it takes before the receipt of the signal is acknowledged. (This process is known as "pinging".) The numbers resulting from these measurements are used as inputs that control Stelarc's left arm, left leg and right upper arm, causing these body parts to engage in rather random-looking movements. At the same time, Stelarc employs his Third Hand, controlled by his abdomen and right leg, and presents video projections and audio amplification of the muscle signals. Stelarc's 1997 *ParaSite Event (For Invaded and Involuntary Body)* uses a similar setup but employs JPEG files from the Internet rather than random pinging to control his muscles [55].

At the Institute of Artificial Art, on the other hand, the muscle-control patterns are becoming more elaborately systematic. In 1997, we developed an algorithm that successively realizes *all* possible muscle-contraction configurations of the face. A limited version of this algorithm, which only enumerates the facial expressions that can be realized by the combinations of on/off settings of 12 specific facial muscles, is shown on a 32-minute videotape entitled *The Varieties of Human Facial Expression (12 Bit Version),* which has been shown in several visual-art exhibitions (Fig. 14).

We are using the insights from such systematic pieces in the development of a new theatrical genre. In "algorithmic facial choreography," the algorithmic approach to facial expression generation is combined with algorithmically generated music. At Ars Electronica 1997 we premiered the electric-guitar band *Arthur and the Solenoids,* which consists of a digital computer controlling the muscle system of a live human face, with precisely synchronized musical accompaniment by MIDI-controlled electric guitars.

These pieces demonstrate one of our major research findings: Most of the muscle-contraction configurations that the human face is capable of are *never* spontaneously used by humans, and many of them cannot even be produced without external electrical stimulation. Algorithmically controlled human faces thus enable us to explore new and unusually complex emotional states.

Conclusion

One of the biggest challenges in the realm of computer-generated art is the production of fully computer-controlled dance and theater performances. Theatrical performances that do not involve people tend to make a rather limited impression on human audiences. The emotional impact that theater can have is the result of visceral resonances between the bodies on stage and the bodies in the audience.

Computer-controlled dance and theater performances thus present a peculiar difficulty: they require interfaces that make the expressive possibilities of the human body directly accessible to the computer. This paper has shown that there are viable techniques that solve this interface problem. These techniques derive from a long research tradition, which from the very beginning has been applied in many impressive manifestations of "electric performance art." But we may hope and expect that the best is yet to come.

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3. Gray [1]; Christian Augustus Hausen, *Novi profectus in historia electricitatis* (Leipzig, 1743); Charles Fran ois de Cisternay du Fay, "A Letter Concerning Electricity," *Royal Society Philosophical Transactions* **38** (1733/1734) pp. 258–266; Margaret Rowbottom and Charles Susskind, *Electricity and Medicine: A History of Their Interaction* (San Francisco, CA: San Francisco Press, 1984) pp. 4–8; Albert Kloss, *Von der Electricität zur Elektrizität. Ein Streifzug durch die Geschichte der Elektrotechnik, Elektroenergetik und Elektronik* (Basel, Boston, Stuttgart: Birkhäuser Verlag, 1987) pp. 30–31.

Note that we conveniently described (and "explained") Gray's experiment in terms of notions from modern physics, which were completely unknown to Gray and his contemporaries. We adopt this policy throughout the historical parts of this paper. It is not within our current scope to discuss the struggle of 18th-century physicists towards the development of an empirically adequate description of electricity. See J.L. Heilbron, *Electricity in the 17th* *and 18th Centuries* (Berkeley, CA: Univ. of California Press, 1979); Roderick Weir Home, *The Effluvial Theory of Electricity* (New York: Arno Press, 1981).

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7. Stephen Gray, "Two Letters Containing Farther Accounts of His Experiments Concerning Electricity," *Royal Society Philosophical Transactions* **37** (1731/1732) pp. 397–407.

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52. Succinct information about several prototypical performances can be found on Stelarc's web site: <http://www.stelarc.va.com.au/cards/index.html>.

53. Huge Harry is one of the voices of the speech synthesis machine DECtalk, designed in the late 1970s by Dennis Klatt at the MIT Speech Laboratory. Harry is president and "spokes-machine" of the Institute of Artificial Art Amsterdam. When he delivers our research reports about human facial expression at scientific meetings, he usually employs Elsenaar's face as a live display device. On these occasions, he cooperates closely with a sequencer or Max program controlling the electrical signals which are sent to Elsenaar's facial muscles. For a transcript of one of Harry's lectures, see: Huge Harry, "On the Mechanism of Human Facial Expression as a Medium for Interactive Art," in Gerfried Stocker and Christine Schöpf, eds., *Fleshfactor. Informationsmaschine Mensch,* Ars Electronica 97 (Vienna and New York: Springer, 1997) pp. 110–120. See also Wilson [10] pp. 38, 162–164, 790–791.

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63. Plate No. 33 from Duchenne [48]; photograph by Adrian Tournachon.

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Arthur Elsenaar is an artist and an electrical engineer. He used to run his own pirate radio station, and he built the transmitters for many illegal radio and television stations throughout the Netherlands. He has developed radar-controlled interactive sculptures, interactive performance pieces, video installations and audio installations. Elsenaar coordinates the New Media curriculum at the Frank Mohr Institute in Groningen. His recent work investigates the artistic potential of the computer-controlled human face ("ArtiFacial Expression").

Remko Scha was trained as a physicist. He worked in linguistics and Artificial Intelligence at Philips' Research Laboratories (Eindhoven), BBN Laboratories (Cambridge, MA), and Tel Aviv University. He built an automatic electric guitar band ("The Machines"), designed an image-generation program ("Artificial"), and developed a language-processing theory ("Data-Oriented Parsing"). Currently, he is professor of Computational Linguistics at the University of Amsterdam, and performs as a DJ on the Amsterdam pirate station "Radio 100."

Arthur Elsenaar and Remko Scha work together at the Institute of Artificial Art Amsterdam (IAAA). Their joint projects include the Huge Harry Lectures on Human Facial Expression (presented by an automatic speech-synthesis system, and involving computer-controlled expressions on a live human face); Arthur & the Solenoids (MIDI-controlled "facial choreography," accompanied by MIDI-controlled electric guitars); and Agent Radio (an automatic radio station, based on random audio-downloads from the Internet).