INVENTING THE MEDIUM

PRINCIPLES OF INTERACTION DESIGN AS A CULTURAL PRACTICE

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10 The Tool Model: Augmenting the Expressive Power of the Hand

Successful interaction design requires a shift from seeing the machinery to seeing the lives of the people using it. In this human dimension, the relevant factors become hard to quantify, hard to even identify.

—Terry Winograd, "From Computing Machinery to Interaction Design" (1997)

Interactivity refers to the maximizing of two affordances of the digital medium, the **procedural** and the **participatory**, in the satisfying experience of **agency.** Previous parts of this book have surveyed ways to *script the computer* in order to represent processes, spaces, and semantically structured information. Part V focuses on ways to *script the interactor*, by identifying four key models that shape human expectations of digital artifacts: the tool, the machine, the companion, and the game. For each of these models we will examine established and emerging design conventions that exploit the affordances of digital media to expand our cultural repertoire for capturing and sharing meaning.

Pointing, Grabbing, and Expressive Gestures

We participate in digital environments first of all by bringing to them a sense of what a computer is. Our simplest model for working with digital environments is the model of the **tool**—something that fits in the hand, whose value lies in its instrumentality, its usefulness in performing an action that the hand could not otherwise do so well.

A tool is not necessarily something that we make. It can be a found object with the right affordances for the job, such as a rolled leaf poked through a hole in the bark of the tree by a hungry chimp in search of termites, or a shard of river rock used by early humans to skin an animal. A tool can be manufactured by skilled craftspeople, such as a quill pen, or by industrial machinery, such as an aluminum knitting needle. Through their own physical affordances and the strategies we invent for employing them, tools allow us to perform beyond the limits of our own strength and dexterity. The industrial age greatly extended our repertoire of tools by taking advantage of a wider range of materials. Magnifying lenses and paper clips, cuticle scissors and corkscrews, ballpoint pens and steering wheels are all highly sophisticated in manufacture and optimized for postindustrial uses, but they function in the same way as flint, twigs, and bone in focusing and augmenting the force of our hands in the service of a specific task.

Although we often see tools as separate external entities, they are best understood as extensions of the hand. In fact, the human hand with its opposable thumb can be thought of as our first and most powerful tool. The hand allows us to grasp, move, manipulate, and reshape objects; to sense heat and cold, texture, contours, and motion; to communicate with visible gestures (pointing, waving, opening and closing fist and fingers, shaking hands) and auditory means (clapping, snapping, thumping); and of course to touch, caress, or strike other sentient creatures. *Aside from the face, the hand is the most emotionally expressive part of the human body, providing us with a repertoire of signals from handshakes to obscenities that mediate our social relationships.* American Indians used such hand signals to communicate across spoken language groups, and the sign language of the deaf richly exploits hand gestures as a syntactical medium of inscription, a transmission code that carries representational messages as precise and expressive as spoken language. Sign language has lately been adopted for use by parents and infants and it has opened a pathway for understanding a baby's desires (Food! More!) and for assigning names to compelling items in their environment (Cat! Ball! Car!) before the child is able to articulate words.

Products made with hand tools are appealing to us because they have a direct connection with the physical body of the maker: the potter, sculptor, painter, carpenter, cook, or seamstress. Handwritten letters, manuscripts of books, autographs of famous people gain value beyond the words on the page reproduced by other means. We see the traces of the hand in the effects of the tools, and we take special pleasure in creating and perceiving those traces. In English, we refer to products created through the expert use of tools as "handicraft," and we use the word "handy" to refer to skillfulness and welcome availability. Other languages make similar connections. We find hand tools appealing because we are hardwired to enjoy using our hands for a mixture of utilitarian and expressive purposes.

The computer can be thought of as just one more set of tools, one more way of augmenting the power of our hands. Engagement with digital environments is usually made through our hands: we nudge a mouse or trackball, we move our fingers across a touch pad, we press down on the keys of a virtual or actual keyboard, we poke at a touchscreen, we jiggle a joystick. *Much of what we do on the computer is an extension of pointing.* Navigating by moving the mouse, entering letters and numbers on a keyboard, clicking on screen-based buttons and icons are all extensions of our ability to isolate an item from the visual field and point at it. The iconized pointer or cursor (whether a finger, an arrow, a vertical line "insertion point," or an image of a pointing hand) is a crucial building block of the digital environment because it acts as our surrogate hand in the virtual world. In fact we can think of pointing as a participatory *primitive, a necessary substructure for all of the interactor's actions*. As we discussed in part I, human babies begin to point at around nine months old, displaying their characteristically human ability to focus on what other people are thinking about, and to share the **joint attentional scenes** that cognitive scientists believe to be the basis of symbolic communication (Tomasello 2001).

Similarly, one might say that the era of interaction begins with the invention of **transparent** pointing technologies (like the mouse) and the conventions (like highlight and clicking/double-clicking) for sharing a common focus of attention with the machine as the basis of issuing commands. When an interactor is confused or frustrated by a set of software tools it is often because the necessary shared focus has not been established. The **WIMP** (Windows, Icons, Menus, Pointing device) desktop interface has had many decades to establish and refine its conventions of pointing and commanding. Mobile phones, social networking environments, graphical virtual worlds, interactive maps and GPS devices, and interactive television are much more recent configurations, and still struggling to establish pointing rituals that are as efficient as the manipulation of files and folders with the mouse-driven cursor on the virtual desktop. One important impediment is the poor fit between human fingers and the miniature buttons on remote controls and the miniature real and virtual keyboards on mobile devices.

As media converge into multifunctional digital devices, pointing devices from television, music players, cameras, slide projectors, game consoles, and desktop computing are also converging. We are making increasing demands on the hand by proliferating devices and expanding the functionality of each individual device. One result is a miniaturization of buttons, often accompanied by poor labeling, which can make it difficult to identify, isolate, and depress the appropriate selection. Designers seem to expect the hand to adapt to the device (figure 10.1) rather than the other way around (figure 10.2). Power users, and especially younger and more dexterous consumers, have been willing to develop specialized manual skills like multitap or thumb typing in exchange for access to the augmented communication networks of the mobile world. But devices that offer simpler direct pointing affordances attract a wider range of potential users (figure 10.3).

The graphical user interface (GUI) has made pointing into an almost magically powerful action, recalling the fantasized omnipotence of infancy when pointing could deliver food or toys through the actions of the parent. Fairytales represent this sense of magical pointing in the figure of a magic wand, and manual technologies—such a joystick game controllers, datagloves, fingertip sensors, or the wand-like Wii remote—especially when they are new, can evoke this sense of magical access. Applications that

Figure 10.1
The size of the buttons on remote controls are confusing to most users, and particularly challenging for the elderly whose fingers lack force, steadiness, and accuracy.

Figure 10.2
This remote is closer to what they would all look like if they had been originally designed for elderly fingers.

Figure 10.3
The Apple iPad, introduced in spring 2010, attracted many first-time computer owners with its touchscreen interface and sub-notepad size, particularly those who wanted access to Internet media files without having to use a computer.

play on the conventions of magic by making things appear and disappear, or grow larger or smaller, with a flick of the fingers, can be particularly satisfying.

The video game industry exploits our pleasure in manipulating digitally displayed objects through the action of our hands. The experimental edge of such expressive interaction eliminates the input device altogether. For example, in Camille Utterback and Romy Achituv's landmark art piece, *Text Rain* (1999), you (the interactor) stand in front of a screen on which your own image appears as in a mirror, but silhouetted and joined with images of gracefully falling letters. By stretching out your arms, and moving your hands, you can capture and rearrange the letters and words as they fall, breaking apart their original poetic words and phrases and creating fluid new combinations. The falling objects have appealing buoyancy, responding like air balloons to the force and direction in which they are flicked or pushed or bounced (figure 10.4). A similar sense of magical potency over text objects is used for dramatic effect in Steven Spielberg's futuristic film *Minority Report* (2002), where the police investigator played by Tom Cruise navigates a vast information array by waving his arms and pointing both hands at a transparent wall screen that reads his gestures without the use of any pointing device (figure 10.5).

In mixed reality environments, where digital objects are superimposed on or embedded in real-world objects, the interactor is often given a simple physical tool,

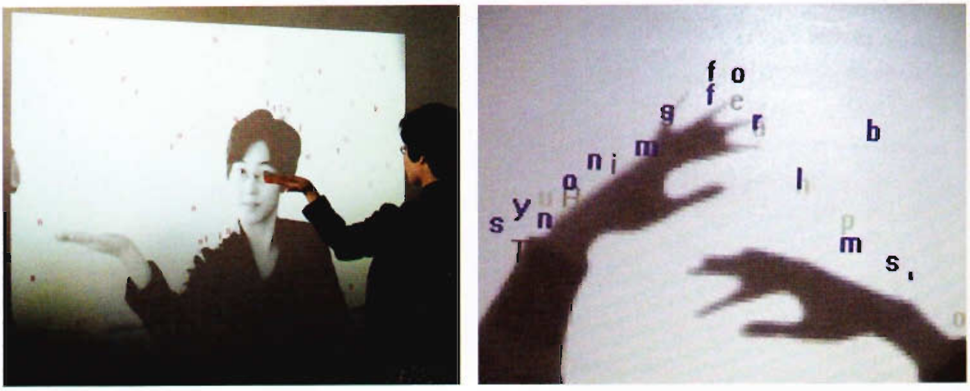

Figure 10.4
Text Rain (1999), an art installation by Camille Utterback and Romy Achituv that entices interactors to play with responsive bouncing letters.

Figure 10.5
Steven Spielberg's futuristic film *Minority Report* (2002) showed Tom Cruise using a gestural interface to navigate a dense information space. The technology was based in part on gestural work done at the MIT Media Lab by John Underkoffle and interface designs by Dale Herigstad of Schematic.

Figure 10.6
Augmented Alice, a research project in augmented reality. The interactor, wearing a head-mounted display, sees the virtual characters sitting at the same table, and has an actual teacup (empty, but equipped with motion sensing) that matches the cups held by the virtual characters (Moreno, Bolter, and MacIntyre. 2001).

which can act as an interface to the digital world. For example, in a mixed reality installation of the Mad Hatter's tea party, created at Georgia Tech, the interactor is placed at a real table with a real though empty tea cup, suggestive of a child playing tea party. Wearing a head-mounted display, the interactor sees the (digital video) characters from the story as if they were sitting at the same table. The teacup is an input device, which can be used to throw tea at another character. By lifting it and aiming the invisible tea the interactor triggers the video segment in which the character is drenched in tea and responds angrily (figure 10.6) (Moreno, Bolter, and MacIntyre 2001). The same strategy would work with procedurally generated characters, which might be able to receive the tea on different parts of the body with dynamically calculated splatter patterns reflecting the force and rotational positioning of the cup. This is a dramatically satisfying action, giving the interactor a strong sense of agency, but there are only so many things one can do with a teacup. Furthermore, the presence of the characters in the same space raises questions about what other actions might be possible: can you point at them accusingly, shake a fist, raise a hand in a "Stop that!" gesture? Can you get out of your seat and grab the Mad Hatter by the throat? The teacup acts as a **threshold object** to connect the interactor with the imaginary world, and to script specific behaviors that have agency within that world (Murray 1997). But placing the virtual object seemingly within reach raises our level of expectation, which can lead to frustration and loss of immersion when we discover the limits of our agency. The challenge for designers in engaging the hand is to establish the consistent boundaries between what can and cannot be grabbed.

The computer magnifies and challenges the pointing power of the hand but it can also eradicate the hand altogether. The life-changing power of the computer as a prosthetic device rests on the ways in which it has abstracted pointing away from the hand and made it possible to point with eye movements, mouth movements, or even

Figure 10.7
IRISCOM system (2009) allows people with limited mobility to control a computer by mapping the movement of the cursor to eye movements captured by a digital camera.

with brainwaves themselves (figures 10.7–10.9). The manipulation of external objects by merely thinking about them or looking at them is a magic beyond the magic of the hand, the realization of the fantasy of controlling the external world merely by the power of our thoughts and desires. Part of the appeal of computational environments is their power to elicit this fantasy.

Digital tools act on information rather than on the physical world: they change the state of bits inside the machine, a change that is reflected by the output display. These changes are hard for users to model, and so designers reach for concrete analogies. Early graphical interfaces relied heavily on images of pointing fingers and grasping hands. These have largely been replaced with arrows, showing that the use of the pointing cursor as an extension of the hand has become transparent. We no longer need to be reminded of the convention.

Current applications rely on iconized hand tools such as pencils, pens, brushes, paint buckets, highlighting pens, erasers, scissors, and magnifying glasses. These metaphorical tools work something like the actual object, abstracting a key affordance of the thing they imitate, but they do not behave exactly as we would expect the physical object to behave, because bits do not behave the same way as atoms.

Figure 10.8
Brain Ball (2000), Interactive Institute, Sweden. Two players compete to move a ball toward them by generating brainwaves characteristic of relaxation.

Users often bring expectations from legacy processes into the digital world. We live in the **analog** world of atoms not bits, and we are more comfortable with analog processes, because they reflect the familiar, immediately understandable messiness of our minds and hands. Erasing a line on a computer screen means switching each byte representing it from on to off, and thereby changing the state of each pixel by which it is displayed. Digital erasure leaves behind no trace of the hand or the tool that performed the act, no messy borders, no half-erased but still visible marks, and no bits of eraser rubber clinging to the surface. Erasing a line on a piece of paper with a rubber eraser leaves a smudge, and graphic designers do not want to sacrifice the expressive possibilities of smudging. The unfamiliar efficiency of the digital medium has led to the creation of virtual tools that precisely simulate the effects produced by the inefficiency of analog tools: the smudge tool in Photoshop, for example, does just that, allowing the user to partially eradicate and blend part of an image. It is iconized by

Figure 10.9
In Mindflex Game (2009), a commercial product, the player controls the movements of a ball (through the action of the fans that position it) by generating the appropriate brainwaves.

a finger, and modified by setting the level of pressure with which the area is smudged. The action simulates finger painting. For those who want the computer display to respond more directly to the pressure of the hand, there are pressure-sensitive input devices, one of which is a stylus with a digital eraser at one end in direct imitation of a pencil. Smudge tools and pressure-sensitive styluses are necessary because human beings crave analog effects produced by analog means.

Unlike analog tools, digital tools can operate in the same way at significantly different scales. We need a different pair of scissors to cut embroidery thread than to trim a hedge, but we can use the same digital scissors to cut out a single letter or 100,000 words. This greater range of effect means that we have to be careful to *specify the scope of action* that we want in any use of a tool. Because their scope is potentially enormous and because digital actions can be parameterized so easily, *digital tools elicit encyclopedic expectations for a large repertoire of variant effects.* One of the design challenges of application software is how to provide this expansive range of choices without overwhelming and confusing the user. For example, Photoshop groups its tools into a menu with variant related tools in submenus; it places a control panel with parameters for the selected tool in a separate pane (figure 10.10).

The complexity of digital tools is somewhat offset by another digital affordance—*reversibility*. The effects of digital tools should always be undoable. Interactors should always be allowed to undo the last action, with a command that is specific: not just "undo" but also "undo typing" or "undo formatting." Undo commands should

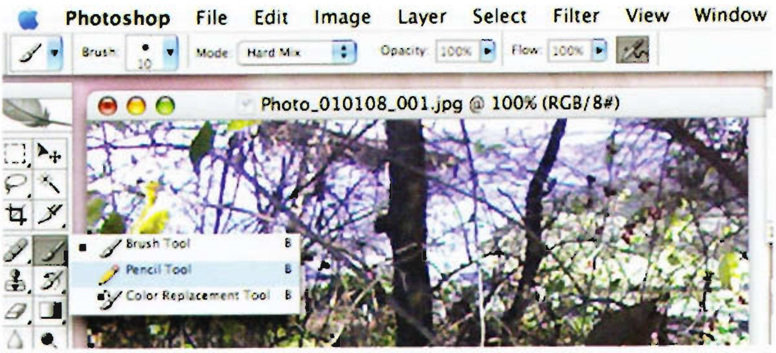

Figure 10.10
Selecting a tool in Photoshop involves selecting from variants in the tool palette (e.g., Brush Tool, Pencil Tool) and then adjusting its settings in the control panel at the top of the window (e.g., Brush size, Mode, Opacity).

themselves be undoable, with paired "redo" choices. It is desirable to allow the user to undo multiple steps, not just the last one, and to cancel anything that has not yet been completed. Undo interfaces should have a history feature, allowing the interactor to step backward through decisions. Wherever possible, undoing should be independent of the order in which an action was performed, allowing the interactor to change one of a sequence of commands without changing the effect of subsequent commands unless they are directly dependent upon it. For example, Photoshop provides a history of actions performed on an image and allows the user to undo an action taken anywhere in the sequence without undoing the ones that came after it. *The more complicated the toolset, the greater the need for fine-grained access to reversibility.*

Because we are so familiar with physical hand tools and because icon toolbars make good use of our ability to select from a range of choices by pointing, application programs tend to turn as many actions as possible into iconized tools. Sometimes the icon is the metaphorical physical tool (such as a scissors for cutting text); sometimes it is a visual **abstraction** of the desired result (such as icons for the Align Text Left, Align Text Center, Align Text Right, and Justify commands); and sometimes it is a metaphorical representation of an abstract process, (such as the counterclockwise circular arrow that means "undo"). Other icons are less specific. For example, the magnifying glass has been used within the same word processor icon bar for three different metaphorical functions: search, print preview, and document map—and in other common applications, like Adobe Acrobat, for zooming. The proliferation and inconsistent use of icons makes them hard to differentiate and remember. Grouping the tools visually and labeling them by function is helpful. *But the congestion of*

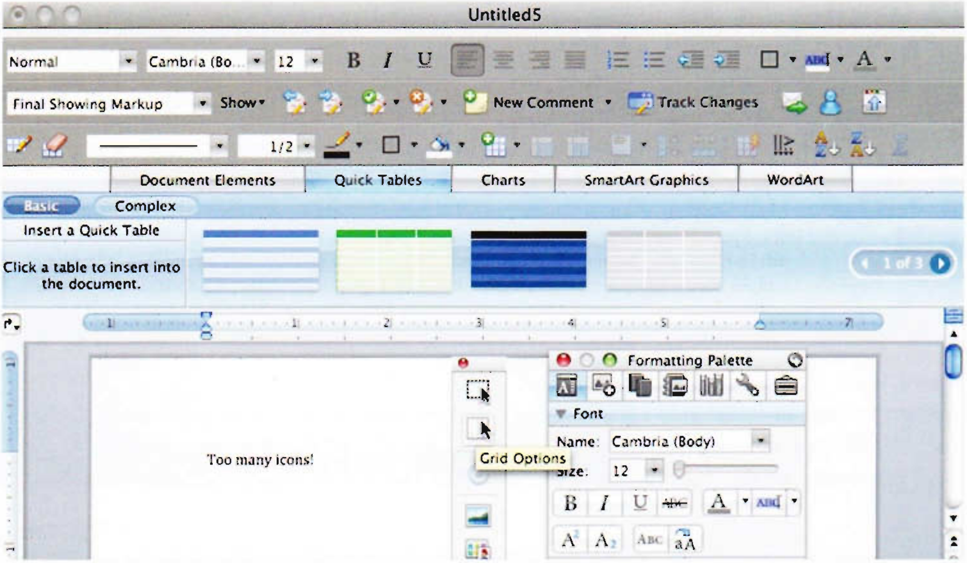

Figure 10.11
Some of the available iconized tools and tool palettes in Microsoft Word 2008.

application toolbars makes clear that as programs increase in functionality they are outgrowing the model of the tool (figure 10.11).

Efficiency, Learnability, Transparency

The **tool model** helps us to focus on key design goals that apply to any digital environment, and are particularly relevant for programs or artifacts that are used instrumentally, as a means for accomplishing a task. Good tools display:

- Efficiency: They allow us to perform tasks in the most immediate and direct manner without unnecessary intermediate steps or delayed results.
- Learnability: Their function and manner of use is obvious and easily demonstrated; they can be used for simple tasks in a simple manner, and complex uses can be mastered incrementally with practice.
- Transparency: The user can focus on the task and not on the functioning of the tool.

The earliest digital tools in the graphical user interface prototypes developed at Xerox PARC supported these design goals through the affordance that Ben Shneiderman later identified as **direct manipulation**. According to Shneiderman direct manipulation is characterized by three specific design practices:

1. Continuous representation of the objects and actions of interest with meaningful visual metaphors
2. Physical actions (or presses of labeled buttons) instead of complex command syntax
3. Rapid, incremental, reversible operations whose effect on the object of interest is visible immediately. (Shneiderman 1992a, 205)

Direct manipulation systems tie visible results to users' direct actions, making them easy to learn. The first instances of direct manipulation, such as the file and folder system, were a clear improvement over the command line interface. When they were embodied in the Macintosh interface they led to the wide adoption of the personal computer as a household item for personal use rather than merely a work tool. They also led to the development of graphic design application programs and a new kind of training of design professionals.

But the representation of objects and actions by visual metaphors can sometimes interfere with efficiency and create confusion. Dragging files into the trash requires unnecessarily traversing physical space on the screen. Direct manipulation sometimes requires disconcerting actions. The classic Macintosh operating system required users to place images of floppy disks in the trash in order to eject them, dangerously confusing destruction of data with removing durable media. In later versions of the operating system the trash icon changes to an EJECT icon—an improvement, but still not ideal. Direct manipulation is not served by a too-literal reproduction of the physical world or by needlessly physical representations of virtual actions. For frequently performed actions command keys can be more "direct" than metaphorical actions, as long as the result of the command is immediately observable and reversible. **Contextual menus** attached to the object that is the target of the action can also provide the experience of direct action without requiring awkward physical manipulations (figures 10.12, 10.13). *The important consideration is not whether the interface affords direct manipulation of a physical representation, but whether it communicates a clear model and supports interactor's experience of agency.*

Efficiency, learnability, and transparency are interrelated values. For most tools in the physical or virtual world, we must go through a period of trial and error and often a period of training in order to put them to best use. Hand tools, such as a hammer, have clearly perceived affordances based on their shape and how they feel in our hands; it would be hard to hold a hammer by its head instead of its handle, so simply picking it up starts the process of learning how to use it. Computer objects like plugs and floppy disks can be made to fit into receptacles in only one orientation, making it impossible and therefore nonintuitive to try to force them in incorrectly. The shape of the computer mouse invites the hand and the immediate **feedback** of seeing the cursor move as it is jiggled teaches us how it works. *The tools are successful because their affordances are so readable, scripting the interactor with appropriate expectations and behaviors.*

Figure 10.12
A contextual menu in a web browser understands that you have clicked on an image within the web page and offers appropriate choices.

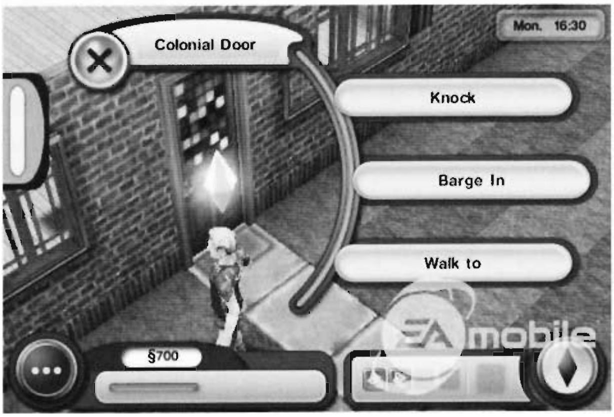

Figure 10.13
A contextual menu from The Sims offers choices relevant to the object selected, in this case the door to a neighbor's house.

The complexity of contemporary digital applications makes them hard to learn and easy to misuse. *The aim of design should be a* **gentle slope system** *in which users can do simple things in simple ways and gradually add to their repertoire of actions.* Adjustable tool bars allow choices to be added incrementally, removing the clutter of mysterious icons from the novice's field of view. The strategy is similar to the practice in video game design of training the player on simpler levels before introducing more challenging ones. But the trend in application design has been to proliferate tools rather than to devote attention to presenting them in a learnable progression.

Mastery of a digital environment need not involve absolute recall but only the ability to be *reminded of things in context.* As Donald Norman has pointed out (1998), we cannot make everything immediately obvious to users, but we can aim to make things that only need to be explained once (182). Learning can be incorporated into the tool itself because we can associate text, video, animations, diagrams, labels, instructions, warning sounds, frequently asked questions, or any other media object that can provide guidance and instruction. The convention of providing context-sensitive help is a significant improvement over the legacy approach of a linear manual. We can find what we need when we need it, through rollover text or help buttons linked to specific tasks. Labeling is often the best way to make a tool's function clear, and it is increasingly necessary as interfaces become more cluttered. Labeling fails when the name does not reflect the function for first-time users (e.g., the Marquee Tool in Photoshop, which selects areas of an image), or the nomenclature is not standardized (e.g., the Contacts button in a calendar program overlaps the Address book feature; a program has both Search and Find commands). Tutorials and help screens can explain tools; animations demonstrating their use are particularly valuable. But the best way to learn a tool is to have a safe and structured way of trying it out so that repeated feedback with reversible results can reinforce the kinetic action of applying the tool. Some programs, such as games, provide **sandbox** areas for this kind of experimentation.

To make a tool learnable, its visual representation and label should reflect a consistent abstraction of the overall process. Much of the confusion of using tools lies in competing models of the task, tool, and product. For example, Photoshop abstracts the process of image making as masking, layering, burning, dodging, painting, lassoing, and even magic. Each of these metaphorical processes assumes a different kind of physicality for the underlying product and a different kind of activity on the part of the creator. Some of these abstractions come from the complexity of visual perception and some of them from the complexity of legacy processes such as photography and painting. Some of them, like lassoing and especially magic are clumsy attempts to find appropriate new labels for actions that are only possible in digital environments. All of these tools may follow Ben Shneiderman's guidelines for direct manipulation, but each of them must be learned individually. The task is made harder from the lack of a common abstraction of the process.

In suites of tools, there should be a consistent abstraction of the overall process and especially of the material being manipulated. The abstraction should be as free as possible from legacy conventions that do not correspond to digital affordances (like "dodging" in Photoshop), and should provide for manipulation at multiple levels of granularity. For example, in a word processor it is appropriate that we not turn virtual pages but scroll up and down through a seamless text. Direct manipulation of the scroll bar or text area makes it clear that progress is from top to bottom of the screen and the position of the scroll bubble makes clear where in the text we are in relation to the whole. This is a consistent abstraction that is easily learnable, memorable, and efficient, and creates the kind of transparency that allows us to focus on the task instead of the mechanics of interaction. It would be much less transparent (and farther from the underlying bit structure) to represent the document as a stack of papers. Similarly, the concept of layering in image manipulation programs is a simple and powerful abstraction based on a familiar physical metaphor, and reflecting the efficient, modular organization of the underlying bits. Organizing an image into layers allows us to change some parts while leaving others intact, and to create duplicate versions of elements of an image to compare by turning visibility on and off layer by layer. Presenting text as a continuous top to bottom scroll and images as manipulable layers allows us to point to the part of the text or image we want to manipulate with our tools, while retaining a larger sense of context. Both of these presentations work because they communicate a concrete model of the artifact that is not literally faithful to the legacy versions, but that reinforces the digital structures that make them available for manipulation.

Expressivity and Virtuosity

In addition to the design goals of efficiency, learnability, and transparency, digital tools can also foster

- Expressivity: Good tools allow the user an appropriate degree of choice, inflection, and individual adjustment, supporting the development of expertise, craftsmanship, and technique.

The precision and scope of digital tools are turned into expressive power when the user is able to apply them with craft-specific technique and task-specific discretion.

Digital tools are now the norm in the creation and transmission of words, images and sounds for art and entertainment, because they exploit the malleability and control that results from changing media from analog signals into bits. Words can be copied, pasted, erased, and reentered with ease; images can be changed dot by dot instead of area by area; whole orchestras can be synthesized at will. The unprecedented manipulative power of digital tools makes them desirable to users, and increases the demand for more specialized functions: outliners and specialty fonts, filters that imitate brushwork, animations controlled by if/then statements, and tools that merge media types into a single presentation format. The novelty and potency of these new tools makes users tolerant of a high degree of awkwardness and difficulty in learning them.

In the long run, however, we demand tools that are easy to use as well as powerful. Although writers once put up with ink-blotting quills, leaky fountain pens, and pencils that had to be laboriously sharpened with penknives, they eagerly embraced ball-points, electric pencil sharpeners, and typewriters once they were invented. Similarly, users would gladly desert the cumbersome interfaces of current image and text-editing applications if they are offered more elegantly designed applications that offer a similar level of control with a more gradual learning curve.

The precision and repeatability of digital actions make digital tools ideal for activities that require standardized results such as color matching, geographical positioning, or closely synchronized behaviors. But standardization can be also dehumanizing, removing the traces of the human hand and obliterating individual effects. Digital reproduction is the antithesis of the "aura" that Walter Benjamin celebrated as part of the essential value of a work of art: its singularity and connection to its maker creates a sense of presence impossible to achieve through mechanical or electrical reproduction (Benjamin 1968). *The remedy for the dehumanization of standardized digital processes is the creation of tools that maximize individual choice and expression.*

To create these new expressive digital tools, we will have to expand our model of the digital tool, thinking of it as not merely efficient but also expressive. *Efficient use* involves getting a known task done in the simplest way with the least effort and time. *Expressive use* involves accomplishing an improvised, novel, or personalized task with the widest appropriate range of choices and discretionary options. Expressive use requires both mastery and technique: the ability to inflect the tool in subtle ways to increase its utility. A pocketknife can be used with expertise to carve wayfinding markings in tree trunks. This is an efficient, instrumental use of the tool. A pocketknife can also be used to whittle figures of animals. This is an expressive use of the tool, which allows for individual variation and meaningful differences in form. In mathematical contexts we talk of expressiveness as capturing complex relationships through symbolic means. In artistic contexts we talk of expressiveness as conveying emotion, sharp observation, or complexity of form. A computational tool can offer all of these forms of expression, both by mimicking analog tools and by allowing access to new expressive forms.

The expressive use of a tool is not merely a matter of efficient mechanical skill and familiarity, but also involves the attainment of technique. *Technique is the graceful* *fitting of the tool to the result, maximizing its expressiveness with carefully adjusted and coordinated choices, often involving manipulations that require specialized skills.* Technique is both science and art, both perceptual and mechanical. We admire it not only for the difficulty of attainment but also for the fitness of the result. The computer is sometimes criticized for eroding technique because it makes complex actions available with a lower level of kinetic mastery and with much less knowledge of materials. Typefaces, for example, are a sophisticated design element, and they used to be hard to come by and to manipulate. Access to the tools was tied with training in their appropriate use. When the computer made multiple typefaces available to those without graphic design training the result was a new kind of visual clutter. By putting sophisticated tools in the hands of those who have very little knowledge of their correct use, the computer can sometimes short circuit the attainment of technique. *The challenge for designers is to scaffold the attainment of technique without sabotaging the novice with too much power.*

When we focus on the expressive power of the computer we often invoke the model of the musical instrument. A musical instrument is expressive by virtue of its physical affordances, and the learned mastery of the performer. The tool itself requires attention before it can become transparent in use. We must practice the instrument and fit our hands to its keys, strings, or buttons; fit our breathing to its apertures; learn to hold the right posture; bear the weight in the right places. Skill at a musical instrument is a matter of fitting the kinetic ability of the player to the affordances of the machine. Musical instruments require more than mere pointing, they require coordinating many expressive affordances of the human body with the affordances of the tool. Computer input devices can require similar degrees of practice but they rarely offer comparable expressiveness at the same level of transparency as a skilled musician. A computer keyboard or touchpad can become an extension of our hands just as a piano keyboard or drumstick does, but it does not register changes in pressure and tempo. A game controller is much more sensitive, affords virtuoso demonstrations of skill, and can be tied to emotionally charged actions, although games are often limited by formulaic situations and a lack of scope for original performance (figure 10.14).

The conventions of musical instruments have been directly helpful in shaping digital interfaces. Keyboarding of various kinds and especially *chording*—the simultaneous use of multiple fingers to expand the range of expressive choices—has been a staple of utilitarian and playful digital input systems. Musicians have a hard time learning to play their instruments, but there is a payoff in mastering the complex range of expressive possibilities, because more control leads to a richer product. In electronic environments, game controllers demand virtuoso control similar to musicianship. The game controller offers considerable versatility of action, calling for

Figure 10.14
The SONY DUALSHOCK3 wireless controller with pressure and motion sensing and feedback vibration, making (according to its maker) "Each hit, crash and explosion . . . more realistic when the user feels the rumble right in the palm of their hand."

movement in space and complex chording of buttons. Part of the pleasure of games is this demand for complex signaling and hand-eye coordination. The demand on dexterity taps into the biological connection between the hand and emotional expressiveness. Video game controllers have turned manual dexterity and rapid pointing reflexes into a competitive sport. The popularity of video games has revealed a surprising enthusiasm for mastering very complicated combinations of multifinger controller sequences for the purposes of simulated battle and vehicle navigation. But the expressive vocabulary of games has been limited, because commercial gameplay is so much focused on vehicles and weapons. There are signs that this is changing, however, and the coming decades may see an exploration of manual dexterity for increasingly expressive uses (figure 10.15), including controlling information spaces and navigating virtual worlds.

Our ability to map fine motor actions with our fingers onto representational worlds underlies our use of many tools: the embroidery needle, the carving knife, the paintbrush, the knitting needle. Facility at one helps to build up aptitude for others. A computer-phobic neighbor was surprised to find she was enjoying her grandson's video games until she realized that she found them easy to play because of her lifelong dedication to the piano. Computer games like musical performance draw on our pleasure in mapping hand movements to complex actions. The pleasure we find in mastering such skills and in finding expression in the movement of our fingers allows us to learn new keyboard arrangements such as the joystick game controller, the arrow key-driven PC game control, the one-handed twiddler keyboard used in experimental devices (figure 10.16), the thumb-operated PDA, or the quickly learned Wii game controller.

Figure 10.15
In the PlayStation video game Heavy Rain (2010), game pad actions mimic in-game actions. For example, climbing up a muddy, slippery hill hand over hand requires similarly challenging finger positioning.

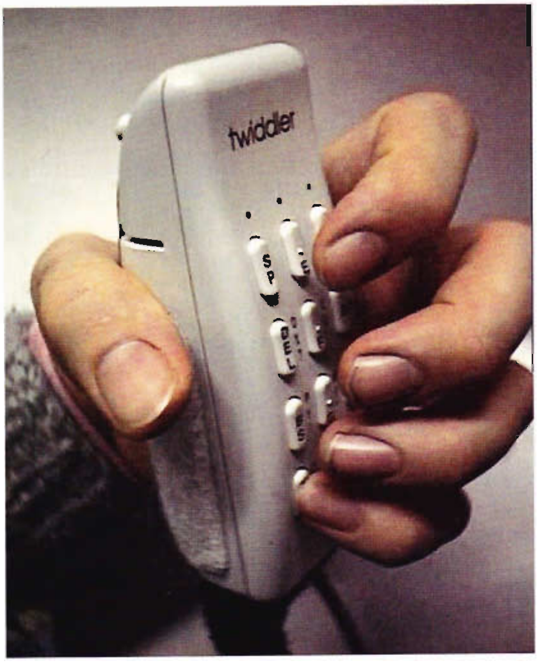

Figure 10.16
Twiddler one-handed chorded keyboard used in wearable computing applications.

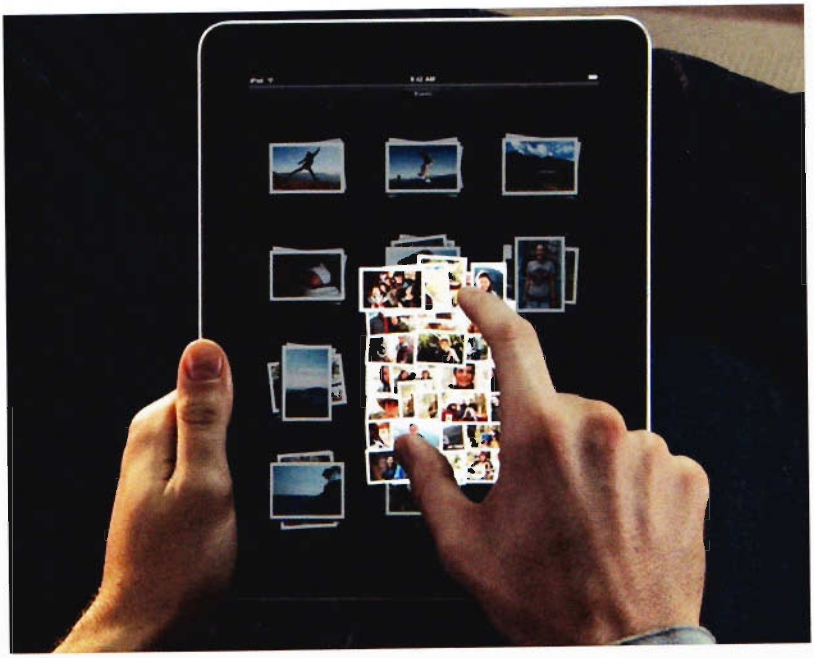

Figure 10.17
Multitouch iPad screen allows navigation of photo archives with pinch and zoom.

The effort of learning complex hand skills can be pleasurable in itself, especially when it is tied to emotionally compelling representational effects, such as rapidly appearing and disappearing colorful objects or the sounds of an explosion. Chording effects performed in a rapid manner within a responsive environment can provide the kind of difficult but achievable challenge that leads to the pleasurable absorption in a task, which Mihály Csíkszentmihályi (1990) identified as **flow**. As we gain speed and accuracy, mastery of the controller feels like an extension of our physical prowess. Some virtuosos gameplay Super Mario without looking at the screen. They have internalized the sequence, rhythms, and timing of the gameplay, in the same way that a dancer memorizes a choreographed dance.

A growing area of design is extending pointing to increasingly sensitive full surfaces, including some that are sensitive to multiple simultaneous points of contact. Touch-sensitive screens and trackpads are elaborating new mimetic fingering techniques, such as the two-finger pinch to zoom, or rapid left-to-right flicking to indicate deletion (figure 10.17). Multitouch screens and multitouch tables (horizontal screens, sometimes with associated coded or sensor-equipped objects) allow rapid sorting of images,

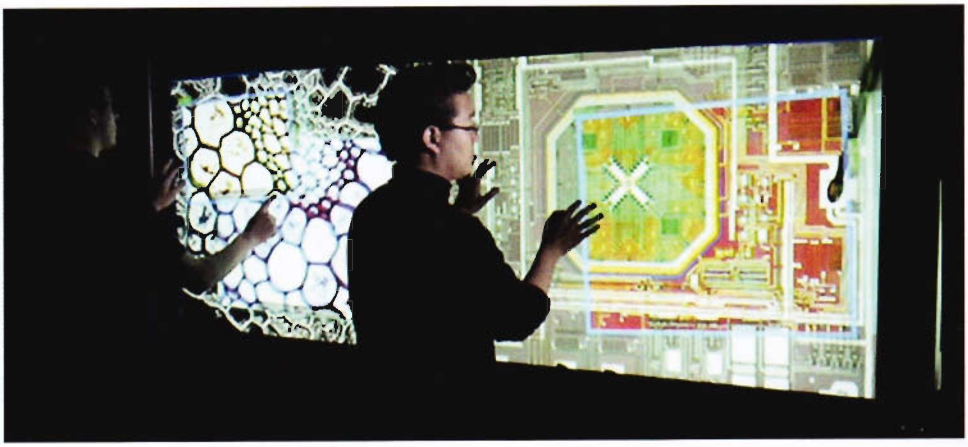

Figure 10.18
Multitouch wall-mounted screen, from Perceptive Pixel.

more detailed zooming of dense information spaces such as data-rich maps, and collaborative work or multiplayer gaming with simultaneous updating of the shared desktop or game board (figures 10.18, 10.19).

As gesture-based consumer devices like Microsoft's Kinect become more common, the range of expression that can be brought to digital applications will increase. Researchers at MIT are experimenting with wearable sensors linked to cameras and projectors that can recognize iconic gestures like snapping a photograph (figure 10.20). As such devices become more available hand gestures to simulate flying, walking, reaching, and grabbing may be particularly useful primitives in creating expressive applications. For example, in the experimental *Egg's Journey* installation (figure 10.21), the interactor is in the role of an egg reaching for one of a number of showering sperm. Grabbing any one of them produces a cartoon image of the possible child that would result from the pairing (<http://synlab.gatech.edu>). The interaction is direct and simple, leading to an experience of agency within a very complex representational world. Experiments like this remind us that the expressive possibilities for engagement with the virtual extend far beyond the familiar point-to-shoot conventions of commercial gaming.

The inclusion of cameras on cells phones has increased the expressive possibilities of pointing. Capturing a barcode or a book cover in the real world can provide access to all the information about that place. Looking at a place through the camera lens (in combination with GPS information) can produce an overlay of information or a related coupon. Similarly, GPS technology can turn the simple act of visiting a place into a kind of pointing, allowing you to display your image on a map so friends can

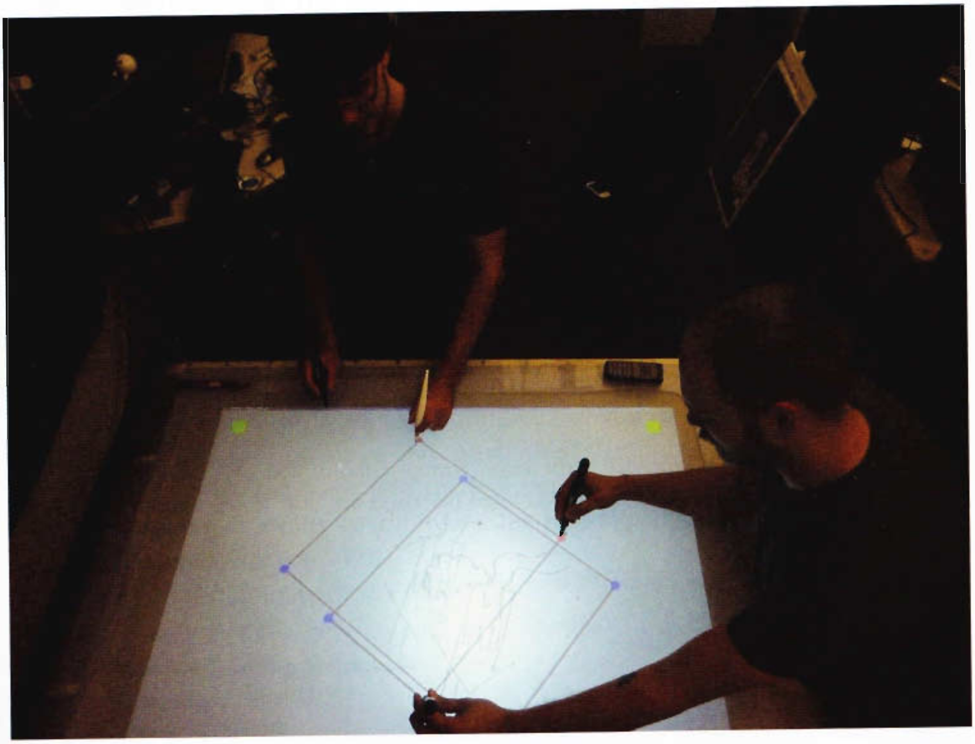

Figure 10.19
Two students copy a sketch for independent editing using SketchTop, a collaborative sketching application for a multitouch tabletop computer, designed in Ali Mazalek's Synlab at Georgia Tech. One student touches and holds two of the corners while the other pulls the copy out from under the page by dragging a third corner.

see where you are, or to claim an actual place within a social networking game as if it were a square on a Monopoly game board.

The next decades will bring an increase in possibilities for hand control, challenging designers to invent new gestural conventions and new gesture-driven device genres that will be as efficient, learnable, and transparent as the WIMP interface, and as expressive as the modern orchestra or rock and roll band.

Many digital artifacts function as tools in that they are used as instruments for achieving other aims, like the creation of a text or the retrieval of a video or the operation of remote telescope, and all digital artifacts have some tool-like elements, such as clickable icons or pull-down menus. Therefore, *the values we apply to tool design should be applied to any digital artifact, especially the value of transparency, which allows us to focus our attention not on the tool, but on the demands of the task at hand.*

Figure 10.20
Pranav Mistry of Pattie Maes's MIT Sixth Sense Group demonstrates a gestural interface to a digital system that includes a camera and colored markings on fingertips.

Figure 10.21
In Ozge Samanci's whimsical installation piece, *Egg's Journey* (2007), the interactor's hand and arm gestures are captured and mapped onto a mirroring animated character positioned inside an ovum surrounded by sperm. Grabbing a particular sperm produces an image of the possible child resulting from the combination.

13 The Game Model: Scripting Interaction as Structured Play

Is play, because it is meta-action, rather than instinctive action, the first appearance of "culture" in animals as well as people?
—Brian Sutton-Smith (Sutton-Smith and Pellegrini 1995)

Game Patterns as Building Blocks for Interaction Design

Games are a fundamental human mode of engaging with the world and one another, and one of the most active **genres** of **digital artifacts**. In this chapter we are concerned not with the design of digital games, but with the ways in which the structured **play** we all enjoy in games can provide a useful model for **interaction design** in general.

Games are a more organized form of the more general experience of play, which is a highly adaptive mode of behavior, common to many living creatures, in which activities are pursued for their own sake without regard for the survival benefits they may offer us, often in an exploratory manner without rules, scores, or winning conditions (Sutton-Smith 1997). Play and especially games take place in a self-contained zone of focused attention that the theorist Johan Huizinga memorably called a **magic circle** (Huizinga 1980), a boundary in space and time, like a theatrical stage during a performance, where actions are detached from the real world. Games may be structured as puzzles or contests, as tests of skillfulness or luck, as controlled performance or the frenzied pursuit of ecstatic disorientation. *What makes all these disparate games—from Pat-a-Cake to bullfights to Scrabble—similar to one another is the explicit rule system that structures the interaction, distinguishing them from free play* (Caillois 1961; Huizinga 1980; Sutton-Smith 1997; Partlett 1999).

Games often exploit the power of external **media** to create shared symbolic tokens of various kinds—playing fields on the grass, game boards carved in wood or printed on cardboard, invading space ships on computer screens. They focus our attention on these media artifacts, and synchronize our behavior with other players. Like digital **artifacts**, games are designed as abstract systems that are only realized by performance; it is not a game until someone plays it, just as digital artifacts only become realized when the computer code is executed in concert with the **interactor** (Salen, Zimmerman, 2003). Designers can therefore look at games not only as a vital and growing genre of digital media, but also as a fundamental model of successful **interaction**, like the **tool**, the **machine**, and the helpful **companion**, that can inform our approach to any genre of digital artifact.

We can see the origin of games in the crucial moment when the baby comes to see other people not merely as magical servants of his desires, but as having intentionality and consciousness like his own. When a baby and a parent, having established **joint attention**, find something that makes them laugh, they repeat it over and over again. The parent plays Peek-a-Boo, hiding and reappearing, hiding and reappearing, in exactly the same way. The baby throws a teddy bear out of the crib, and the parent picks it up. Out it goes again, and again it is picked up; repeat forever . . . or until the baby stops laughing or the parent is exhausted. For parent and baby, this prototypical game is a way of celebrating their mutual awareness of one another. It is playfulness becoming ritualized into game.

Playfulness is an attitude of mind that can lead to many behaviors, some of which might be thought of as work under other circumstances: it is exploratory, and motivated by curiosity and active engagement; playfulness is usually marked by a desire to try things out and see what will happen, and to repeat a surprising, pleasurable, or emotionally charged cause-effect sequence in order to experience **agency** over it or gain mastery over the requisite skills. Although it may seem contradictory that playfulness is marked by both an openness to the unexpected and a desire to repeat significant cause-effect sequences, they can both be seen as part of an active exploration of the rules by which things work. The baby wonders what will happen if he drops that teddy bear, and then he drops it again and again to verify the result and his ability to produce it. When we act playfully we take pleasure in the world around us and also in our own abilities. As a result we get attached to the situations and artifacts that induce a state of playful enjoyment. The conjunction of computation and media has created a potential playground of infinite proportions where *every digital artifact is potentially an opportunity for playful attachment.*

New technologies trigger a state of playful exploration when they afford **direct manipulation** with immediate **feedback**. Designers can exploit this propensity by aiming for a mixture of the familiar and the surprising. If interaction with an artifact is completely predictable and familiar, and the results are merely practical task completion, the element of playful attachment will be minimal. The opposite of playfulness in games is called **grinding**, the repetition of game actions that are so formulaic they become joyless, usually done in order to score points that lead to more enjoyable game play, such as power-ups or admission to a new level of the game. Adventure games and online role-playing games based on character development are often marked by grinding, which players complain about and sometimes illicitly automate or hire out.

On the one hand, once an activity is no longer challenging or fun it becomes work. On the other hand, if an interaction is confusingly unfamiliar and unpredictable, it will produce only minimal playful attachment. But there is a sweet spot in design between the overly familiar and the overly challenging. An artifact that is composed of both familiar and novel elements behaving in a discernable though complex pattern is more likely to arrest our attention, and to create a mood of playful attachment. For example, the classic game Pac-Man (1980) combines familiar game patterns such as a maze, collection of tokens, and enemies for eluding and chasing (behavior which folktales and animated cartoons often associate with ghosts), with novel elements like the central activity of eating, the computer-based automated behavior of the game pieces, Pac-Man's mouthlike shape, and the power pellet upgrades. The direct manipulation of the highly responsive Pac-Mac figure made for a challenging but transparent and learnable interaction, reinforced by rich immediate feedback (figure 13.1). Game designers are always aiming for that sweet spot, but it is an elusive goal, usually requiring intensive game **tuning** through iterative playtesting and redesign (Fullerton 2008).

Games focus playful exploration into repeatable, patterned behaviors. When we put our hands over our faces and then remove them, exclaiming "Peek-a-Boo!" or

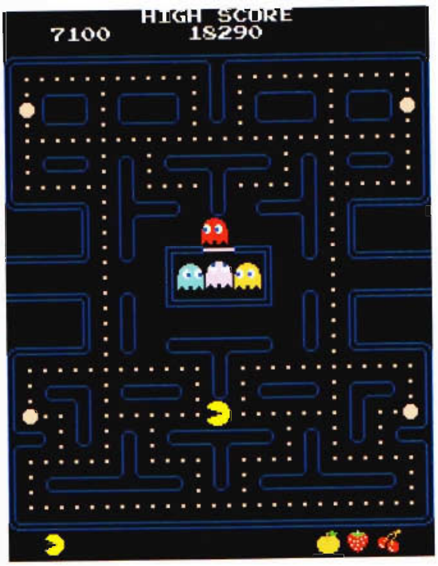

Figure 13.1
The game Pac-Man (1980) was developed by a team led by Toru Iwatani at Namco. It provides a useful model for interaction design, mixing familiar and unfamiliar elements in a challenging but learnable environment based on direct manipulation, trial-and-error learning, and the reinforcement of playful exploration with rich feedback.

when we retrieve and return a baby's teddy bear over and over again, or move a bishop chess piece diagonally or press a sequence of keys to make Mario jump across a gap in a platform game, we are performing little rituals of interaction. These **rituals**, once learned, are **transparent** to the players, performed without consciously thinking about them, allowing players to focus their attention on the larger game goals like making the baby laugh, attacking the opposing queen chess piece, or saving Mario from a pursuing enemy. The more repeatable or combinable the game rituals, the more they extend the pleasurable experience of shared attention between human beings, or between the human being and the companionable computer system. Human culture draws on ritualized behaviors that begin as playful exploration—like hand clapping, collecting things, swapping things, associating sounds with gestures or objects—to create coherent symbolic communication and social organization. Once they are absorbed into culture these game patterns become available for playful exploration and then for further ritualization in more expressive games. For example, playful swapping behaviors become patterned into pebble-based games and eventually developed into a monetary system that becomes the basis of play money, which can then be used as part of the real-estate-buying game pattern in a board game like Monopoly.

Game designers build upon such age-old and modern rituals to make the explicit procedures they think of as **game mechanics.** A game mechanic is any behavioral pattern that can be expressed as part of the game rules. Game mechanics specify how players perform game actions and how they evaluate symbolic elements within the game. For example, many games have mechanics for introducing elements of chance into a game, such as picking playing cards from a shuffled deck or letter tiles from a sack or spinning a "wheel of fortune" or using a software-based random-number generator to govern the appearance of nonplayer characters in an adventure game or colored gems in a grid. *Game making involves assembling such mechanics into a coherent, rule-based system that provides a predictable, synchronized, yet surprising experience.* Game designers can draw on a large repertoire of game mechanics. Some of them are cross-genre, like turn taking or score keeping with points, some are specific to particular game genres. For example, the designer of a new board game (Parlett 1999) could draw on such genre mechanics as these:

- Dividing a board into squares or other segments
- Representing players with game tokens that are alike but differentiated
- Moving a token through a segmented path toward a goal
- Using spinner, dice, or cards to calculate moves by chance
- Designating board squares as beginning, end, lucky, or unlucky
- Organizing the winning condition as a race or territorial battle

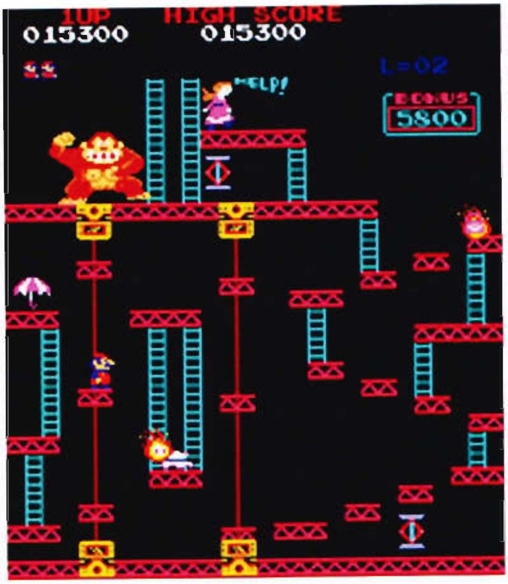

Figure 13.2
Donkey Kong (Nintendo 1981) designed by Shigeru Miyamoto, the first platform game and forerunner to Super Mario Brothers (Nintendo 1985).

Platformer video games (figures 13.2, 13.3) also have **genre**-specific mechanics, derived from multiple media sources including board games, arcade games, and animated cartoons such as:

- Segmented, obstacle-filled space, traversed by a cartoon figure controlled by the player
- Jumping from platform to platform with penalties for falling
- Enemies who must be jumped over, stomped, or otherwise evaded or destroyed
- Collection of items by colliding with them, usually small and coin-like
- Changes of state of the player character (e.g., bigger, smaller, more powerful)
- Earned or lucky power-ups to create change of state
- Levels with increasing difficulty and novelty of challenges
- "Boss" monster or most powerful adversary in the last level
- A goal, often a rescue or retrieval as the object of the game

The same game mechanic, such as movement across a board in increments determined by chance, can be instantiated using different game actions, such as turning a spinner or rolling dice. And the same mini-mechanics can represent different actions in

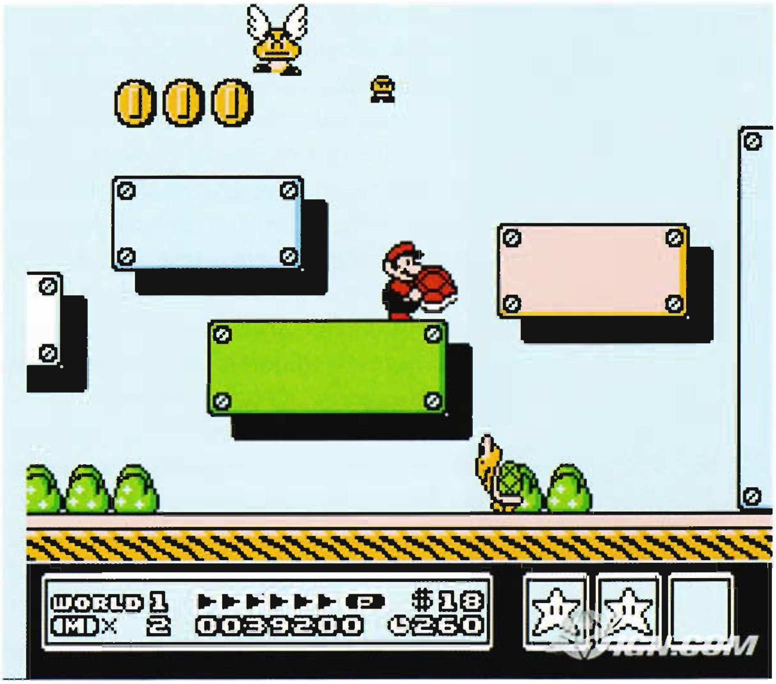

Figure 13.3
Screenshot from Super Mario 3 (Nintendo, 1990) here shown in a screenshot from the Wii Virtual Console version (2007). The Mario games extended the gameboard with side scrolling, elaborating the platform jump into the navigation of an increasingly inventive and challenging landscape.

different games: such as rolling dice in a six-year-old's board game, in a role player's battle simulation, or on a Las Vegas craps table.

Designers often exploit the abstract quality of games to generate formulaic versions of the same underlying gameplay with different surface branding or representational elements, such as a stock maze game with a newly popular cartoon figure, or the numerous variants of Monopoly, themed with the Simpsons, Batman, Coca-Cola, or New York City. But there is always room for invention within established genres when designers reimagine the experience of the player in the light of the particular affordances of new platforms or the deeper representational affordances of culturally complex game elements. For example, the game mechanics of the platformer and other video genres have been deconstructed into microgames of WarioWare (Gingold 2005; see figures 13.4, 13.5), and adapted by independent game designers to express themes usually associated with serious dramatic genres like mortality (figure 13.6) and regret (figure 13.7).

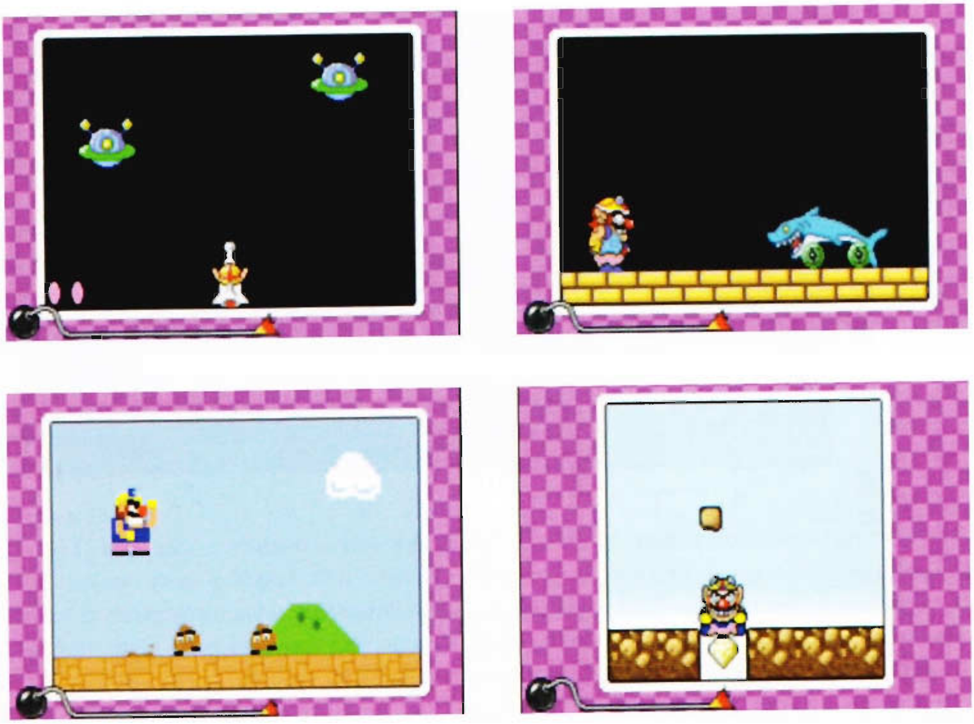

Figure 13.4
Screenshots from WarioWare for the Nintendo Gameboy (2003), which makes extremely rapid microgames out of the core mechanics of videogames like the Mario series.

The same playful attitude can also turn the formulaic mechanics of other digital artifacts to more expressive uses. Even the much ridiculed genre of the automated slide show (Tufte 2006) drearily familiar from thousands of predictable business and academic presentations, can be transformed into the expressive subgenre of Pecha Kutcha (see <http://www.pecha-kucha.org>) for imaginative stage presentations by designers; or into a party game in which players are asked to improvise presentations to nonsense slides; or into the idiosyncratic art installations of a former rockstar (<http://www.davidbyrne.com/art/eeei>).

Convening Shared Attention with Game Mechanics

Games exploit the pleasure of synchronized companionship, discussed in chapter 12, to build up complexity. For example, one-year-old children playfully explore the manipulation of their own hands and take pleasure in clapping, and in imitating the clapping of others as a demonstration of agency and sameness. Older toddlers enjoy

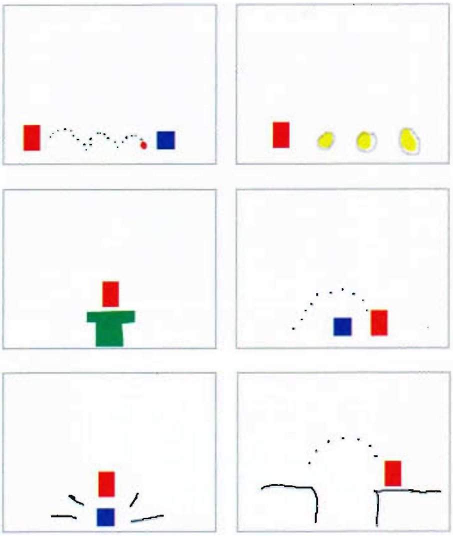

Figure 13.5
The core mechanics of Super Mario Brothers abstracted into WarioWare microgames by game designer/theorist Chaim Gingold: shooting fireballs, collecting coins, entering pipes, dodging enemies, stomping enemies, jumping over gaps (Gingold 2005).

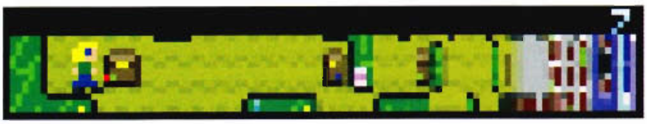

Figure 13.6
Jason Rohrer's Passage (2007), an art game that is an explicitly autobiographical meditation on mortality, in which the protagonist meets up with a mate whose presence limits his access to treasures (like the one in this screenshot) but increases the intensity with which they are enjoyed. The landscape scrolls horizontally like a platform game simulating a life journey ending in death. The nostalgic low-resolution graphics reinforce the theme of the passage of time. Game and artist's statement are available at <http://hcsoftware.sourceforge.net/jason-rohrer>.

the more complex interaction of Pat-a-Cake, which requires more precise timing and observation because the clap is achieved with a partner. Pat-a-Cake turns the skill of hand clapping into a more complex mechanic of social interaction. Games reinforce the synchronization of behavior needed for participation in human society, and game mechanics form an expressive vocabulary that can be adapted and repurposed, providing the basis for survival-oriented social rituals like hunting, gathering, and food sharing, and for the cultural elaboration of social life like singing, dancing, and law

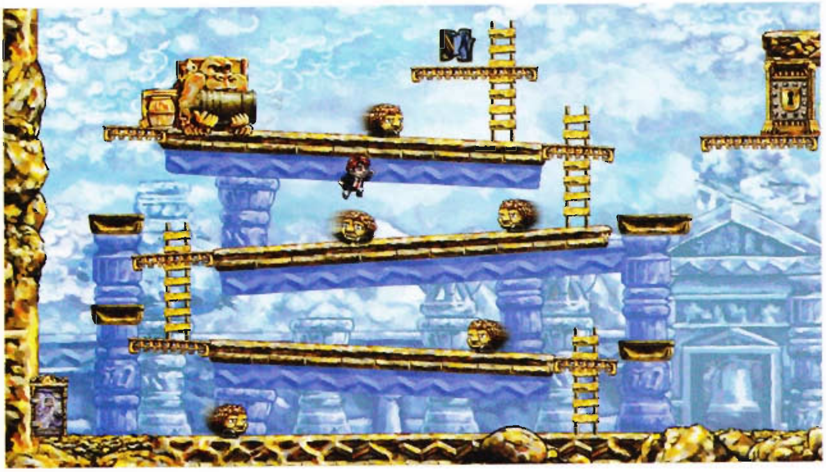

Figure 13.7
Braid (2008), an experimental game created by Jonathan Blow that plays with conventions of the platform game to explore the subjective experience of time and engage themes of regret and failed relationships. In this screen, the design explicitly echoes Donkey Kong. See <http://braid-game.com>.

making. Having mastered just-for-fun synchronized hand clapping as preschoolers, we are prepared for attendance at theater and political events as adults where hand clapping has a semiotic role in expressing approval. Having mastered Pat-a-Cake, we are prepared for handshakes, high fives, fist bumps, and other expressions of exuberant, shared celebration.

We are also prepared for hand-based communication with machines, with joysticks, keyboards, mice, and **haptic** game controllers that respond to our grip by vibrating against our palms. Like game makers, interaction designers build complex structures out of simpler, conventionalized mechanics. Just as game designers adapt the same conventional mechanics of behavior, like rolling the dice, for diverse situations from Shoots and Ladders to Craps, interaction designers draw on standardized *interaction mechanics* to express very different actions. Click-and-drag, for example, is a symbolic ritual, like moving a piece on a game board, that can be mapped to the act of reorganizing a set of file folders or ejecting a hard disk or repositioning a battleship or placing shoes in a shopping bag. Our current interface conventions may someday seem like a kind of human–computer Pat-a-Cake, a primitive language of shared attention that is laying the basis for more complex cultural structures, with larger groups of participants drawn into a global magic circle.

The widespread use of digital mobile devices in the first decade of the twenty-first century has produced new ways of convening groups and focusing the attention of

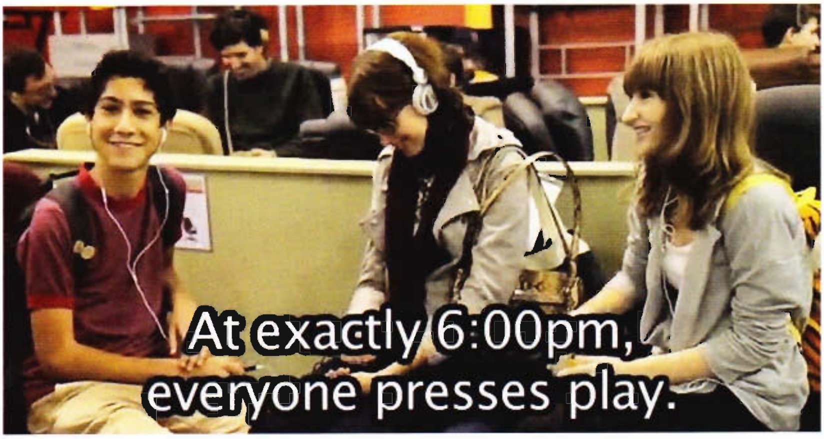

Figure 13.8
Improv Everywhere MP3 Experiment 7 (2010). Improv Everywhere stages fanciful, synchronized participatory events by drawing on theatrical and game conventions to coordinate the behavior of crowds of people. The participants download an audio file and show up at the same time and place to follow the directions of the disembodied pre-recorded voice. See <http://improveverywhere.com>/ for videos of their past "missions.".

like-minded strangers in live-action public events. Instant messaging, email, and other digital communication channels were first used as part of the youth culture to organize "meet ups" and to convene unannounced "flash mobs, " and grew to become an important form of global political action and a growing site of artistic expression. Improv Everywhere, an experimental theater group, has playfully explored the possibilities for coordinated whimsical actions by large groups of people in public places (<http://improveverywhere.com>), using mobile media players to choreograph their actions and drawing on play rituals like tossing beach balls around, game mechanics like Rock Paper Scissors, and theater games that have people imitating outlandish characters like bumblebees, dolphins, and astronauts (figure 13.8). Such mass-synchronization events are likely to become increasingly common in coming decades with greater ambition for the coordination of behaviors across geographical distance, and expanded use of more complex game mechanics for both serious and playful purposes.

Sustained casual games have been an important component of the success of large social media sites. The huge popularity of the Facebook game Farmville (Zynga 2009), which had over 80 million players in 2009, was surprising to veteran game designers because the mechanics seemed so trivial, and the game so unchallenging (figure 13.9). But simple games work well in social media environments because they produce a sense of a shared daily ritual that is more about presence than performance. The fun

Figure 13.9
Farmville (2009), a social networking simulation game in which players cultivate farm plots adjacent to those of Facebook friends. The game requires repetitive actions to keep the farm in cultivation, and encourages players to purchase items that give the game world more variety, but it does not reward skill or engage players in mechanics of chance. Farm plots can be adjacent to those of friends and game items can be exchanged, providing some of the pleasures of playful companionship with a relatively small investment of social and cognitive energy. The enormous popularity of Farmville, despite its evident simplicity and crass commercialism, bewildered and irritated both mainstream and independent game designers, a response that is epitomized by the title of Ian Bogost's parody Facebook game, Cow Clicker (2010).

of games like Farmville comes from the low level of coordination and skill needed to achieve a shared play experience with people who are drawn from an already meaningful network of "friends." Young children learn to play together through "parallel play" experiences, sitting beside one another, aware of one another's presence, without directly interacting. Games like Farmville can be seen as parallel play experiences for large virtual communities.

Game mechanics can also be used for researching knowledge transmission across social networks. For example, in December 2009, the U.S. Defense Advanced Research Projects Agency (DARPA) celebrated the 40th anniversary of the establishment of ARPANET, the forerunner of the Internet, with a contest structured like a treasure hunt (<https://networkchallenge.darpa.mil/Default.aspx>). In order to explore what strategies were most effective in obtaining and relaying information quickly across a geographically distributed social network, they launched ten weather balloons in locations across the United States and challenged players to form teams to find them in order to win a $40,000 prize (Greenemeier 2009). The winning team from MIT, who found all ten balloons in under seven hours, motivated participation by sharing the prize money along the chain with the finders of each balloon and whoever was directly linked to their recruitment. The runner-up team from Georgia Tech, who found nine of the ten balloons in the same amount of time, took a more cooperative approach to motivation by pledging to contribute the prize money to charity. Like the huge raiding parties in World of Warcraft or the plant-gifting Farmville players, information researchers are repurposing ancient game mechanics. Each in their own way is contributing to the common cultural project of reinventing the rituals of shared attention to suit the increased speed and scale of the global village.

Playing with Media Conventions

Games employ many of the same media conventions as nongame applications, often demanding a high degree of focus on complex media objects. One of the most striking examples of a game with elaborate print components is the classic print-based tabletop role-playing game Dungeons & Dragons (D&D), invented in the 1970s as an outgrowth of tabletop war games (Gygax 1978; Fine 1983). D&D is not a single game but an encyclopedic game system for individual game masters and players to use as the basis for improvised collaborative adventures that can be set in elaborately specified D&D fantasy worlds. Gameplay is based on thick books of quantitative tables that specify the rules for creating characters and for performing actions in the game, based on rolls of special dice (figures 13.10, 13.11). Each dice roll provides a significant parameter for the calculation of a dramatic game action, such as whether you have hit a target and how much you have injured the enemy. The point system is cumulative with action in one game session affecting the skill and experience points that your character carries over from one quest to another.

Among the game mechanics that D&D has made conventional for the tabletop role-playing genre are:

- a game master, who sets up game sessions by designing quests and describing the action including the parts played by nonplayer characters
- player-designed characters based on a substitution system of differentiated character types (e.g., warrior, wizard, cleric, thief) and attributes (e.g., strength, intelligence, dexterity, charisma), who persist from game session to game session, changing in experience and skill points.
- a system of rule books with fantasy elements specified as mathematical formulae determining the probabilities of game events
- the use of dice to decide game events
- the use of a grid system for the game map, and of concealed or progressively revealed custom maps as game boards
- the inclusion of nonplayer characters (NPC) controlled by the game master
- team-based gameplay in questing parties of four players with complementary skills

Class Level Name	Level	EP Needed	Hit Points	Open Locks/ Remove Traps	Pickpocket or Move Silently/ Hide in Shadows	Hear Noise D6
Apprentice	1st	0	1D4	15% / 10%	20% / 10%	1-2
Footpad	2nd	1200	2D4	20% / 15%	25% / 15%	1-2
Robber	3rd	2400	3D4	25% / 20%	30% / 20%	1-3
Burglar	4th	4800	4D4	35% / 30%	35% / 25%	1-3
Cutpurse	5th	9600	5D4	40% / 35%	45% / 35%	1-3
Sharper	6th	20000	6D4	45% / 40%	55% / 45%	1-3
Pilferer	7th	40000	7D4	55% / 50%	60% / 50%	1-4
Master Pilferer	8th	60000	8D4	65% / 60%	65% / 55%	1-4
Thief	9th	90000	9D4	75% / 70%	75% / 65%	1-4
Master Thief	10th	125000	10D4	85% / 80%	85% / 75%	1-4
Master Thief	11th	250000	10D4	95% / 90%	95% / 85%	1-5
Master Thief	12th	375000	10D4+1	100% / 95%	100% / 90%	1-5
Master Thief	13th	500000	10D4+1	100% / 100%	100% / 95%	1-6
Master Thief	14th	625000	10D4+2	100% / 100%	100% / 100%	1-6

Figure 13.10
A representative Dungeons & Dragons table, used by players for calculating the "experience points" needed to attain the different levels (e.g., Apprentice, Cutpurse, Master Thief) within the overarching professional category of Thief, and showing for each level the values to use in calculating vulnerability to attack and likelihood of success in some of the essential tasks of thievery.

The D&D players are imaginatively role playing in a world of dungeons, dragons, and wizards, and yet the game mechanics involve a lot of arithmetical calculation with reference tables, an activity more generally associated with work than play. The combination of magic and arithmetic works because the dice focus attention in real time within the social world of the players on a chance event happening in the shared fantasy realm. The physical mechanics of choosing and throwing the oddly shaped dice according to instructions in arcane tables is evocative of the world of wizardry and spells that forms the dramatic context of the game.

Moving tabletop team fantasy games to the computer has taken the dice away as well as the physical presence of other players, while opening up many rich representational possibilities. Graphic role-playing games are one of the most popular genres of digital entertainment, with best-selling fantasy games like BioWare's Neverwinter Nights (2002) and Blizzard's World of Warcraft (2004) using interactive substitution displays to emphasize the choices of character classes, attributes, and inventory items open to players (figure 13.12). Digital games preserve the underlying mathematical mechanic for the blow-by-blow calculation of battles, including a randomized element, but eliminate the need to look up tables or roll physical dice.

The D&D calculation tables and dice are transmission codes, and playing with them compared to playing a similar video game is like looking up a phone number in a

Figure 13.11
Dice used in a session of Dungeons & Dragons, from Wikipedia Commons, created by Franganghi.

paper directory and then manually dialing the number, compared to touching a hyperlinked name and letting your smartphone do the lookup and dialing for you. But for tabletop players, the dice and tables are part of the enjoyment of the game, providing a different pleasure from the visualized instantiation of the fantasy world (see <http://www.helium.com/debates/155881-which-is-better-online-roleplaying-games-or-tabletop-roleplaying-games>). In fact, visualizing a role-playing world in moving images can make it less real for some players, just as film adaptations made from novels can disappoint fans of the original, because the film version does not correspond to the individual's imagination of the world.

Interface transparency is not always valuable in a game. We may not want to eliminate the decoding, because logical codes are classic game elements. Symbol systems used in games are interesting to us because of the novelty of the symbol or the intricacy of the system and not, as in life, for what they represent. Clapping in Pat-a-Cake is only clapping; it does not hold the meaning of clapping in a theater or high fiving, but is enjoyable in itself as the synchronized intersection of hand on hand. A map in a game is not interesting as a way of getting around an actual place—it is the place, and the pleasure comes from navigating from one segment to another and noticing the relationship between places. Play money in a game functions like real money, but it has no practical value outside the game. When we receive it as pay, take it from other players, save it,

Figure 13.12
World of Warcraft talent calculator for a member of the Rogue class, including the Mutilate refinement of the talent for assassination.

or spend it, we are enacting rituals that have value in the real world but are pure performance in the context of the game. Words in a crossword puzzle game like Scrabble are equally meaningless. Their denotation and connotation are merely decorative details in the context of our focus on placing letters in legal arrangements to increase our score. Games allow us the pleasure of thinking of clapping, mapping, accumulating money, and formulating words as *abstract codes* and *pure mechanics of interaction* with a satisfying cognitive complexity that is independent of what they buy or mean.

Human beings are capable of seeing any complex set of interactions or media codes as a game, of getting lost in the signifiers and ignoring the things signified. The allure of computational artifacts draws on this pleasure, and it can work against transparency, efficiency, and expressivity—the values we discussed as part of the more instrumental **tool model**. We do not necessarily value efficiency in game interactions; sometimes we value cumbersome processes because the extra effort needed to focus our attention on their arbitrary, excessive elaboration brings us a welcome detachment from the world of time and consequence outside the magic circle. Games allow us to indulge our predilection to fetishize numbers, letters, or currency-like tokens, or to become enraptured with complexity for its own sake. Completing the *New York Times* Sunday crossword puzzle or assembling a 1,000-piece jigsaw puzzle or an intricate Lego model of the *Millennium Falcon* can create the satisfying sense of absorption and challenge recognized as a **flow** experience (Csíkszentmihályi 1990). The intricacy of a system, the pleasures of manipulating complex coded objects, even when they are part of a real-world task, like moving gambling chips around a colorful roulette table, buying and selling securities, operating a military remote targeting system, estimating the risk of a natural disaster with mathematical probability tables, can create a seductive sense of being in a magic circle, intensely engaged but distant from consequences in the real world. *Computers reinforce the danger of losing sight of consequences in the physical world, even as they help us to manipulate ever more complex and powerful symbol systems. Designers should bear this danger in mind and look for ways to remind interactors of what is at stake in real-world systems whose complexity can create game-like immersion.*

Games also remind us of the human tendency to fetishize cumbersome mechanics when they are embedded in familiar media formats, and to confer the status of specialized wizard upon those who have mastered them. Processes that have long been mystified by paper-based professional rituals, like writing a will or filing a tax return, become more transparent when digital media automates the rules or makes the previously hidden mechanics visible to nonprofessionals. Practitioners who are used to privileged access to the mechanics of their profession often expect designers to reproduce the older, print-based rituals. Literary scholars have made ill-considered but passionate arguments for retaining a library cataloging system based on heavy drawers overstuffed with handwritten index cards. Technologists can be equally passionate in finding hidden virtues in obsolete command-line text editors or seductively complicated and insufficiently tested programming packages. *Designers faced with requests for the reproduction of unnecessarily cumbersome practices or the use of cultish technologies should ask themselves whether the specialists involved are clinging to their magic dice and secret tables, enraptured by the game-like immersion of the secret code, instead of focusing on the best mechanics for instantiating the underlying practical quest.*

The plasticity of bits allows us to blur the boundary between actual artifacts and playful forgeries, everyday identities and masquerades, real events and make believe. The new genres of **alternate reality games** and **pervasive games** exploit this heightened awareness of how easily we can be deceived and focus attention on the game-like structures of our real social, political, and economic structures, by mixing game elements with real-world experiences and convening groups of players to identify, share, and decode the purposely ambiguous puzzle pieces. Instead of setting gameplay within a self-consistent, safely insulated magic circle, alternate reality games often use intrusive tactics such as emails and instant messages, and plots that involve violent conspiracies, suppressed information, and secretive informants to blur the distinction between in-game events and events in the real world. As pervasive game designer and theorist Jane McGonigal puts it, "If we could make your toaster print something we would" (McGonigal 2005). Pervasive games involve players in highly participatory and complicated games by relying on ritualized mechanics such as mystery solving, decoding of media artifacts, treasure hunting, and fantasy role playing to structure social interactions. Often the game mechanics are meant to serve the purposes of creating enjoyable or ideologically desirable social interactions, rather than creating transparent, immersive, or conventionally satisfying game experiences. As McGonigal points out, designers of such games create team missions

> that require players to misread (non-game) people, places and objects as a part of the game. For example: "Some time today you will be approached by the Speaker. The Speaker could be anyone, anywhere. all we know is that the Speaker will say something to you. It could be anything, and you'll only know it's the Speaker if you form a circle around him or her and dance wildly." Or "Sometime today you will find the Mystery Key. It won't look like a key, but it will work some kind of magic when you encounter a locked door later in the game. So make sure you take with you any unusual objects you find along the way." With this built-in ambiguity, teams must approach everyone and everything with a game mindset. When encountering a person, a team must assume he or she is a plant; when finding an object, a team must assume it is a prop to be deployed creatively. These missions require teams to affect a confident belief, to act *as if* the game is everywhere and everything at all times. (McGonigal 2003)

The after effects of the **pervasive game** are as important to McGonigal as the game experiences. People are left with a "game-play mindset" in their ordinary lives, defamiliarizing the **naturalized** environment. Perhaps they become aware of their desire for life to be more like games, more shapely and predictable, with clearer rules of behavior. Perhaps they become aware of their impatience with the rules of existing social games. Participating in a pervasive game with the aesthetic of "performing belief" as McGonigal describes it, invites the players to think of the world as it is as just one instantiation of the possible worlds it could be.

Of course, defamiliarizing the mechanics of interaction only works as a design strategy if the mechanics are already quite familiar, and the point of the defamiliarization is clear. *The risk in creating games or art pieces that subvert familiar media conventions is that interactors will experience frustrated befuddlement rather than the intended heightened understanding of the way the world is put together.*

Art is another kind of playful magic circle, free to invent its own mechanics. Artists explore the plasticity of the new digital medium, intentionally stretching and transgressing familiar media conventions and rituals, and sometimes inventing new expressive mechanics of interaction that can be adapted by designers. For example, Camille Utterback' *Liquid Time Series* (2000–2002) translates the interactor's physical approach to a digital video image into the immediate agency of pushing part of the image "deeper" in time:

Figure 13.13
Camille Utterback's *Liquid Time*, an art installation project in which segments of the moving image change, reflecting temporal movement, in response to the viewer's movements in the space in front of the image.

In the *Liquid Time Series* installation, a participant's physical motion in the installation space fragments time in a pre-recorded video clip. As the participant moves closer to the projection screen they push deeper into time—but only in the area of the screen directly in front of them. Beautiful and startling disruptions are created as people move through the installation space. As viewers move away, the fragmented image heals in their wake—like a pond returning to stillness. The interface of one's body—which can only exist in one place, at one time—becomes the means to create a space in which multiple times and perspectives coexist. (Utterback 2000–2002)

Utterback's piece evokes the continuities and discontinuities between present consciousness and memory, by disrupting "a basic premise of time based media—that the unit of recording is also the unit of playback" (figure 13.13).

Similarly, David Rokeby's *Machine for Taking Time* (2001–2004) displays a composite image that mimics the familiar cinematic pan, from individual images that are continuous in space but compellingly discontinuous in time (figure 13.14), and Jonathan Blow's

Figure 13.14
David Rokeby, *Machine for Taking Time* (2001–2004). The camera pans still images taken at different seasons but stitched together to form a dynamically reconfigured, continuous cinematic space in which "Time moves very slowly and very fast at the same time."

experimental platform game Braid (figure 13.7) offers multiple variations on the theme of rewinding the past as the focus of gameplay. Works like these radically challenge familiar media conventions for structuring time, perhaps providing the basis for new genre conventions that can capture our complex experience of temporality including the distortions of subjective memory, the relativistic time of physicists, or the ways in which our brain dynamically reknits the web of connections linking past, present, and future events.

Playing with Cognition

Game design elements often focus us on and support core cognitive activity such as matching, sorting, collecting, and sequencing, as well as pattern recognition for symbolic codes (like the alphabet), and math skills. For example, the Royal Game of Ur, perhaps the oldest surviving board game, dated to the third millennium B.C., is structured as a race across a game board of meaningfully patterned squares, with patterned tokens differentiated by color, and moves determined by casting dice made of animal bones (Green 2008). Playing this game involves some mathematical and sequencing skills and the ability to interpret a symbol system, which presumably would have reinforced the skills involved in deciphering the proto-alphabetical symbolic writing of the period (figure 13.15).

Since games are interactive systems based on abstract patterns, game conventions can help us to think concretely about complex computational artifacts. For example, consider the classic board game Go (figure 13.16), which is played by placing black or white stones on a board of 19×19 squares in patterns that enclose the opponent's stones. There are few rules beyond placing one stone at a time in alternating

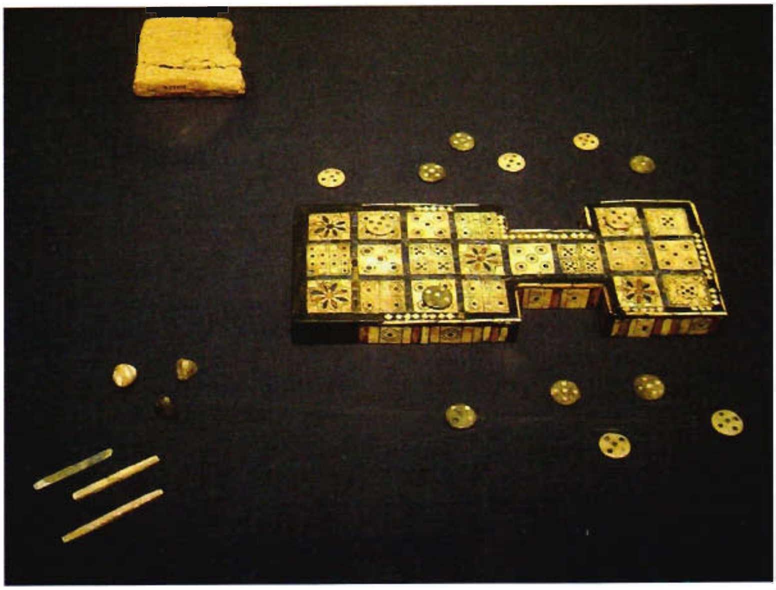

Figure 13.15
The Royal Game of Ur in the British Museum, from a tomb in modern day Iraq, dated to 2600 BC. There are seven white and seven block game pieces, and a game board with inlays of shell, red limestone, and lapis lazuli. The eight-petal rosette squares are believed to confer advantage on the token that lands on them. The game has survived in recognizable form to modern times, and is a forerunner of backgammon.

turns, yet Go opens up a large possibility space, engendering complex strategies. In fact, Go is many times more complex than chess in the possible moves that can be made at any given time and the effect of individual moves on later moves, making it so far impossible for computers to outplay human beings. It serves as a model for interaction design in gaining such expressive power out of such an elegant economy of rules.

Go is also a good example of a game whose **state** is readable from the position of pieces on the game board. *Games in general offer a useful palette of conventions for representing state, which as we saw in chapter 4 is one of the key concepts in a procedural medium.* As game worlds become more elaborate, it is increasingly challenging for game designers to display the many elements that make up the dynamically changing state of the world—a problem that is increasingly important in the visualization of real-world systems as well. Go, like Othello, chess, and checkers, is structured as a contest between tokens of contrasting colors, and viewing their numbers and positions on the board reveals who is winning. Casual video games that focus on removal, such as Tetris, Jewel Quest, Collapse, and Zuma, display state as the number of remaining pieces. In Tetris and Zuma, the position of pieces on the board also

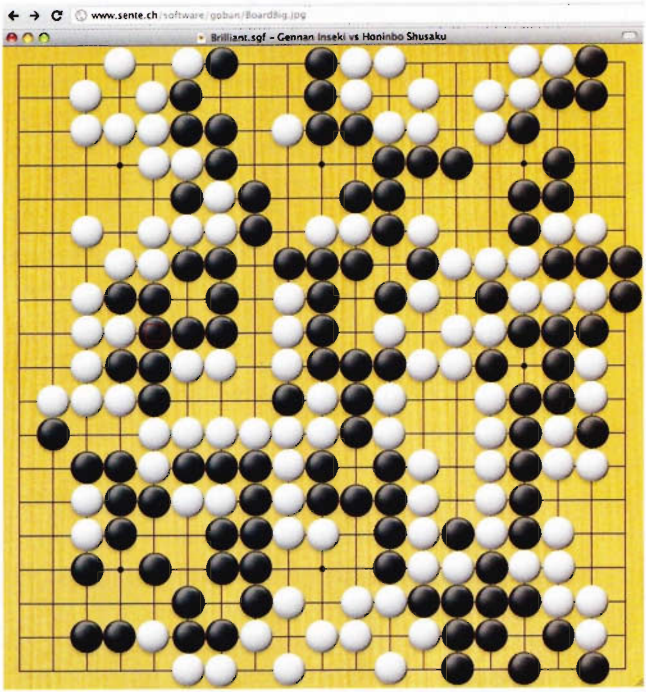

Figure 13.16
A game board for Go, which has been played in China for more than 2,000 years. The object is to surround the opponent's stones in order to occupy the most space. Stones can be placed at any intersection (point) in the grid as long as there is at least one connected point open. Surrounded stones are removed (captured by the opponent). Although the mechanics of the game are very simple, the strategies are in some ways more complex than those of chess.

reflects the building time pressure—as time runs out, the board starts filling up or the pieces get closer to the hole. By eliminating the need for a separate timer, the game designer reduces distraction and increases the dramatic tension of the gameplay. Videogames and board games that focus on the player's movement through an abstract map (Pac-Man, Donkey Kong, Shoots and Ladders) can similarly display state in the positioning of the tokens on a single overview image.

Simulation games, like Civilization, SimCity, and The Sims are so complex that they require multiple displays to keep track of all the changing variables. Players split their attention between the main display, which gives a good summary image of the state of system (for example, in the appearance of the furniture and friends in the Sims house), and the control panels at the margins or on other screens lower in the menu hierarchy. The strategy of a main summary view with strong representational elements—such as a a map or scenario mock-up—augmented by deeper details in quantitative control panels can be applied to the visualization of other kinds of simulations as well. For example, we might summarize global warming effects with map-based images of rising sea levels and melting ice caps, while presenting a graph of specific measurements in a separate display.

Replay as Repetition with Variation

Closely related to the display of state is the game-like pattern of **replay**. **Parameterized** repeatability, or the ability to replay a game with significant changes, is an important affordance of digital game environments for the presentation of simulated systems. In a game like Lemonade Stand, for example (figure 5.5), we can try multiple strategies for maximizing profit, such as changing the recipe or increasing the advertising budget. By playing the game more than once we learn from our mistakes and we get a clearer picture of how the lemonade business is modeled by the program.

Over the past twenty years games have developed elaborate mechanisms for replay, which can also be useful when applied to informational systems such as educational simulations. Most games allow players to save the state of the game at intervals in order to be able to repeat the last portion of the game without having to start over from the beginning if you lose a round (i.e., if your character dies). In some games repetition is by levels; in other games it is by puzzles or challenges within a level; some games will allow greater freedom, so that players can save at will anywhere throughout the game. Some games allow multiple instances of the same game to be saved, which allows the player to try out more than multiple strategies and compare the results. Often a game will establish specific explicit **save points** and will automatically save or prompt the players to save before and after completing a particularly treacherous challenge. It is conventional to endow characters with multiple lives so that they can be reinstated after a failed attempt. Often a new instance of a character who has died but has lives remaining will automatically reappear at the save point. The many variations on such mechanics for restoring a game world and **respawning** a character are equally useful for creating simulated worlds for analyzing complex processes. For example, if we were analyzing the effects of multiple pollutants on the ecology of a pond, we could save the simulation of a period of time with one hypothetical pollutant, and then run parallel instances of the same time period with and without a second pollutant. Or we could respawn instances of threatened species to try multiple strategies for survival, or save multiple versions of the same scenario and play through them to compare strategies for favoring one species or another.

Repetitive plays of simulated systems can lead to deeper insight when the scenario design and interface elements support clear comparison between different instances. In quantitative simulations, such as economic models, election forecasting, or epidemiology studies, providing continuous sliders for key parameters (sales, voters, vaccinations) and readable color coding for the salient outcome (profit/loss, Republican/Democrat, disease decline/spread) can anchor understanding in physical gestures tied to sensory feedback. Games with sharply differentiated avatar choices (e.g., fighters vs. sneaks, opposing sides in a conflict) encourage repetition for the exploration of alternate strategies or points of view.

Repetition with variation can also lead to dramatically satisfying juxtapositions in interactive narratives. For example, in Sarah Cooper's Reliving Last Night (2001), an interactive romantic comedy, we can juxtapose short scenes covering the same moment under different conditions. The story concerns a young woman entertaining a young man, and the interactor can choose what she wears (sloppy or sexy), what she serves (coke or vodka), and what music she puts on. In every version of the story another young man, whom she has recently broken up with, arrives and reacts to the presence of the potential new boyfriend. The story is divided into short dramatic segments and the navigation scheme allows for repetition of the same scene with different parameters (figure 13.17).

Figure 13.17
Sarah Cooper's interactive story, Reliving Last Night (2001) is divided into dramatic segments that maximize the dramatic contrast between parameterized events. Here an old boyfriend is about to arrive and the protagonist and her potential new boyfriend can be in varying states of inebriation and listening to one of three choices of music, changing the way the scene plays out while keeping the basic characters consistent.

The Mechanic Is the Message

In making an interactive system, as in designing a game, as game designer Tracy Fullerton has pointed out, *the mechanic is the message* (Fullerton 2007). Most commercial games are structured around a small number of mechanics: moving fast, shooting (or knifing, punching, etc.), and evading. But mechanics can have expressive qualities even within this narrow range. Mario, the classic platform game hero, is forced to relentlessly run and jump to evade disaster, squash his enemies, and make his way through the many obstacles of his world. But his jumps are exhilarating and varied, with mushroom-shaped enemies, trampolines, and magic spinners to propel him, and surprising landscapes opening up in unexpected places, constantly expanding the boundaries and the inventive possibilities of the game. Mario's cheerful resiliency is like the dogged hopefulness of the slapstick film hero Buster Keaton or the antic evasiveness of Bugs Bunny. Like all archetypal comic heroes, Mario can be beaten down, but he will always rise up again; or he will as long as the player is willing and able to enact his story. By playing Super Mario Brothers we enacting a rule system in which the villains will keep coming but the hero will triumph in the end if the player puts in the time and effort to master the necessary skills. The game is a semiotic system encoding meanings about what makes for success in a thrilling but hostile, competitive world.

The Sims finds expressive mechanics in the everyday rituals of middle-class suburban life, like finding a job, taking a shower, picking things off the floor, asking friends to a party, and giving someone you like a backrub. The ordinary furnishings of a home are game objects with behaviors that satisfy our expectations taken from the real world and affect the state of the game. For example, you can use the telephone to order a pizza for your Sims. The pizza will be delivered in a dramatized event that will decrease the amount of money the household has and satisfy the appetite counter of the characters who eat it. It will also create trash that will impact the messiness counter and require cleaning up afterward. The Sims is an interpretation of the rewards and risks that attend our everyday activities.

Many of the activities we are familiar with can be recast as game mechanics and interpreted as part of a cause-and-effect rule system. We are surrounded by systems of ritualized behaviors, and we can choose to represent them as games by identifying the reward systems they belong to, the limited resources they use up, the competitions they are part of, and so forth. For example, a family holiday celebration might be represented by game mechanics based on any of the following elements:

- scoring of points in bragging contests
- competing for consumption of food
- depletion of limited resources (money for presents, food)

- scoring of transgressive behavior (nose rings, alcohol consumption)
- rituals of synchronized behavior (singing, echoing praise, gift exchange)
- role playing (nurturer, authority figure, trickster, political opponent)
- contests for attention
- success at keeping/revealing secrets
- using the dinner table as a game board with place settings representing territory, and placement reflecting teams' organization

In ordinary life we may find ourselves playing multiple games at the same time and losing track of the score in some of them. We may be assigned to roles in social games that we do not want to play or do not know how to play. We often find ourselves in social situations that feel like a single playing field is being used simultaneously for conflicting sports, as if some players are suited up for football while others are in a leisurely round of miniature golf. The pleasure of actual games is that they substitute a controlled, consistent area of focus where a limited group of people agree, within the constraints of the game, to act according to the same rules. *An awareness of the game-like structure of social behavior can provide a palette of interaction mechanics for designers, and should be increasingly helpful as computation is embedded in more and more ever-day objects and becomes increasingly important to everyday social rituals* (Goffman 1959, 1967; Berne 2004).

Because games are such a fundamental building block of culture, they are often used as a metaphor for social situations ("He won't play by the rules." "They threatened to pick up their ball and go home." "That remark was out of bounds."). Games can also be used as a conceptual framework for understanding complex issues. The branch of applied mathematics called **game theory** attempts to reduce the messy world of social organization into neat game-like abstract patterns, so that they can be analyzed by mathematicians and philosophers and used by economists, political scientists, and computer scientists to model social behavior. For example, the Prisoner's Dilemma game is based on a scenario in which each of two prisoners can either cooperate with one another or defect from their partnership to seek individual advantage:

> Two suspects are arrested by the police. The police have insufficient evidence for a conviction, and, having separated both prisoners, visit each of them to offer the same deal. If one testifies (defects from the other) for the prosecution against the other and the other remains silent (cooperates with the other), the betrayer goes free and the silent accomplice receives the full ten-year sentence. If both remain silent, both prisoners are sentenced to only six months in jail for a minor charge. If each betrays the other, each receives a five-year sentence. Each prisoner must choose to betray the other or to remain silent. Each one is assured that the other would not know about the betrayal before the end of the investigation. How should the prisoners act? (<http://en.wikipedia.org/wiki/Prisoner%27s_dilemma> retrieved August 8, 2009)

Game theory analysis of the Prisoner's Dilemma usually stresses the advantage of the defection choice, and is based on an assumption that the partners have no reason to be loyal to one another against their own self-interest. The scenario has been extensively used as a way to understand a wide range of social behaviors, from nuclear disarmament to steroid use among athletes, where choices have to be made between self-interest and collective interest, and where there is imperfect knowledge and distrust among the participants. Game theory scenarios form the basis for much large-scale economic modeling, and they have been used in everyday practical applications such as the automated auction system used by Google for selling online advertising (Levy 2009).

Although some would claim that such economic game scenarios can explain many complex social phenomena, such approaches have been criticized as ahistorical (Levitt and Dubner 2005; Fine and Milonakis 2009). Humanistic disciplines, like history and literary studies, are skeptical of approaches that reduce human behavior to logical formulas, believing that our actions reflect complex cultural motivation, social traditions, and unconscious needs and desires that resist quantification. The Prisoner's Dilemma game assumes that ideology, moral values, personality, and personal relationships are irrelevant to prisoners' choices. This is not a value-neutral or scientifically objective assumption; it reflects an **ideology**, rooted in modern European political thought, that focuses on narrowly defined self-interest as a determinant of human behavior and privileges quantifiable phenomena (How much time do they spend in prison?) over qualitative phenomena (What is the relationship between the two prisoners? What is their attitude toward the police?). In the actual world, people regularly act against their rational self-interest, and economists as much as anyone else can be deceived in assessing the value of objects of desire. Though game theory models seem reductive to humanists, they will continue to be seductive to social scientists, if only because they lend themselves so well to programmed simulations. *Designers should look to game theory for useful procedural models of behavior, while remaining skeptical about how well their compelling mathematical complexity represents the complexity of the real world.*

Once more, designers will do well to remember the programmer's adage, Garbage In, Garbage Out. The representation of a situation as a quantitative game is not necessarily more reliable or precise because it involves complicated computer-based calculations. It is part of the designer's responsibility to make sure that users of such a system fully understand the rules of the underlying game, including what has been left out of the representation.

Patterns Make Reality

We have been concerned in this book with understanding the patterns by which we can design more expressive and coherent interactive artifacts and advance the development of the new digital medium. In summing up this effort I return to Danny Hillis's words, the epigram for this book: "Whenever I design a chip, the first thing I want to do is look at it under a microscope—not because I think I can learn something new by looking at it but because I am always fascinated by how a pattern can create reality" (Hillis 1998).

Patterns make reality, and media patterns—like the circuits on a computer chip, the divisions on a map, the fields in a database, the sections of a Wikipedia page, and the mechanics of a game—shape reality by providing the templates by which we exchange meaning with one another. Games are a fundamental building block for designers because they ritualize behavior. But playfulness is even more important because it disrupts ritual patterns and reconfigures reality. *I encourage every designer reading this book to approach your career with an attitude of radical playfulness, looking for ways to disrupt the patterns that define us in order to reconfigure reality to better serve human needs.*

Patterns make reality. What we can represent determines what we can do, what we can know, and who we can be. The hardware and software platforms on which digital information is inscribed and transmitted will change over the coming decades, as will the job opportunities in this evolving field. But the task of shaping a powerful new medium of representation will remain the same.

The creation of a more coherent and expressive digital medium is not something that is achievable in any single project or over the course of a single career, nor is the future inevitably weighted in favor of free expression and deeper knowledge. We did not come into possession of the computer as a medium of representation through patterns of perfect benevolence, but through the common human history of exploitation and conflict as well as aspiration and achievement. But design is an intrinsically optimistic profession, and a more expressive medium is worth reaching for, and achievable through a collective professional dedication to the principles of design as a cultural practice.

The contribution of digital design to human culture goes beyond the usefulness of any particular application. Every designer who struggles to make a particular artifact more coherent and expressive is contributing to the collective project of expanding human understanding by inventing the medium.

DESIGN EXPLORATIONS: THE GAME MODEL OF INTERACTION

Recognizing the Conventions and Structure of Games

- Play a game (like bridge or charades) that involves closely coordinating your thoughts with a partner or teammates.
  - How well could your partner read your thoughts and intentions?
  - How well were you able to read your partner's thoughts and intentions?