Research in Brief

New Old Things: Fabrication, Physical Computing, and Experiment in Historical Practice

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ABSTRACT *Matter is a new medium for historical research, providing the opportunity to explore physical and experiential questions while working with digitized and materialized forms.*

KEYWORDS *Fabrication; Physical computing; Experimental method*

RÉSUMÉ *La matière est un nouveau sujet pour la recherche historique, donnant l'occasion aux chercheurs d'explorer des questions physiques et expérientielles tout en leur permettant de travailler avec des formes numérisées et matérialisées.*

MOTS CLÉS *Fabrication; Informatique physique; Méthode expérimentale*

> We young ones have a perfect right to take toys and make them into philosophy, in as much as nowadays we are turning philosophy into toys.
>
> —*Michael Faraday* (1861, p. 136)

The discipline of history is as old as the academy, and it sometimes looks it. The academic study of communication is much younger, and it exhibits at times both the strengths and weaknesses of its youth. Yet there are deep parallels between the two fields that the tweedy fustiness of one and the trendy flash of the other belie. John Durham Peters, at once an eminent historian and a communication scholar, has pointed out the striking resemblances between historical inquiry and the study of communication. History, Peters argues, is a communication problem. "Both fields," he writes, "face the methodological problem of how to interpret under conditions of remoteness and estrangement. They share a strikingly common vocabulary of sources,

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Canadian Journal of Communication Vol 37 (2012) 121-128

records, meanings, and transmissions" (2008, p. 20). Historical inquiry is always a matter of intercepting and decoding transmissions from some remote place and time.

If, in history as in communication, the medium is the message, what is the historian's medium? For almost all historians, the answer is the documentary record of the past. Historians work with primary sources: texts and representations created by historical actors that contain clues as to what their worlds were like. Of course, these sources were rarely created for our benefit. We are detectives, piecing together forensic evidence; we are eavesdroppers, listening in on messages that were never intended for our ears. We try to read our sources against the grain, looking for things our subjects took for granted or left unspoken, rather than what they wished to record for posterity. Historical writing is thus an imaginative recreation of the past.

Every medium has its biases. Perhaps the most basic bias shaping historians' engagement with the past is the primacy of text. Historians seek out written documents in the archives and write papers and monographs interpreting the words they have found. The privileging of written evidence above all other kinds was part of the professionalization of history, demarking the discipline from the realms of anthropology and archaeology. A few decades ago, people and places without writing were deemed to be part of "prehistory," having no history at all (Smail, 2008). A subsequent generation of work using oral histories, visual sources, and material objects as evidence has complicated this picture and immeasurably enriched the historical field, but it can hardly be said to have dislodged the dominance of written texts.

Almost 10 years ago, the late Roy Rosenzweig (2003) foresaw a paradigm shift in historical research, from a culture of scarcity to a culture of abundance. Past historical projects were often defined by the scarcity of sources, by gaps in the historical record, or by information costs. Today, the proliferation of digital sources—both the born-digital and the digitized—has created an economy of abundance for historians. The challenges and opportunities of abundance have fuelled the emergence of a group of "digital historians" and "digital humanists" who take advantage of the computational properties of their sources to ask and answer new kinds of questions.

Much of this work remains rooted in textual practices of various sorts. Computer-aided text mining and data analysis make it increasingly possible to read and interrogate vast corpuses—millions of books or documents at a time—in sophisticated ways. The popularity of the international Digging into Data Challenge (co-sponsored by the Social Sciences and Humanities Research Council, the National Endowment for the Humanities, the Joint Information Systems Committee, and now other funding agencies) has resulted in new interpretations of historical evidence and the creation of new tools for such research. It would be ironic indeed if the rise of digital history only reinforced the historical profession's bias toward written texts. As one digital historian has written, "using computers strictly to store, transmit, and retrieve words is akin to using an automobile only to park" (Staley, 2003, p. 4). But the power and potential of computational text analysis threatens to do just that.

Here we highlight a different potential: matter as a new medium for historical research. Working with actual, physical *stuff* offers the historian new opportunities to explore the interactions of people and things. We fabricate objects related to our own

historical interests, and then we play with them, modify them, share them with other people, and use them to ground conversations about the past and our relationship to it. What has been digitized can be re-materialized, and digitized again, and so on, in a tight loop that allows us to take best advantage of the different affordances of bits and atoms. Emerging technologies, many of them created by open source hacker, maker, or do-it-yourself groups, provide historians with the opportunity to explore physical and experiential questions while working with digitized and materialized forms.

Historians are not accustomed to conducting experiments. "For us," writes William Cronon, "the past is a single vast experiment that can never be run a second time" (2006, p. 330). But in other disciplines that excavate the past, especially archaeology, there is already a long-standing tradition of experimentation. We believe that the present moment offers unprecedented opportunities for experimentally minded humanists, artists, and social scientists of every variety.

The three of us are collaborating on a series of projects that allow us to imaginatively remake past technological artifacts and to experiment with past technological worlds. The example we sketch here is based on Elliott's research on the history, culture, and technology of stage magic (Turkel & Elliott, in press), but the experimental method applies equally to questions raised by MacDougall's (2011) work on nineteenth-century "crank" inventors and self-taught scientists, and to those from Turkel's (2011) study of the history of analogue computers and numerically controlled machines.

The decades around the turn of the twentieth century, from the 1880s to the 1930s, were a golden age of stage magic. Magic acts were a staple of the vaudeville circuit, and celebrity magicians such as Alexander Herrmann, Harry Kellar, and Howard Thurston reached huge audiences with performances of illusion and legerdemain, while Harry Houdini achieved superstar status. Levitating, sawing people in half, vanishing objects, and so on, the stage magicians of this era were masters at confounding the senses. The history of magic is interesting for many reasons, but not least among them is the spotlight it shines on the senses and sense-making in the past. New work in "sensory history" tries to historicize the faculties through which we apprehend the world (Jay, 2011). Have all human cultures seen—literally *seen*—the world as we do? Are the regimes by which we interpret aural, visual, tactile, gustatory, or olfactory stimuli historically constant, or have they changed over time? Magical effects and illusions offer an ideal site for exploring these questions, both because they highlight the limits of perception and because they often provoked historical actors to reflect on their own senses and sense-making.

But magical effects are slippery, ephemeral, and subjective, produced as much by the imagination of the viewer as by the magician's craft. Historical scholarship on magic and similar phenomena, such as mesmerism or the spiritualist séances that many stage magicians worked to debunk, is often obliged to bracket as unanswerable the question of "what was *really* happening" and retreat to analysis of the written texts surrounding such performances. Fabrication and physical experimentation will not transcend the impossibility of directly accessing the past, but they do offer another route toward apprehending what was happening and how events such as magical performances were constructed and experienced.

We have detailed descriptions of how magical effects appeared to both participants and observers. Often we have photographs, models, or blueprints that provide information about how a particular effect might be achieved. We start our experiments, then, by creating digital representations of this material culture. From photographs and blueprints, we can construct 3-D models with varying levels of detail. In cases where we have access to physical artifacts, we can scan them with a laser scanner. We then fabricate small-scale physical versions of these 3-D models: rather than working on a stage, we work in a dollhouse. Some components from our 3-D models are scaled and printed directly in plastic, using RepRap (www.reprap.org) and MakerBot (www.makerbot.com) 3-D printers that we built in our lab. Other components are machined from wood, metal, or plastic with table-top CNC mills and lathes. Some we make by hand, using the same kinds of tools, materials, and techniques that our original effect-builders did.

Figure 1: Model of levitation effect.

Photo by William J. Turkel.

Creating a dollhouse version of, say, a magician levitating his or her assistant allows us to explore a range of questions (see Figure 1). Many of these have to do with human perceptual characteristics; others involve the role of explicit and tacit knowledge in the construction of apparatus; yet others engage the interaction of a magician's performance with various factors—the venue, the expectations of the audience, the publicity preceding and surrounding a performance—in shaping the experience of an effect. Working with actual physical recreations, we can experiment with viewpoint, lighting, colours, patterns, posture, misdirection, sightlines, material properties, and so on, discovering which set of factors makes an effect seem more or less convincing to our senses and comparing our own subjective experiences with those recorded a

century ago. Since a single effect could often be achieved in many different ways, recreating effects also allows us to study processes of technological innovation and reuse.

Work with photographs and images can take place at this stage, too. Digital photographs or video are useful for capturing points of view. We might not know why a recreated effect fails to convince when we experience it in person, but telltale shadows in a high-contrast digital photo draw attention to something that was subliminal before. These experiments can help us to understand why particular choices were probably made. Historical photographs were framed in carefully thought-out ways. They are evidence of how an effect was presented and of how attention was manipulated. As we present and photograph our own models, we become more aware of factors that may have played a role in the framing of historical photographs or in decisions made in order to stage performances.

Figure 2: Shadows in this photograph indicate the method used to perform a model levitation.

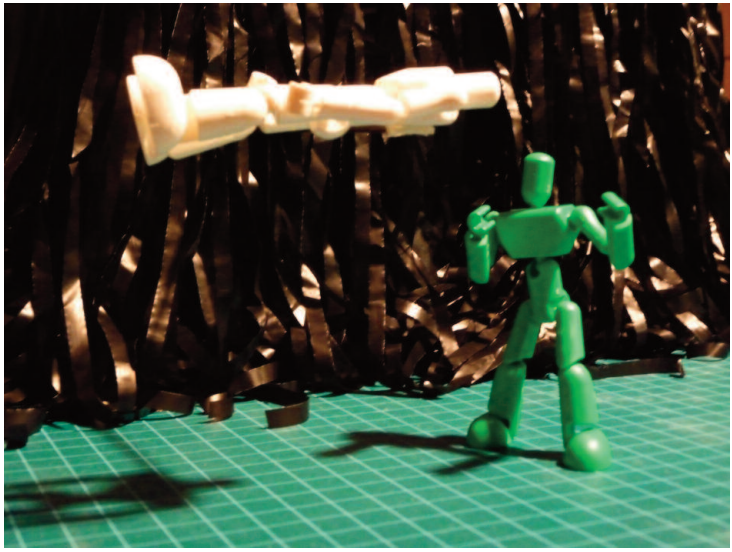


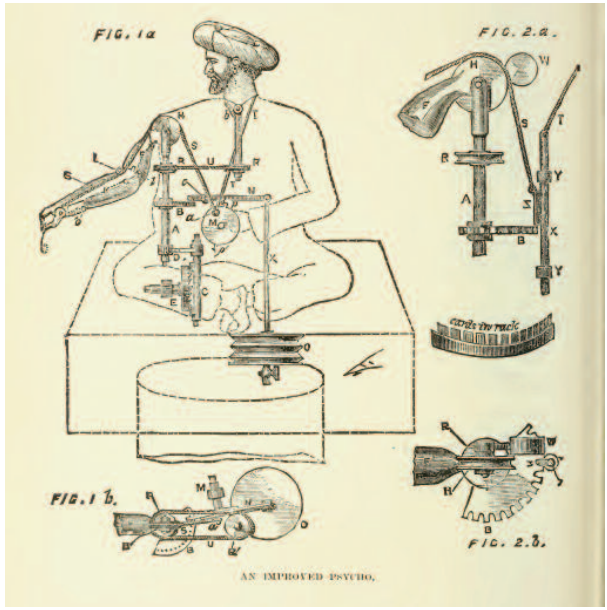
Photo by Devon Elliott.

In staging a model illusion (see Figure 2), we cycle back and forth between working with the digital (programming, signal detection and manipulation, communication) and the material (hardware, electronics, and electromechanical stuff). Dollhouse "performances" can be digitally recorded in obvious ways—with photos, audio, and video—and in non-obvious ways, too. We might use our laser scanner to make a 3-D model of the whole stage at a particular moment, for example, or we might want to record the output of a vibration sensor mounted on the underside of the stage during a performance.

Magicians' blueprints often contain hidden "gotchas," crucial details that are left unspecified or are simply incorrect as shown. Without rebuilding the apparatus, we would never know about these problems. By studying what was manifest and what

was latent, we can also find valuable clues about the ways in which magicians kept methods secret from audiences and lesser performers, while establishing credit and authority among their own peers. Here we draw on research in the history of science that involves re-enacting or recreating historical experiments. Such studies have yielded insight into the performance of experimental events, the role of embodiment, forms of gestural and tacit knowledge, the importance of artisans and witnesses, and cultures of secrecy (e.g., Sibum, 1995).

Figure 3: "An Improved Psycho" depicts a potential method for replicating the effect of a popular nineteenth-century automaton (Hopkins, 1897)



On a live stage, magicians employed stagehands to trigger or operate machinery (see Figure 3). In our dollhouse models, we use something closer to robotics, drawing on work in physical computing. The "brains" of a particular effect are usually provided by an open source Arduino (www.arduino.cc) microcontroller. (Imagine a 1980s-era personal computer that is the size of a deck of cards, battery-powered, and only costs $40.) Sensors hooked up to the Arduino provide information about physical states: for example, a beam of light has been broken, a hidden switch triggered, or a magnetic field detected. Actuators such as servos, stepper motors, and solenoids, and even fancier components such as shape-memory alloys ("muscle wire") and invisible thread, allow the Arduino to execute physical actions. It can be programmed to draw curtains, turn LED lights on or off, spring open a hidden hatch door, or route compressed air through a pneumatic mechanism. For more elaborate builds, we also incorporate parts from off-the-shelf robotics kits. For example, we are currently working

on a model re-creation of a nineteenth-century pneumatic card-playing automaton named "Psycho" (see Figure 4). Automata were, Simon Schaffer (1999) has written, "both arguments and entertainments" in the eighteenth and nineteenth centuries—and so they are for us.

Figure 4: Draft pneumatic model of "Psycho" automaton made with VEX robotics components and Arduino microcontroller.

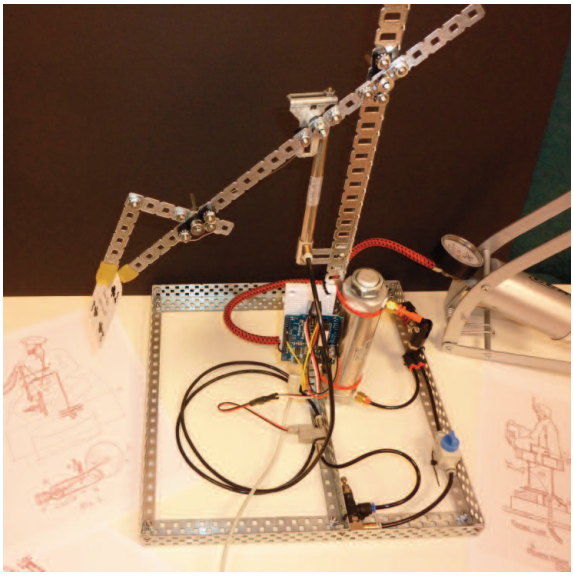


Photo by Devon Elliott.

Obviously, there is an element of play to this kind of research. In fact, one of the main reasons that we do it is because it is fun. The students in our graduate public-history program find it fun to do this kind of work, and members of the public with whom they share their work seem to enjoy themselves, too. Working with toy-like objects at model scale puts us in touch with children; with hobbyists, male and female; with people who like the microcosms of puppet theatres, dollhouses, dioramas, aquariums and terrariums, bonsai gardens, play sets, simulation games, model railroads, and construction toys. There is also an element of performance in this work, something we share with the historical actors we are studying. Stage magicians, attic inventors, and crusading machinists all depended on public engagement to make sense of their activities, and we do too.

Exact reproduction of the past is not our goal. Instead, we want to create situations in which aspects of the past can be revisited, explored, interrogated, and remixed. The performers and audiences of the golden age of stage magic were steeped in assumptions and prejudices we now find deeply problematic. Rather than faithfully re-enacting sexist or Orientalist practices for the sake of historical accuracy, we can play with them for the sake of experiment. Let Barbie be the magician and Ken her lovely assis-

tant, or let a giant snake charm the magician. By eliciting and engaging with affects and effects, we do our best to construct a dialogue with the past.

We know that the real past is inaccessible, and all that remains is evidence and inference. This realization creates no licence for interpretive abandon, but rather the opposite. It is our deep obligation ever to seek out new ways of learning from and listening to the past. "The historical record does not only degrade over time; it can also become more articulate," Peters writes in his exploration of history as communication (2008, 24). New questions and techniques reveal new historical sources that were there all along. The "lack of evidence" that once was held to prohibit a history of the senses—or of sexuality, the environment, disease, childhood, peasants, or women—gives way to a voluble historical record. "That old things can be new is the secret to the dynamic historical record" (p. 24), Peters concludes. "The historian's job is … to see that the world is ever replenished with new old things" (p. 32). In fabrication and physical experiment, we are discovering a new old way to do just that.

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