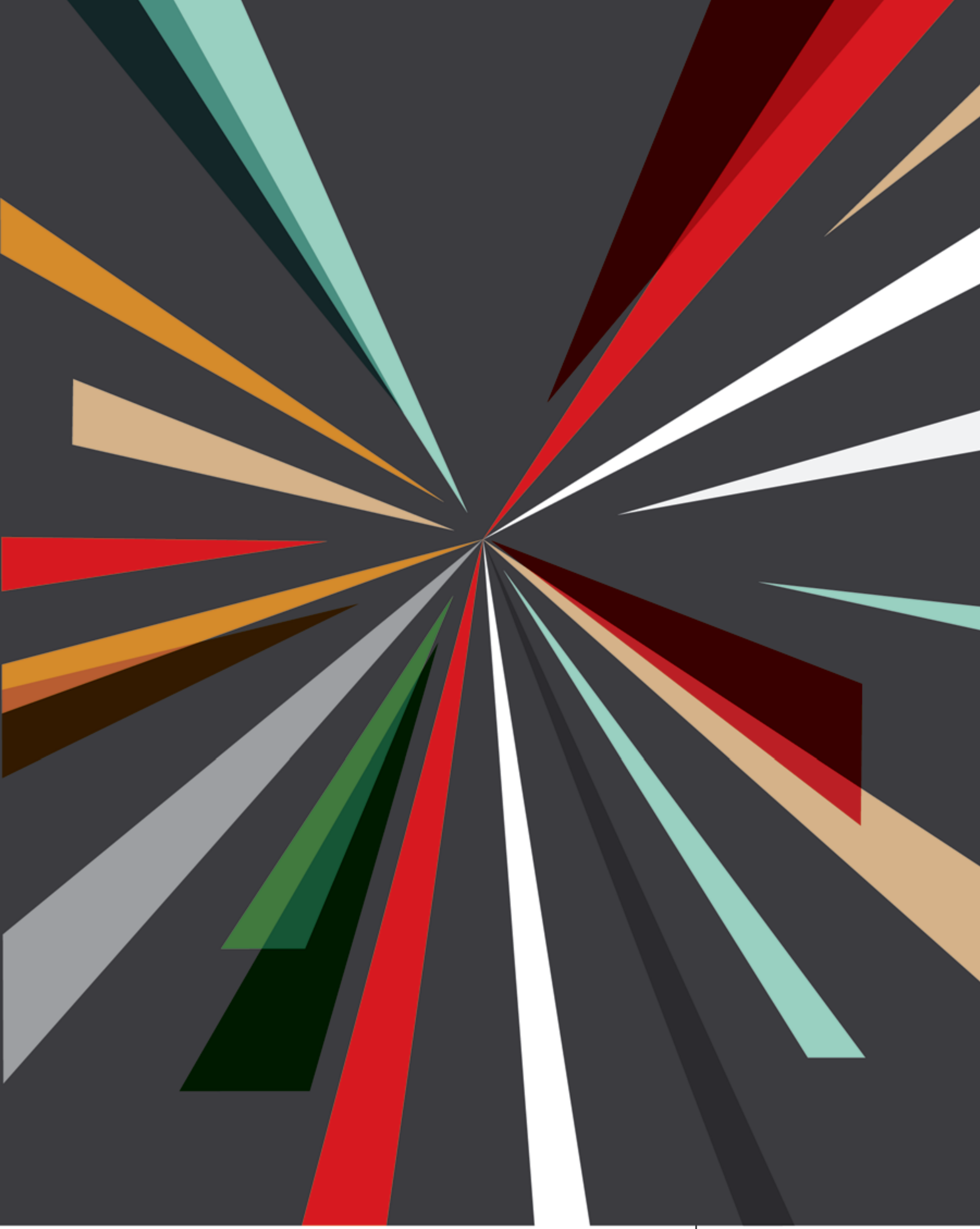

# MAKE IT SO

Interaction Design Lessons from Science Fiction

by NATHAN SHEDROFF & CHRISTOPHER NOESSEL

foreword by Bruce Sterling

Rosenfeld

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## INTERACTION DESIGN LESSONS FROM SCIENCE FICTION

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*Make It So: Interaction Design Lessons from Science Fiction*

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# DEDICATION

To my nieces, Aleksandra and Isabella, who have yet to see their first sci-fi. However, I have big plans for them and plenty of time to combat Barbie.

—Nathan Shedroff

To my nieces, nephews, and goddaughters: Hunter, Abby, Ava, Kaili, Andrea, Craig Jr., and Evan; and to my little, forthcoming boy (and any more to come). The vision of the future is increasingly in your hands.

—Chris Noessel

# HOW TO USE THIS BOOK

Being an interaction designer colors how you watch science fiction. Of course you're enjoying all of the hyperspacey, laser-flinging, computer-hacking action like everyone else, but you can't help but evaluate the interfaces when they appear. You are curious if they'll disable the tractor beam in time, but you also find yourself wondering, Could it *really* work that way? *Should* it work that way? How could it work better? And, of course, Can I get the interfaces I design in my own work to be this cool or even cooler?

We asked ourselves these questions with each new TV show and each new film we watched, and we realized that for every eye-roll-worthy moment of technological stupidity, there are genuine lessons to be learned—practical lessons to be drawn from the very public, almost outsider-art interfaces that appear in the more than 100 years of sci-fi cinema and television. Then we wondered what we would learn from looking at not just one or even a dozen of them but as many as we could.

This book is the result of that inquiry, an analysis of interfaces in sci-fi films and TV shows, with lessons that interface and interaction designers can use in their real-world practice. We've learned a great deal in writing it, and we want to share those lessons with you.

## Who Should Read This Book?

We have written this book principally for interface designers interested in learning best practices from sci-fi, understanding sci-fi's role in design history, and using sci-fi interfaces in their own work.

If you're a sci-fi fan with an interest in interface design, use this book to explore your favorite movies and TV shows more deeply and to discover new ones.

If you make sci-fi, you can learn how the interfaces you create are evaluated by audiences and influence real-world developers.

Similarly, individuals interested in media theory through the perspective of sci-fi can find insights here, though a more thorough and deep discussion of theory will have to wait for more research.

## What's in This Book?

To make the material easily accessible, we've organized the discussions in two sections: the first examines the elements of user interfaces in sci-fi, and the second looks at how these interfaces are used to assist basic human activities such as communication and learning.

Discussing interface elements first should make it clear where to find information, examples, and lessons pertaining to individual user interface components. These deal with inputs and outputs. Lots of examples can be found throughout sci-fi for each of these, but we've chosen some of the most interesting and unique.

The second section focuses on things people do. This content is organized around the flow of activities and the system interactions that support users' goals. There's even a chapter on sex-related systems, of which there are more than you might at first think, and which reveal some surprisingly applicable lessons to everyday, less titillating work.

All of the lessons and opportunities in the book have been gathered in an appendix for quick reference.

## What Comes with This Book

There is a lot of material in this book, but we've still only scratched the surface. Lou Rosenfeld has been generous in giving us so much space, but there is a lot that couldn't be included, some of which is available on the book's companion website, www.scifiinterfaces.com. There we'll be adding material as new films and TV series are released, a list of all of the titles we've reviewed so far, as well as links to where you can buy or rent titles, or watch clips. We're in the process of adding more detailed reviews of particular sci-fi interfaces, our extensive tag cloud, larger versions of the images used in the book, and more.

# FREQUENTLY ASKED QUESTIONS

## The topic of this book is a fun idea, but how is science fiction relevant to design?

Design and science fiction do much the same thing. Sci-fi uses characters in stories to describe a possible future. Similarly, the design process uses personas in scenarios to describe a possible interface. They're both fiction. Interfaces only become fact when a product ships. The main differences between the two come from the fact that design mainly proposes what it thinks is best, and sci-fi is mostly meant to entertain. But because sci-fi can envision technology farther out, largely freed from real-world constraints, design can look to it for inspiration and ideas about what can be done today. See Chapters 1 and 14.

## Do you distinguish between *science fiction* and *sci-fi*?

In a 1997 article, Harlan Ellison claimed the term "science fiction" for the genre of story that is concerned with science and "eternal questions," with an implied focus on literature.[1] We wanted to look at interfaces, and this led us quite often into that *other* category of story that he characterized as a "debasement" and "a simplistic, pulp-fiction view of the world" called "sci-fi." We don't entirely agree with his characterization, and it's true that we didn't look at literature for this project, so we don't make the same distinction. We just use *sci-fi* as an abbreviation for *science fiction* to save space. Hopefully Mr. Ellison won't be too mad.

## Where is [insert an example from sci-fi here]?

To misquote Douglas Adams: Sci-fi is big. Really big. We couldn't get to everything, and we didn't have the room to include everything we got to. Fortunately, many sci-fi examples build on very similar ideas. Sometimes we passed over one example in favor of another that might be more well known or, alternatively, we included an unsung one that deserved some credit. Most of what we've reviewed is sci-fi from the United States, but we've also ventured into sci-fi from other countries. Even given what we've managed to achieve, we've barely scratched the surface. You can find additional material on our website: www.scifiinterfaces.com.

1 Ellison, Harlan. (1997, April 7). Strangers in a strange land. *Newsweek*.

## Why didn't you talk about [insert interaction design principle here]?

The lessons are derived from sci-fi, not the other way around. If no example in the survey pointed us toward, say, Fitts's Law, then it doesn't appear, and some principles didn't make the final cut due to space constraints. Another style of investigation would have been to write a textbook on interaction or interface design using only examples from sci-fi, which would be interesting, but isn't this project.

## Wouldn't this have worked better as a movie or an ebook that can play video clips?

Because our lessons and commentary involve moments from movies and television, it's a little problematic to publish them in a medium that doesn't allow us to show these interfaces in action. But because our focus was on studying interfaces and deriving lessons, we've started with media that would work best for later reference: traditional book, ebook, and website. If you're eager to see some of these interfaces in action, certainly check out the original movies or TV shows, or come to one of the workshops and lectures we give on the subject, where we share relevant clips. And be assured that we're exploring alternative media for these lessons and ideas next.

## These interfaces weren't designed to be studied or for users in the real world. Aren't you being a little unfair?

Indeed, we are using real-world criteria for interfaces that aren't in the real world—the vast majority of which aren't meant to be. But as fans and designers, we can't help but bring a critical eye to bear on the sci-fi we watch, and with most of the world becoming more technologically savvy as time goes on, audiences will become so, too. But it's the "outsider" nature of these interfaces that make them fascinating to study, as their creators produce both blunders and inspired visions.

## What was the most interesting thing you discovered when writing the book?

We were surprised at how productive it was to investigate the "bad" interfaces. The "good" interfaces often serve as reminders of principles with which we are already familiar. Sometimes they are inspiring. But the "bad" interfaces, because they still worked at a narrative level, revealed the most surprising insights through the process of "apology," discussed in Chapter 1.

## What was left on the editing room floor?

One of our early ideas for the book was to include interviews with sci-fi makers and science practitioners. The interviews didn't make it into the final iteration of the book, but these people gave their time and shared much with us, and we'd like to acknowledge them individually with special thanks: Douglas Caldwell, Mark Coleran, Mike Fink, Neil Huxley, Dean Kamen, Joe Kosmo, David Lewindowsky, Jerry Miller, Michael Ryman, Rpin Suwannath, and Lee Weinstein.

Additionally, we had early draft chapters on sci-fi doors, chemical interfaces, weapons, and spacesuits/spaceships. Early reviews of the sheer size of the book forced us to make some hard choices. Perhaps in some future work we will be able to develop this content further, but for now it will have to wait.

## Why didn't you mention [insert title] more?

Several movies and TV shows are incredibly seminal and culturally influential. *Star Trek*, *Minority Report*, and *2001: A Space Odyssey* are three we can name off of the top of our heads. But we didn't want to lean too much on a small set of movies and shows. Rather, we wanted to use these examples for their most salient aspects, then branch out into other examples from the survey when the topic warranted.

## What about other speculative technology found in video games, futuristic commercials, or industry films?

The hard-core genre nerds know that conversations about defining *science fiction* often lead to conversations about *speculative fiction* instead, which is a much broader topic of interest to us, but isn't the focus of this project. Anyone interested in these related media should read Chapter 14.

# CONTENTS

# FOREWORD

## They Made It So

This book has accomplished a feat that's valuable and rare: it comprehends design and science fiction. Better yet, it's found specific areas where they are of practical use to one another.

This is a design book, and meant for designers. It concerns itself with science fiction cinema. To my delight, it does this in a deft, thoughtful, and sympathetic way.

*Make It So* never asks science fiction to be "scientific." More tactfully, it doesn't even ask that science fiction be "fictional." Instead, this book comprehends the benefits that science fiction can offer to designers. There aren't a lot, but there are some. Those benefits are all about making the unthinkable thinkable. "Cognitive estrangement," as we science fiction people call that in our trade.

*Make It So* teaches designers to use science fiction as a designer's mood board. It's science fiction as an estranging design tool, a conceptual approach, best suited for blue-sky brainstorming, for calling the everyday into question, and for making the exotic seem practical.

This approach allows designers to derive all kinds of exciting design benefits that science fiction never intended to bestow on designers.

How do the authors do it? With a classic, people-centered design approach. They look and they listen. They are at ease with the creators of science fiction cinema, because they can enter into their worldview.

Consider Georges Méliès, that silent-film maestro of cinema's earliest days, that French stage magician turned movie fantasist. For most of us, Méliès is a remote historical figure whose accented French name is hard to properly spell. He's of real, immediate use to Shedroff and Noessel.

Even us science fiction writers—(I write novels, by the way)—we rarely derive any coherent inspiration from our remote spiritual ancestor, Georges Méliès.

But Shedroff and Noessel are able to enter into the Méliès conceptual universe with all the attentive consideration that designers commonly grant to users. So the authors of this book can see that the best-known film of Georges Méliès, *A Trip to the Moon* (*Le voyage dans la lune*), has no interfaces.

That's the truth, of course—obviously a silent-film spaceship from 1902 has no interfaces, because the very concept of an "interface" didn't show up until the 1960s. However, it requires a design perspective to see past the frenetic razzle-dazzle on the silver screen and point that out. Méliès was a major media pioneer, and yet he was interfaceless.

Furthermore, this is an exciting and refreshing thing for a science fiction writer to read. Although Shedroff and Noessel don't intend to write their book for us science fiction creatives, I'd boldly say that they're every bit as useful to us as we could ever be to them.

Méliès had no interfaces. This startling realization blows the dust of the ages off of Méliès and conveys a new sheen to his time-dulled glamour and wonderment. As soon as I read this, I put the text of *Make It So* aside—(because, to tell the truth, I was reading the book on a screen)—and I sought out and watched the Méliès 1902 film on YouTube (on the same screen).

The authors are correct. Try it for yourself! The characters in this Méliès movie are inhabiting an attitude toward technology that's alien to us. Watch them go through their entirely mechanical design paradigm, all anvils and chalkboards. They have no push buttons, no rheostats, no dials, no screens, no return keys. They have no systematic abstraction of the forces that surround them, other than books and papers. They're on a sci-fi trip to the Moon to meet space aliens, and they might as well be paddling a steel canoe.

How mind-stretching that realization is.

Furthermore, Shedroff and Noessel gently suggest—(this book was written by designers, so they're very urbane, low key, and eager to be of service)—they suggest that, for an interface designer, the best way to look at a Méliès spaceship is as a potential way forward. Not a historical curiosity, a thing frozen on aging film like a fossil in amber, but a potential future for interface design. What a fascinating thing to say! What if the controls of future spacecraft were so natural, so intuitive, so invisible, that they were Méliès-like in their magical simplicity?

Why has no science fiction writer yet written this scene? Where is the science fiction set within a gesture-controlled, augmented, and ubiquitous environment? I've often wondered that—but I know that it's difficult to conceive, it's hard to sketch out as any workable scenario. It never occurred to me such a high-tech situation might have the look and feel of Méliès' fantasy movie: ritualized, formal, very gestural, everything tightly framed. It's a brilliant notion, though. It jolts that prospect from the remote to the immediate. Why, it's almost tangible.

People commonly expect science fiction to be predictive. Shedroff and Noessel, to their credit, avoid that mistake. I happen to believe that science fiction often is predictive: but so what? If you successfully predicted 1975 while you were writing in 1960, there's no reason why anyone nowadays would know or care about that. The works of science fiction that last are never accurate forecasts. They're compelling evocations—they're visionary grotesques, funhouse mirrors.

That funhouse mirror is never accurate, yet it doesn't merely deceive either—it always bears its human intent to inspire wonderment, its innate need to capture the imagination. Sci-fi, even at its most analytic and mechanical, is always haunted, allusive, and esoteric. Sci-fi is like a Rorschach blot the size of a house.

*Make It So* is like sci-fi film critique, but of a new kind: with kindly instructors equipped with a remote control and a freeze-frame. They deliberately break sci-fi cinema into its atomic design elements.

It's wonderful how they waste no time with any stereotypical sci-fi criticism—the characters, the plot, the so-called political implications. Legions of other critics are eager to get after that stuff, whereas Shedroff and Noessel have created a lucid, well-organized design textbook. I recommend this textbook for class work. I can't doubt for a moment that contemporary students would be illuminated and grateful.

Science fiction and design have a relationship: it's generally cordial, yet remote. Design cannot realize the fantasies of science fiction. Science fiction can't help design with all its many realistic problems. Design and science fiction were born in the same era, but they're not family: they're something like classmates. The two of them have different temperaments. Sometimes design is visionary and showy, and in sync with its classmate, sci-fi. At other times, design is properly concerned with its own issues of safety, utility, maintenance, and cost, areas where science fiction always stares moodily out the window.

But eras appear when the technological landscape changes quickly and radically, and design and science fiction are dragged along in tandem.

Interface design is one of those areas, and inhabiting one of those times. Science fiction is unlikely to be of great help in the task of giving form to a vase. However, interface design requires a certain mental habit of speculative abstraction. That isn't science fiction, but it's not so far as all that. "Interaction design" is quite similar to "interface design"—interaction designers are obsessed with boxes and arrows, not clay or foamcore. When design genuinely needs to be conceptual and abstract, science fiction can put a face on that. Science fiction can embody and literalize that, it can tell that story.

Somewhere over the horizon, beckoning at us, is "experience design."

This is something we associate with computer games and thrill rides and imaginary *Star Trek* holodecks, but it will likely have something to do with tomorrow's cloudy, post-cybernetic environments. When it comes to battling those obscure future phantoms, design and sci-fi are in a masked-wrestler tag-team match. It's us—an unlikely duo—against that, a futuristic prospect. We're gonna pin that phantom to its augmented, ubiquitous mat someday, but it's gonna take some sweat and bruises first.

It will take sweat, bruises, and also some intense blue-sky thinking. Some of that is already visible within modern big-budget sci-fi movies—*Minority Report*, *Iron Man*, they're full of pricey interface thrills, just as these authors will show you. But, increasingly and interestingly, a great deal of that necessary conceptual work will never appear in big movies, but in small-scale, atelier-like, design-centered videos. It will appear on this screen, not the big silver screen but this interactive, designed screen, the screen where I read this book, and where I saw that public-domain Méliès movie. This is no accident.

I like to call this small-scale, speculative work "design fiction." Design fiction is the deliberate use of diegetic prototypes to suspend disbelief about change. There's a lot of "diegetic prototyping" going on now, and that situation has come to exist, primarily, because of interface design. It is a consequence of interfaces built for the consumption and creation of what used to be called "text" and "film."

The movies, and television, as analog industries, as 20th-century commercial entities, would never have done that on their own. They would never have imagined the viral creation and global spread of speculative videos about futuristic products and services. This did not fit their business model. It was outside their paradigm.

Even science fiction writers didn't imagine that. But it's an area of great ferment: these attempts to employ digital media to convince people to transform conceptual things into real things. I see it every day. Interface design is powerful. It changed my life, and I expect it to transform my future life even more so. People who read this book will be better equipped to undertake that effort.

I never imagined that I would be reading a book like this, or that it would be this good.

—Bruce Sterling
Turin, Italy, May 2012

CHAPTER 1

# Learning Lessons from Science Fiction

Science fiction and interface design were made for each other. An interface is the primary way a sci-fi audience understands how the characters in stories use nifty, speculative technologies. And interface design (cautiously) loves to see fresh ideas about potential technologies unbound by real-world constraints writ large in the context of exciting stories.

This gives interfaces in the real world an interesting and evolving relationship with interfaces seen in sci-fi. With technology advancing quickly in the real world, sci-fi makers must continually invent more fantastic technologies with newer and more exciting interfaces. As audiences around the world become more technologically sophisticated, sci-fi makers must go to greater lengths to ensure that their interfaces are believable and engaging. And as users compare sci-fi to the interfaces they use every day, they're left to dream about the day when their technology, too, will become indistinguishable from magic.

But the relationship between the two is also an unfair one. Sci-fi can use smoke, mirrors, and computer-generated imagery to make things look incredibly exciting while ignoring practical constraints like plausibility, usability, cost, and supporting infrastructure. A sci-fi interface is rarely shown for more than a few seconds, but we use real-world interfaces, such as word-processing or spreadsheet software, for hours on end, year after year. Interfaces in the real world must serve users in an unforgiving marketplace, where lousy interfaces can quickly kill a product. But those same users might overlook a lousy interface in a great movie with no questions asked.

The relationship is also one of *reciprocal influence*. Every popular real-world interface adds to what audiences think of as "current" and challenges sci-fi interface makers to go even further. Additionally, as audiences become more technologically literate, they come to expect interfaces that are more believable. Sci-fi creators are required to pay more attention to the believability of these interfaces, otherwise audiences begin to doubt the "reality" created, and the story itself becomes less believable. This raises the stakes for sci-fi. Real-world interface designers are wise to understand this dynamic, because audience expectations can work the same way for their creations.

*Make It So: Interface Lessons from Science Fiction* investigates this relationship to find a practical answer to this question: What can real-world interface designers learn from the interfaces found in science fiction?

To begin to answer this question, we first need to define what we mean by "interface" and "science fiction."

## What Is an Interface?

The term *interface* can refer to a number of different things, even in the world of software. In this book, we use it specifically to mean *user interface* as it pertains to human–computer interaction. With most people's computer experience centering on mobile phones, laptop computers, and desktop computers, familiar examples would be the keyboards, mice, touch screens, audible feedback, and screen designs of these objects. We generally mean the same thing in sci-fi, though the inputs and outputs of speculative technology stray pretty quickly from these familiar references. For example, does a hologram or volumetric projection count as a screen? And where's the keyboard in a *Star Trek* tricorder?

A more abstract definition allows us to look at these fictional technologies and speak to the right parts. The working definition we're using to define an interface is "all parts of a thing that enable its use." This lets us confidently address the handle and single button of a lightsaber as the interface, while not having to address the glowing blade in the same breath. While researching this book, we've had this definition in mind.

This definition leads us to include some aspects of interfaces that we might not ordinarily consider in a more conventional, screen-and-mouse definition. For instance, the handle of a blaster is three-dimensional and doesn't do anything on its own, but if that's how you hold it, it's definitely part of the interface. This means that, over the course of our investigation, we may touch on issues of *industrial design*.

Similarly, we may run into problems with the organization of information that we see on sci-fi screens, which is part of what enables use. Does the character's screen make sense? Addressing this question means we may touch on issues of *information design*.

We may also need to look at the connection between the actions a character performs and the output they see—their intent and the outcome. Interactions over time are a critical element of the interface, and this requires us to evaluate the *interaction design*.

The "interface," then, is the combination of all of these aspects, though we try to focus on the most novel, fundamental, or important of them.

## Which Science Fiction?

Science fiction is a huge genre. It would take years and years to read, watch, and hear it all. Even before we had a chance to step back and study all we've taken in, there would be even more new material requiring our attention. (Oh, but for a Matrix-style uploader: "I know all of sci-fi!") Fortunately, looking specifically for interfaces in sci-fi reduces the number of candidates for this survey. The first way it does so is through the *media* of sci-fi.

For the purposes of this investigation, to evaluate an interface we have to *see and hear* it. This is so that we can understand what the user must take into account when trying to make sense of it. Literature and books often describe the most important parts of interfaces, but often fail to describe details, which each reader might imagine quite differently; this makes interfaces described in writing nearly impossible to evaluate. Take this description from H. G. Wells's *The Time Machine* (1895), for example:

> "This little affair," said the Time Traveller, resting his elbows upon the table and pressing his hands together above the apparatus, "is only a model. It is my plan for a machine to travel through time. You will notice that it looks singularly askew, and that there is an odd twinkling appearance about this bar, as though it was in some way unreal." He pointed to the part with his finger. "Also, here is one little white lever, and here is another."
>
> The Medical Man got up out of his chair and peered into the thing. "It's beautifully made," he said.
>
> "It took two years to make," retorted the Time Traveller. Then, when we had all imitated the action of the Medical Man, he said: "Now I want you clearly to understand that this lever, being pressed over, sends the machine gliding into the future, and this other reverses the motion. This saddle represents the seat of a time traveller. Presently I am going to press the lever, and off the machine will go. It will vanish, pass into future Time, and disappear. Have a good look at the thing. Look at the table, too, and satisfy yourselves that there is no trickery. I don't want to waste this model, and then be told I'm a quack."

Although this description of the interface is useful, it's incomplete. Are the levers in easy reach? Are they a meter long or a couple of millimeters? Do they press away from the Traveller, toward him, or parallel to his chest? How are they labeled? Are there forces in effect while time traveling that make the machine easier or harder to operate? The archetype that the reader imagines is probably sufficient for the purposes of the story, but to really evaluate and learn from it requires much more detail. For these reasons, we decided not to consider interfaces from written science fiction.

For similar reasons, we need to see the character's use of an interface *over time*. If we were to evaluate only still pictures, we might not know, for example, how information appears on a screen, or what sounds provide feedback, or whether a button is pressed momentarily or held in position. Comic books, concept art, and graphic novels sometimes supply this information, but unless their creators provide unusual levels of detail, the resolution is too crude and the interstices of time make it difficult to get a complete sense of how an interface is intended to work. Due to this complication, we have not considered comic books, graphic novels, or concept art either.

And finally, even with visual depictions across time, as in animation, the interface needs to remain *consistent* from scene to scene. Otherwise, we would have to interpret the intended interface (much like with written sci-fi) and risk conflicting, confusing conclusions. For this reason, we've mostly avoided hand-drawn, animated interfaces like those found in anime or *Futurama*. Of course, these problems can crop up in film and TV sci-fi, too, but for most 3D-animated or live-action interfaces, the depictions are consistent enough to evaluate them as single systems.

These three requirements—that the medium be audiovisual, time-based, and consistent—leave us with 3D-animated or live-action sci-fi for cinema and television. Sci-fi in these media give us candidate interfaces that we can examine for design lessons.

## What Counts?

A trickier question is, What counts as science fiction? Of course, some are obvious, such as tales of people racing spaceships between planets, shooting ray guns at villains, and making out with the comelier of the aliens. But what about the spy genre? From self-destructor bags to pen guns to remote-controlled Aston Martins, they certainly feature speculative technology. And what about steampunk fiction and superhero movies? Or slapstick comedy sci-fi like *Spaceballs*? Media properties in each of these genres contain all sorts of gadgets with interfaces that could bear some kind of examination.

These are good questions, but ultimately we've avoided the academic pursuit of defining science fiction and tried to remain purposefully agnostic. Generally speaking, if the Internet Movie Database (www.imdb.com) defines a movie or a TV show as science fiction, it has been up for consideration.

Occasionally we've looked outside of sci-fi, comparing interfaces for real-world systems, products, and prototypes with similar goals or functions, when it's relevant and space allows. We've also looked to speculative interfaces in notable industrial films from companies that posit new computing experiences. In this sense, it might be most accurate to say we're looking at *speculative fiction*, but because most people haven't heard this term, we use the common term *sci-fi* throughout the book.

We have watched and analyzed a great many sci-fi properties, but there is no way we could cover everything. We've tried to include the most notable and influential properties, both in the sense of influencing design as well as culture as a whole. However, it's likely we haven't yet covered something interesting or dear to all readers. The accompanying website to this book, www.scifiinterfaces.com, includes notes and more extensive analysis of many more properties than there is room for here. In addition, the website will serve as a place for ongoing updates and commentary on new properties after the publication of this book.

## Why Look to Fiction?

With a working category of sci-fi and having decided what to focus on, we next ask the question: Why look to fiction for design lessons at all? How can it inform our non-fictional, real-world design efforts?

One answer is that, whether we like it or not, the fictional technology seen in sci-fi sets audience expectations for what exciting things are coming next. A primary example is the *Star Trek* communicator, which set expectations about mobile telephony in the late 1960s, when the audience's paradigm was still a combination of walkie-talkie and the Princess phone tethered to a wall by its cord. Though its use is a little more walkie-talkie than telephone, it set the tone for futuristic mobile communications for viewers of prime-time television. Exactly 30 years later, Motorola released the first phone that consumers could flip open in the same way the *Enterprise*'s officers did (Figure 1.1). The connection was made even more apparent by the product's name: the StarTAC. The phone was a commercial success, arguably aided by the fact that audiences had been seeing it promoted in the form of *Star Trek* episodes and had been pretrained in its use for three decades. In effect, the market had been presold by sci-fi.

Another answer is that with media channels proliferating and specializing, common cultural references are becoming harder and harder to come by. Having common touchstones helps us remember design lessons and discuss ideas with each other. Sci-fi is a very popular genre, and the one in which speculative technology is seen most often. If you want to discuss an existing technology, you can reference a real-world interface. But to discuss future technologies, it's easier to reference a movie than to try to define it a priori: "Kinect is, you know, kind of like that interface from *Minority Report*, but for gaming."


FIGURE 1.1a,b
*Star Trek: The Original Series* (1966); the Motorola StarTAC (1996).

A last answer is that interface makers in the real world and in sci-fi are, essentially, doing the same thing—creating new interfaces. In this sense, all design is fiction—at least until it gets built or is made available to users and customers. When designers create anything that isn't the real, final product that ships, they're creating speculative interfaces—fictions. Each wireframe, scenario, pencil sketch, and screen mockup says, "Here's how it might be," or even "Here's how it ought to be." Designers for each domain ask similar questions: Is this understandable? What's the right control for this action? What would be awesome? Although they ultimately work with different audiences, budgets, media options, goals, and constraints, the work is fundamentally similar. Each can learn something from the other.

## The Database

Once we had a set of movies and TV properties to review (see the complete list online at www.scifiinterfaces.com), we watched and evaluated everything we could get our hands on. We entered screenshots and descriptions into a custom database, which formed the basis for our investigation. This database is also available on the website, where you can make your own contributions and see much of the content that could not fit into this book.

### Finding Design Lessons

Armed with this tool, we then identified what we could learn from the interfaces. There are four ways we go about this.

#### *Bottom Up*

To learn lessons from the bottom up, we investigated an individual interface in detail. To do this, we need an interface whose use we understand and that has sufficient screen time to allow us to analyze its inputs, compare these with its outputs, and evaluate what works for the user in accomplishing his or her goal. If it doesn't work, we may still be able to learn a lesson from a negative example. If it does work, we can compare it to any similar interfaces we find in the real world to see what might translate. The things that can translate are captured as lessons, and we can later look for other examples in the survey that support or refute it.

#### *Top Down*

To examine the survey from the top down, we tagged each description in the database with meaningful attributes. The example in Figure 1.2 shows a set of tags for the write-up on the wall-mounted videophone seen in *Metropolis*.


Description: Joh verifies that he's seeing the correct channel visually when he sees Grot's nervous pacing in camera view. Confident that he's calling the right place, Joh picks up a telephone handset from the device and reaches across to press a control on the right. In response, the lightbulbs on Grot's videophone begin to blink and, presumably (it's a silent film), make a sound.

Tags: analog, calling, communication, dial, dials, filmmetaphor, hangingup, hangup, messages, printedoutput, telephone, telephony, tickertape, tuning, turningoff, videophone, wallmounted, wristroll, wristtwist

**FIGURE 1.2a–c**
*Metropolis* (1927).

With the interfaces in the database tagged, we looked at the aggregated tag cloud to see what stood out. We then drilled down into the tags that appeared most often: *glow*, *screen*, *red*, *blue*, *video*, and *holography* (Figure 1.3). We then tried to explain why the tag appears so frequently, compared the interfaces similarly tagged, considered their commonalities and differences, and compared them with interfaces in the real world.


**FIGURE 1.3**
This tag cloud, created using tools at Wordle.net, illustrates the major top-down themes.

### *Chasing Similarities*

Another way to glean design lessons from the survey is to notice and pursue personally observed similarities between properties. For example, fans of gestural interfaces may have noticed similarities between the controlling gestures appearing in completely different movies and TV shows, from different writers and even different studios. What's going on here? Since there's not a gesture czar calling the shots, what's underneath these similarities? Are they coming from existing interfaces, common sense, or somewhere else? Investigating questions like these is something of a top-down approach, but it comes from pursuing particular questions rather than letting the questions emerge from the tags. (See Chapter 5 for some of our answers to these questions about gestural interfaces.)

### *Apologetics*

One of the most rewarding techniques is *apologetics* (we're borrowing the term from theology). When we found an interface that couldn't work the way it was shown, we looked for ways to "apologize" for it; that is, we thought of ways that the interface *could* work the way it was depicted. In a few cases, this led to some interesting insights about the way technology *should* work.

One example of this comes from *2001: A Space Odyssey*. From an Earth-orbiting space station, Dr. Floyd has a videophone conversation with his daughter back on Earth. During the scene, we see the young girl's hands mash on the keypad of the phone, but the call isn't interrupted (Figure 1.4). Although this may have been an oversight on the director's part, it is nonetheless the way the system *should* work. If the system knows that a child is using it and the button mashing is likely unintentional, it should disregard these inputs and not interrupt the call. Although this presumes sophisticated technology and an interface idea even the film's producers probably didn't think about, we can still use this principle even as we work with our real-world technology today.

FIGURE 1.4
*2001: A Space Odyssey* (1968).

This technique, more than any of the others, may have pragmatic readers scratching their head, and asking if sci-fi interface designers really put as much thought into their creations as we have in examining them.

It's entirely possible that they don't, that sci-fi interfaces are a product of pure inspiration, produced under tight deadlines with little time for research or careful reflection. But to be of use to us who *are* able to reflect on the interfaces we create, we have to examine them as if they were produced exactly as the designers intended them to be. It's a choice you have to make when writing critique, an issue referred to in literary circles as *authorial intent*. We chose to look at the interfaces without trying to reverse-engineer intent. If we didn't, we might get spun out on vicious cycles of second-guessing.

We used all of these techniques in the development of this material. The bottom-up approach provided many individual lessons. The top-down approach provided a reliable path through the vast amount of material we had to work with, and provided much of the structure of the book. Chasing similarities resulted in a few particular chapters, like Volumetric Projection (Chapter 4) and Gesture (Chapter 5). Apologetics resulted in the most satisfying results from the material, though, because we had to use what worked right from a narrative stance—a human stance—to arrive at new interaction design ideas. We couldn't count on finding these opportunities in sci-fi, since we had to wait to find "mistakes," but we could take advantage of them when we did.

## The Shape of a Lesson

When capturing lessons, our goal was to provide them in a useful format. We want them to be easily spotted as you read or skim through the material, so they are set off in green type. The titles of the lessons are written as unambiguous imperatives, so their intended lesson is clear. We've included a description in accessible language that calls out nuances, extends the examples, and describes when the lesson is applicable.

Sometimes, the analysis points to something that wasn't seen in the survey. These particular lessons are called out as Opportunities, but are otherwise similar in appearance.

Finally, we gathered together all of the lessons in an appendix at the back of the book so you can find a particular one more easily and consider them as a set.

## Finding Inspiration in Science Fiction

In the year 2000, Douglas Caldwell was successfully petitioned by his teenage son to see the film *X-Men*. Douglas wasn't really a fan of sci-fi, but wanted to spend time with his son, so he agreed to go. Watching the film, he was amazed to see a solution to a 2,000-year-old problem that he dealt with every day.

In a scene near the climax, the X-Men are gathered around a large display surface, which looks something like a circular, metallic tabletop. As Cyclops describes the mission they are about to undertake, the map changes shape, as if it was made of hundreds of tiny pins, each rising and falling to form the topography needed (Figure 1.5).

The reason this speculative technology was so important to Douglas was that he worked for the US Army Topographic Engineering Center. Part of his job was to create 3D maps and ship them to generals in the field, so they could study the theater of battle and consider tactics. These maps are called "sand tables" because they were originally created by generals thousands of years ago using actual trays of sand. Military leaders still do the same thing when they don't have a better map on hand (Figure 1.6).

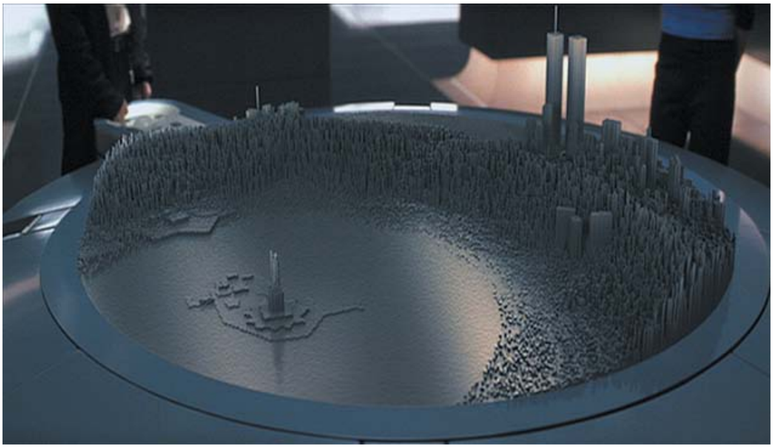


FIGURE 1.5
*X-Men* (2000).

FIGURE 1.6
President Lyndon Johnson consulting a sand table of Khe Sanh during the Vietnam War.

The main problems with modern 3D sand tables, while very accurate, are that they're expensive, static, somewhat delicate to transport, and useless if you guessed the wrong terrain.

The animated pin board Douglas saw in *X-Men* solved a number of these problems all at once. Such a table could depict the topography of any location in the world, at any scale, at any time, and a general would ideally only ever need one.

When he went back into work, he immediately wrote a request for proposal that referenced the scene in the film, so that military contractors would be inspired in the same way. One of the companies responding to the proposal, Xenovision, was awarded the development contract and, four years later, developed a working model: the Xenotran Mark II Dynamic Sand Table (Figure 1.7).

FIGURE 1.7
The Xenotran Mark II Dynamic Sand Table, with its top raised.

FIGURE 1.8
A still from a video showing the Xenotran Mark II Dynamic Sand Table with active topography and projected satellite imagery.

The Mark II independently moves small metal rods that, together, create a new surface, much like what is implied in *X-Men*. Alone, this solution closely matches the technology implied in the film. While in development, though, the team took the concept even further. They covered the pins with a thin, white rubber sheet and vacuum-sealed it to create a smooth surface across the pins. Then, they projected imagery onto the surface from above, creating topography in full relief, with up-to-date satellite imagery and overlays of data (Figure 1.8). All of it can change over time, to create realistic, animated surfaces, depict tsunamis traveling across the sea, or even show landscapes shifting over geologic time.

The main lesson from this story is that the technology might never have been developed if Douglas hadn't seen the film.

**LESSON** ***USE* SCIENCE FICTION**

Sci-fi, with its ability to present design fictions of speculative technologies with only narrative constraints, can do more than entertain us. It can inspire us with what's possible, what's ideal, and what would just be plain awesome. This book is meant to encourage you to look at sci-fi in the same way and come away inspired and ready to change the world.

## Let's Begin

Now that we have outlined our constraints, explained our intentions, and gotten the coordinates from the navicomputer, let's make the jump to light speed.

CHAPTER 2

# Mechanical Controls

Science fiction is always rooted in the present, and it almost always reflects contemporary paradigms. This phenomenon is no more apparent than when looking at the common mechanical controls used to interact with devices—mechanical interfaces. As we'll see, buttons, knobs, and switches have been a mainstay of interface controls, both in reality and in sci-fi, since the early days of sci-fi, and they still show up in interfaces today, despite the sophisticated mechanical and virtual controls now available. Partly this is due to history and legacy: digital controls, such as touch screens, require sophisticated technology that only recently has become available. But mostly it's due to the fact that our hands are facile, and tactile and mechanical controls make fine use of these aspects of our fingers and bodies. (Our feet can control pedals, too, when our hands are busy, but we don't see a lot of this in sci-fi.) Let's head back to the beginning and see what role these mechanical controls were playing in 1902.

## At First, Mechanical Controls Were Nowhere

In the first sci-fi film, *Le voyage dans la lune,* one detail that may be surprising to modern viewers is that it contains nothing that a modern audience would recognize as an interface. When the "astronomers" open the rocket door, they simply push on it—there's not even a handle (Figure 2.1). To launch the rocket, they load it, bullet style, into an oversized gun and shoot it at the moon. That there are no interfaces isn't really surprising, because this short movie is a vaudevillian comedy sketch put to film. But more to the point, when the film was released at the turn of the 20th century, very few interfaces existed in the modern sense. Audiences and filmmakers alike were working in an industrial age paradigm. The few controls that did exist in the world at this time were mechanical. People interacted with them using physical force, such as pulling a lever, pushing a button, or turning a knob.

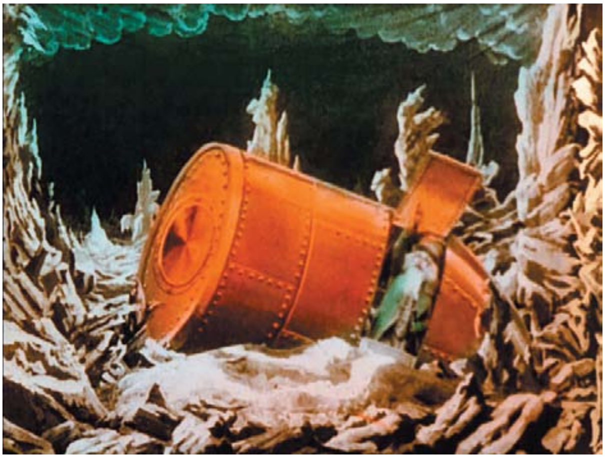


FIGURE 2.1
*Le voyage dans la lune* (1902, restoration of the hand-colored release).

### More Direct Than "Direct"

Industrial age users experienced direct, mechanical feedback in the interfaces they used. For instance, if they pushed a lever forward, the machine would translate that to mechanical motion elsewhere. There was little abstraction between cause and effect. With the dawn of computation, the feedback between cause and effect became abstracted in the circuits of the machine. Pressing a button could result in any of a practically infinite number of responses, or it might not result in anything at all. This abstraction continued through the development of the DOS prompt.

The development of the graphical user interface (GUI) returned some of the principles of the physical world to the experience of computing. For example, users could drag file icons representing data on a disk into a folder icon to move or copy it. Designers called the tight relationship between user actions and interface elements "direct manipulation," since it was more direct than typing commands via a text interface. Still, even with this physical metaphor, mechanical manipulations are much more direct than these "direct manipulations."

## Then They Were Everywhere

In the 1920s and 1930s, as the developed world moved into the electric age, buttons, switches, and knobs made their way into industrial machinery and consumer goods that people used every day. As a result, these mechanical controls began to appear everywhere in sci-fi, too. In one example, the control panel from the Lower City in the 1927 dystopian film *Metropolis* shows an interface crowded with electric outputs and controls (Figure 2.2). As we continue to trace interfaces throughout this section, note the continued dominance of mechanical controls like momentary buttons, sliders, and knobs.

FIGURE 2.2
*Metropolis* (1927).

FIGURE 2.3a–c
*Buck Rogers,* “Tragedy on Saturn” (c. 1939).

World War I played a role in shaping the physical appearance of sci-fi interfaces as well, as servicemen brought their experiences with military technology back home as consumers, audiences, and sci-fi makers. In the 1939 serial *Buck Rogers,* we see this in action. Buttons already inhabit the interface at this point, as in the “Tele-vi” wall viewer, controlled by just a few knobs, like televisions of the day (Figure 2.3a). When Captain Rankin and Professor Huer surmise that one of Killer Kane’s ships they’ve detected is being flown by Buck, they want to contact the ship. Instead of invoking audio functions right there at the screen, they move to an adjacent “radio room” where they can hail him (Figure 2.3b, c). To modern audiences this seems silly. Why aren’t these two capabilities located in the same spot? But the state of military technology at the time held that the radio room was a special place where this equipment was operated, even if it was set far apart from a periscope or other viewing device.

Sci-fi has long built its spacefaring notions by extending seafaring metaphors. (The word *astronaut* literally means “star sailor.”) By the 1940s and 1950s, sci-fi films like *Forbidden Planet* typically depicted its starship interfaces with large banks of mechanical controls of many types, such as those that sailors might have seen in the control rooms of great ships of World War II (Figure 2.4).

FIGURE 2.4
*Forbidden Planet* (1956).

**LESSON** **BUILD ON WHAT USERS ALREADY KNOW**

As the examples in *Metropolis* and *Buck Rogers* show, new interfaces are most understandable when they build on what users (and audiences) already know. If an interface is too foreign, it's easy for users to get lost trying to understand what the interface is or how it works. This is true of novice users and those who are not interested in technology for its own sake. It's also true for applications that are meant to be used intermittently or in a state of distraction.

Make the interface easier to learn by providing familiar cues to what its elements are and how they fit together. This could mean building on current interface conventions or controls that map to the physical world. Metaphors can also be a bridge to this kind of learning as they help form analogies for users to make connections between things they already know and new interface elements that confront them. But take care, because holding too closely to a metaphor can become pointless skeuomorphism[1] or confuse users when the interface's capabilities and metaphor diverge.

Often, the mechanical controls of early sci-fi seemed disconnected from displays and neatly ordered by type in rows as in the image from *Forbidden Planet.* In some cases, like the 1951 film *When Worlds Collide,* production designers imagined putting the controls around the displays, where the user's actions and the system's results would be more connected. In Figure 2.5, the V and F knobs control the spaceship's trajectory, seen on the display as white points along the red and green lines.

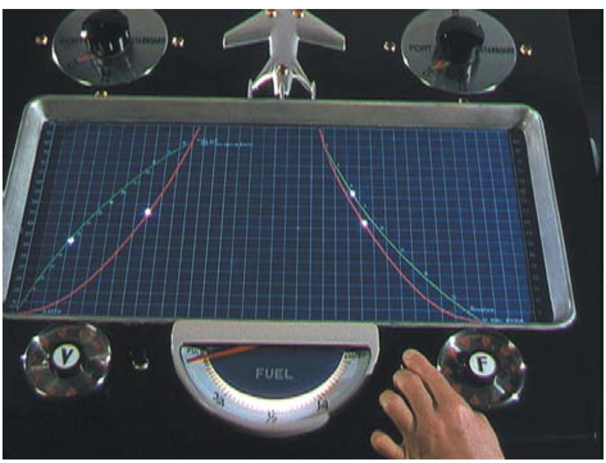



**FIGURE 2.5**
***When Worlds Collide* (1951).**

1 Objects that retain a decorative appearance from previous technological solutions despite no longer being required.

In *Buck Rogers*, the two parts of the communication interface are in separate rooms. If Professor Huer wanted to tell Buck how to level his spaceship, the professor would have to run to the radio room to provide spoken instructions, or input, and back to the Tele-vi to check on Buck's progress, the output (see Figure 2.3b, c). Where the *Buck Rogers* scenario requires far too much work to be considered an efficient feedback loop, the navigation interface from *When Worlds Collide* is much tighter, with its controls abutting the output screen and fuel gauge, making much less work for its navigator. Imagine the disaster if the *V* and *F* controls were in the next room.

**LESSON TIGHTEN FEEDBACK LOOPS**

Interaction designers call the cycle between input and output while optimizing toward some desired state a *feedback loop*. The faster and more fluid these loops are, the more a user can get into the flow of use and concentrate on managing the system to the desired state. Even when the controls in question are all on screen rather than mechanical, the more that a designer can do to tighten these loops, the more effective the user's interaction will be.

This period also saw early sci-fi endeavors to depict the future with a dedicated realism. For example, *Destination Moon* made an earnest attempt to describe a trip to the moon with real science and plot, 19 years before the Apollo 11 mission would launch. Renowned science fiction author Robert Heinlein acted as contributor and technical advisor to the film. Unlike competing films of the era, which simply crammed as many buttons, switches, and knobs as possible onto the set to make them look sophisticated, *Destination Moon* portrayed a more serious and believable story through its constrained interfaces of more-considered controls and displays (Figure 2.6). These suggested a thoughtful reality behind them, even though at the time they were still entirely fictional. They were designed *as if* they could be real, not unlike a real prototype of a spaceship might be.

FIGURE 2.6
*Destination Moon* (1950).

FIGURE 2.7
*Design for Dreaming* (1956).

By the 1950s, buttons, switches, and knobs were seen as a panacea to life's drudgeries. A delightful example of this appears in General Motors' 1956 production of its annual touring auto show Motorama. It was one of the first examples of a corporation creating speculative fiction to promote its brand (and although not technically sci-fi, illustrative enough to bear mention here). It included the wonderfully melodramatic industrial film *Design for Dreaming*, in which a near-future housewife prepares a meal while dancing around her Frigidaire kitchen of the future (Figure 2.7). All of her once-dreary tasks, such as baking a cake, carrying dishes, and cleaning up, were accomplished simply by pushing buttons.

Between the 1950s and 1980s, the trend for mechanical controls continued, despite a few new interface paradigms appearing. There were voice interfaces on robots, like Gort in *The Day the Earth Stood Still* (1951), and Twiki with Dr. Theopolis from the 1979 TV series *Buck Rogers in the 25th Century*, as well as artificial intelligences like the ship computers in *Star Trek* and *2001*: *A Space Odyssey*. There was also a gestural interface in *The Day the Earth Stood Still*. (See Chapters 5 and 6 on gestural and sonic interfaces for more on these topics.) These alternative interfaces were in the minority, though, until some budget constraints introduced a new paradigm.

## For a While, Mechanical Controls Started Disappearing

When *Star Trek: The Next Generation* was green-lighted for production in the mid-1980s, the budget didn't allow for the same kind of jewel-like buttons as in the original series (Figure 2.8a). The money for so many buttons, individually installed and lit, simply wasn't available. Instead, production designer Michael Okuda and his staff devised an elegant and much less

FIGURE 2.8a,b
*Star Trek: The Original Series* (1968); *Star Trek: The Next Generation* (1987) LCARS interface.

expensive solution—vast backlit panels of plastic film with simply printed graphics representing controls (Figure 2.8b). The result was thoughtfully futuristic as well as cost-effective, and the result inadvertently launched a new paradigm in interfaces that we see throughout the sci-fi genre today, in which controls exist only as a flat touch-screen surface. In *Star Trek,* this interface is known as LCARS (Library Computer Access and Retrieval System). Though the characters never use this term in the shows or films, it has appeared in some of the on-screen interfaces. (We'll discuss it in detail in the next chapter as a case study in visual design.)

Setting the stage for Okuda's solution were new, experimental interfaces that had been developing between the first and second *Star Trek* series. One example is the Aesthedes computer, a graphics workstation produced by the Dutch company Claessens in 1982 (Figure 2.9). The computer's functions were arrayed across a seamless tabletop surface, with each function given a separate button, arranged in logical groups. This made it wide enough to be a literal desktop of controls. Like the LCARS interface, these buttons had almost no depth. Instead, they were part of a seamless membrane that stretched over the entire surface, printed with labels and borders, with simple contact sensors positioned underneath. They were a transitional technology, still mechanical but very different than the kinds of buttons seen and used before. They represented a half step toward interfaces like LCARS, but, unlike LCARS, they weren't changeable, since they weren't also a display. This style of mechanical interface, on the border between mechanical and virtual, didn't catch on, but during this time of experimentation, it was an option very much like what was explored in *Star Trek: The Next Generation*.


FIGURE 2.9
Aesthedes computer (c. 1982).

## Less Is More *and* Less

Are fewer controls with more modes better than more controls with fewer modes? In the *Star Trek* and Aesthedes examples (see Figures 2.8 and 2.9), each button controls only one function (as best as we can tell from studying the use of the fictional *Star Trek* interfaces). Contrast that with contemporary computer systems in which controls perform multiple duties. The A key on your keyboard, for example, can mean the letter *a* or Select All or å, and so on.

These examples raise similar questions with displays. Are fewer displays with more modes better than more displays with fewer modes? *Star Trek* shows different kinds of information and different views of the same information on a few screens, but the Aesthedes had multiple screens dedicated to different types of information.

The tension between ease-of-use and control is a central element in interaction design. It isn't clear whether there is a one-size-fits-all approach, but one best practice is to let the user's experience with the interface be a first determining factor. For users who are untrained or use an interface only occasionally, you can ease their learning curve and reduce the burden on their short-term memory by providing more controls with clear labeling and fewer modes. For expert users, you can increase their speed and efficiency by providing fewer controls with easily accessible and memorable modes.

These issues are compounded by the design constraint of cost. For example, the LCARS interface with its large, backlit control panels was created for *Star Trek: The Next Generation* because the budget didn't allow for banks of mechanical switches as in the original *Star Trek* series. And the Aesthedes couldn't compete with the much less expensive IBM PC XT with its fewer component parts. Designers working on the industrial design of their products need to balance this constraint with those of usability and learnability.

## Now They Coexist with Other Interfaces

We see that even in modern sci-fi with advanced digital controls, mechanical controls are still present. In the reboot of *Star Trek* the interfaces on the *Enterprise* use a blend of touch-screen surfaces and mechanical controls. The throttle for the helm is mechanical and familiar for the audience, who has experienced or seen similar controls on ships and airplanes (Figure 2.10).

One of the benefits of mechanical controls is that, unlike touch-screen controls, they can be well-designed for our entire hands rather than just the fingertips, offering ergonomic shapes and rich haptic feedback. Additionally, mechanical controls can take advantage of a user's finer motor control and offer industrial design that telegraphs to the user how it can be used. For example, the shape of a button or knob might better communicate optimal position or the amount of force to be used. The diameter of a knob can make fine control easier or more difficult, depending on the exertion needed for fingers or hands to move it. This not only increases control and comfort, making some actions easier but also communicating function through the physical form, itself, the property that interaction designers call "affordance."

**LESSON** **USE MECHANICAL CONTROLS WHEN FINE MOTOR CONTROL IS NEEDED**

Mechanical controls are more appropriate when fine motor control is needed. It's not that screen controls can't accept fine movement, but, as many users find with their trackpads, touch interfaces are often so sensitive to movement that holding a specific position is difficult. For example, taking your fingers off of a knob doesn't change its position, but it can change a sensitive touch-screen control, even if that isn't the intent (as can touching it again). Users can "have their finger on the button" without actually depressing it, but on-screen buttons can be unintentionally or prematurely activated in this way.

FIGURE 2.10
*Star Trek* (2009).

**LESSON** **DON'T GET CAUGHT UP IN THE NEW FOR ITS OWN SAKE**

Even with new advances in natural gesture technologies, such as Microsoft's Kinect, there is comfort and ease in mechanical controls for some operations. Take typing for example. It's terrible with the Kinect, OK with a controller, and much better with a physical keyboard that has been optimized for this purpose. Voice control may make even keyboards obsolete, but they have their own limitations.

Screen-based controls can mimic some of what mechanical controls have always offered, like a satisfying click when turned to the desired position, or alignment between several buttons to indicate common settings. And screen-based controls can do many more things than mechanical controls, such as incorporating animation, appearing only when needed, or changing entirely based on context. Finding the right control for the job is why even the most advanced smartphones still have a few mechanical buttons for controls like Volume, Home, and Power.

Just as in real design and engineering, the presence of mechanical controls followed trends pertaining to material costs and scarcity. At one time, buttons and other components were relatively inexpensive due to their materials and manufacturing processes, so they abounded in both real and fictional interfaces. When the sheer number of controls and their expense (both for materials, installation, and maintenance) rose, however, they began to be used more sparingly. We see this today as touch-screen interfaces are able to incorporate many functions with no added cost, so many mechanical controls are disappearing. In addition, too many undifferentiated buttons can breed confusion, and overload for audiences and users alike.

For example, we see this in the lineage of *Star Trek* interfaces. The original series used many, individually lit buttons, often positioned in rows circling the user (which is more complicated than rectilinear rows). But when the production budget available for the next series, *Star Trek: The Next Generation*, didn't go as far, that was no longer an option. Instead, the mechanical buttons disappeared almost entirely from control interfaces, in lieu of flat-panel touch screens. This persisted throughout the following TV series and many of the films, until the latest film, *Star Trek*, created a rebooted aesthetic based on a complement of mechanical and touch-screen interfaces.

FIGURE 2.11
*Star Trek: Insurrection* (1998).

Be warned, though, that hybrid controls can still seem out of place or even laughable. A funny example comes from the climactic sequence at the end of *Star Trek: Insurrection*. After an entire film of *Star Trek's* signature touch-screen (LCARS) interfaces for controlling nearly everything that happens on the ship, Commander Riker calls for the "manual weapons interface," and a 1990s-era joystick pops up from a console designed specifically for this one purpose (Figure 2.11). It isn't that this is a worse interface for this use—indeed, it may actually be better. The joke is that everything in the film leading up to this, including flying the ship and shooting weapons, never used such an interface. If it was a useful and even better weapons control, why wouldn't it have been the used in battles before this moment in the story?

**LESSON MIX MECHANICAL AND OTHER CONTROLS WHERE APPROPRIATE**

Mechanical controls are better for some uses, though they can't as easily serve multiple functions. Nonmechanical controls, like touch-screen buttons, are easier to change into other controls but don't offer the same kind of haptic feedback, making them impossible to identify without looking at them and creating questions about whether they've been actuated. Design interfaces with an appropriate combination that best fits the various uses and characteristics.

## Mechanical Controls Are Used to Evoke Moods

Sci-fi can use mechanical controls to evoke moods. For example, the use of almost exclusively mechanical controls can help to establish a steampunk or alternate-history feeling. In the film *Brazil,* a patchwork of elements from many eras grafted onto each other references the hazards of an overly authoritarian, anonymous, and hyper-administrative future (Figure 2.12). Any comfort that the audience might find in familiar controls only underscores the nightmare of a dystopian information age.

FIGURE 2.12
*Brazil* (1985).

**LESSON** **GESTALT IS IMPORTANT TO USERS**

The interface seen in *Brazil* doesn't look ready for use (see Figure 2.12). It looks haphazard, thrown together, and prototypical. It looks like it would be hard to figure out and easy to break. Director Terry Gilliam was imparting a sense of dystopia throughout the film, so we can take this computer interface to underscore what should not be done for real-world systems. System interfaces that are instead cohesive and look whole, complete, and considered inspire confidence in users and reduce anxiety.

## Mechanical Controls: Will We Come Full Circle?

Not only do mechanical controls and virtual ones coexist today, both in sci-fi and real-world interfaces, but they are likely to in the future as well. This is because each offers benefits that are important to our use of systems. Our hands still have physical characteristics that make touch, hand position, and fine motor control a better interface for those tasks that benefit from them. In addition, many complicated interfaces now must fit into small displays, such as on tablets and phones. As such, they must change elements within the screens in order to show all controls in these small spaces. This means that mechanical buttons can't be used for all controls since their type and orientation may not fit the next screen of controls. This coexistence isn't surprising, but it will require interface designers to understand and determine when each serves the best purpose and how best to put them all together.

The recent popularization of gestural interfaces and voice controls hint at a future where computer systems watch and listen to us for their inputs instead of our poking or prodding at them. Though these technologies are crude and inaccurate at the moment, as they mature and become more ubiquitous and precise, will the need for mechanical controls disappear? Will we return once again to a world like the magical one envisioned by the filmmaker Georges Méliès in *Le voyage dans la lune* at the dawn of cinema, when to open a spaceship we would just push at its door?

CHAPTER 3

# Visual Interfaces

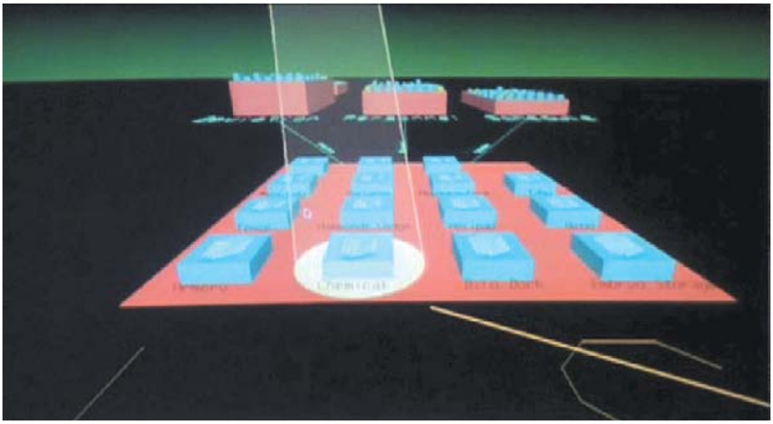


FIGURE 3.1
*Jurassic Park* (1993).

Most fans of the film Jurassic Park remember the tense scene in which two fearsome velociraptors chase the park's remaining visitors into a computer lab, and while the two adults desperately try to barricade the door, the two children rush to a computer terminal. The young girl, Lex, looks at the screen and proclaims, "It's a UNIX system. I know this." It's a memorable geek moment (Figure 3.1).

Lex then searches for the lab building controls so she can activate the door locks to keep the velociraptors out. (Let's not inquire, for the moment, why the doors themselves don't have lock controls on or near them.) As she uses the workstation, we see a spatial user interface at work—an actual Silicon Graphics product from the time the film was made, known as 3D File System Navigator.

As the camera cuts back and forth between the kids at the computer and the adults blocking the door, the filmmakers are careful to show Lex's hand as she uses the mouse. Although it wouldn't be necessary today, back in 1993 many audience members would not have been familiar with a graphical user interface (GUI) with a windowing system and mouse.

There's an odd moment, however, as Lex navigates spatially to the block that represents the lab so she can click on it to access the controls. At first, it's a small block on the horizon, and it only shifts forward slowly as the 3D map is redrawn (Figure 3.2). Once the desired block is in the center of the screen, Lex clicks on it to access its controls. The music swells to increase the tension—will she make it in time before the dinosaurs break in?

But if she can see the block on the screen when it's on the "horizon," can't she simply click on it and activate the locks immediately? Why must she (and the audience) wait until it comes closer to the center of the screen and becomes a bigger target?

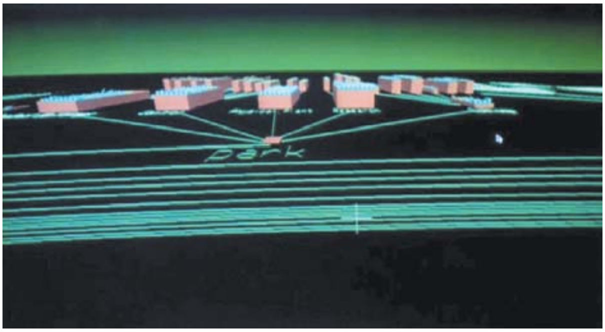



FIGURE 3.2
*Jurassic Park* (1993).

The answer is that it doesn't—or shouldn't—except that the director and writer needed to create tension in the scene, and this was a novel way to do so. The film sacrifices credibility in order to generate this tension, because, in real life, an interface like this should be quick and easy to use.

A *spatial metaphor* is a sensible way to organize locational data. It can even be useful in situations in which the data isn't geographic (think of a spatial map of the body or of an automobile). While the use of a 3D spatial file system in *Jurassic Park* highlights an example of how great ideas in interfaces can become misused in films and television to serve the narrative, the more important point is that the novel visual style of the interface was purposely selected for its futuristic look. The director and designers weren't content with a standard visual interface of the time, such as a floating window with buttons arranged inside. That would not believably establish that the organization was technologically advanced enough to grow dinosaurs from scraps of ancient DNA.

**LESSON THE VISUAL DESIGN IS A FUNDAMENTAL PART OF THE INTERFACE**

Interaction designers are used to thinking in terms of goals and users navigating complex systems to achieve those goals. The appearance of a system can be relegated to secondary importance. But the visual design shapes the user's impression of the system—how it compares to competing systems, its desirability, and even how capable and usable it is.[1] Designers ignore appearance at their—and their users'—peril.

1 Kurosu, M., & Kashimura, K. (1995). Apparent usability vs. inherent usability: Experimental analysis on the determinants of the apparent usability. In J. Miller, I. R. Katz, R. L. Mack & l. Marks (Eds.), *CHI '95 conference companion on human factors in computing systems: Mosaic of creativity* (pp. 292–293). New York: ACM.

## What Counts?

Television and film are visual and auditory media. Cataloging every visual element or style throughout sci-fi would take much more space than we've got, so, for brevity, we have limited the elements to the use of graphics and text to convey information and controls.

## Text-Based Interfaces

The visual design of computer interfaces began simply: with text on screens and little else.

### Command-Line Interfaces

Early computer interfaces displayed input prompts, commands, responses, and system status as text. The earliest stored-program computers, such as ENIAC, printed their output on paper punch cards for the programmers to read. Later, time-share systems, which used remote teletype terminals to communicate, typed system status and commands on text-based paper rolls. When cathode ray tubes (CRTs) became more feasible, screens became the primary display technology. All of these were command-line interfaces (CLIs), and CRTs signaled the rapid expansion of computers into all aspects of work. Hollywood wouldn't catch up to show CLIs on its screens for a few decades, by which time the style of these interfaces was firmly established in the real world.

Beginning in the 1950s, the typography of command-line interfaces was bitmapped and almost always fixed-width capital letters. Although as of the early 1960s ASCII encoding included lowercase letters, many implementations on popular platforms of the time, like CDC (Control Data Corporation) and DEC (Digital Equipment Corporation), didn't allow for the use of lowercase characters. These screens resembled the output of cheap typewriters with a stuck shift key more than the professional typesetting used in publishing at the time.

Though all-text output had been seen in some prior films like *Logan's Run* (1976), the first mainstream CLI in the survey appeared in the 1979 movie *Alien*, as Captain Dallas communicates to the ship's control system, named Mother. Mother's menace is underscored by her inhuman quiet and emotionlessness (Figure 3.3). This interface embodies the look of computer systems three decades old at the time, but it established a style that could be seen for decades to come.

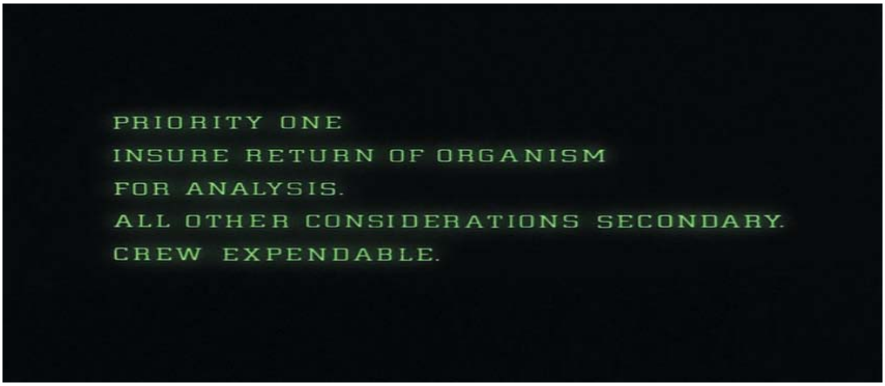



FIGURE 3.3
*Alien* (1979).


FIGURE 3.4a,b
*War Games* (1983); *Brainstorm* (1983).

Since the advent of advanced GUIs with more refined typographic details that better resembled the typography in print, these crude bitmapped and fixed-pitch typefaces (and, to some degree, command-line interfaces in general) are used to denote either an older system or a character's having deep access to a system. Gone, too, are the common use of all capital letters and the limited number of glyphs available in early computer typefaces. Now this style serves to bring to mind a very particular date and time, as seen in the examples from *War Games* and *Brainstorm* (Figure 3.4).

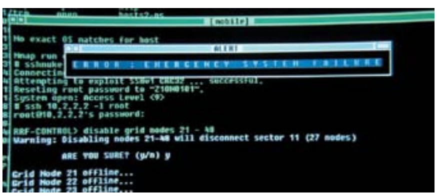
**LESSON** **USE ALL CAPITAL LETTERS AND A FIXED-WIDTH TYPEFACE TO EVOKE THE LOOK OF EARLY COMPUTER INTERFACES**

Nothing ages an interface like all capital letters, lots of numbers, little punctuation, and no accents. In addition, the more bitmapped the type is, the older it looks, reflecting a time when screen resolutions were low and computer typefaces were pixel-based instead of constructed from outlines.

## LESSON OTHERWISE, AVOID ALL CAPS

Because people first read word shape rather than the individual letters in each word, fixed-pitch typefaces and, even worse, text in all capitals are more difficult to read. The variations in letter rhythm and shape make words distinctive and help us to identify them quickly. But it's still a part of our collective visual language to see this as less sophisticated typography and identify it as more serious and aimed at high-functioning experts, even if it's much slower to read.

Once established, command-line interfaces were the dominant interface for nearly 50 years and still haven't gone away entirely, in part because this is how most programmers learned to program, and in part because it's often faster and more efficient to code in text-based interfaces—since code *is* text. Although 2D GUIs have risen in prevalence since the 1980s, we still see command-line interfaces in sci-fi. For the most part, directors, writers, and designers today use command-line interfaces when they want to communicate one of two things: that a system is older, or that a user has sophisticated computer skills. Sometimes a character with technical expertise will drop into a command-line interface in a window of a more sophisticated graphical interface for just this reason. One such example occurs in *The Matrix Reloaded*, when Trinity breaks into the power utility's control center. Despite the many more-sophisticated graphical interfaces available, in order to defeat the security system and shut down the city's power grid, she drops into a command-line interface to conduct her sabotage (Figure 3.5).





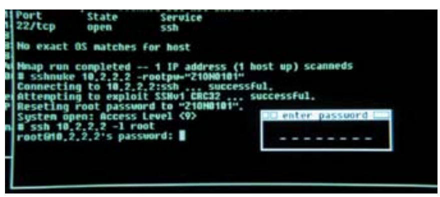



**FIGURE 3.5a–c**
*The Matrix Reloaded* (2003).

```
    <script src="/ui/script/rm-base.js?t=071012-1400"></script>
    <script src="/ui/script/section-homepage2.js?t=071012-1400"></script>
<script src="http://use.typekit.com/ntv1fpz.js"></script>
<script>try{Typekit.load();}catch(e){}</script>
    <link rel="Shortcut Icon" type="image/ico" href="http://www.rosenfeldmedia.com/favicon
    <link rel="alternate" type="application/rss+xml" title="RSS" href="http://feeds.rosenf
</head>
<body id="rosenfeldmedia-com" class="section-home layout-content with-sidebar" data-curren
<div id="accessibility">
    <a href="#main-nav">Skip to Navigation</a> |
    <a href="#content-area">Skip to Content</a>
</div>
<div id="container"><div class="c">
    <header>
        <div class="account-bar style-paper"><div class="wrap">
            <ul>
                <li class="total"><a href="/checkout/cart.php">Your cart is empty</a></li>
                <li><a href="/checkout/login.php">Login</a></li>
                <li class="last"><a href="/contact/">Contact</a></li>
            </ul>
        </div></div><!-- /account-bar -->
        <div class="banner"><div class="wrap">
            <div class="logo-type">
                <a href="/"><span>Rosenfeld Media</span></a>
            </div>
```

**FIGURE 3.6**
**Adobe Dreamweaver CS6 code interface.**

Despite the technical sophistication they convey, command-lines interfaces can be difficult to parse and scan to find a specific line or command, especially when everything looks the same. This is where real systems have excelled past fictional ones. Coding interfaces such as Adobe's Dreamweaver apply color to HTML code to make it easier to parse (Figure 3.6). Tags are blue. Links are green. Functions are purple. Different coding environments use different color schemes, but it's a rare system that doesn't help break up the "wall of code" with color. We only see hints of this in sci-fi, probably because the interfaces are there to embody plot, rather than be used.

### LESSON HELP EXPERTS DISPLAY THEIR MASTERY

These kinds of "Wow, they're good!" moments work because the interface looks to the novice overfull, undifferentiated, and complex, while the hacker works through it at breakneck speed. Real-world experts enjoy the same social cache when they have mastered a tool that appears dauntingly complex to a novice. The expert is rewarded with respect in these moments, and the need for the services of the expert is reinforced. To ensure that these moments can happen, designers need to include ways for the expert's mastery to be seen and appreciated—without being too understandable.

## Graphical User Interfaces

Interfaces that move beyond the command line are considered graphic user interfaces, or GUI. These include those with WIMP interface elements (windows, icons, menus, pointing devices) as well as those with shadows, refined typography, layering, and graphic controls such as buttons. Because there are so many GUIs to consider, this section looks at these interfaces by component.

### Typography

We reviewed the main typefaces for each property in the survey. This wasn't always easy, as typefaces aren't always identifiable, even with the help of resources like Identifont.com, and it's often tough to identify which might be the main typefaces of several used. With those caveats, here's what we found.

Typographers may not be surprised to learn that sans serif is the overwhelming typeface choice for sci-fi, with serifed typefaces appearing in only a handful of interfaces. In the current survey of movies and TV shows, only seven serif typefaces were found: *Alien* (see Figure 3.3 above), *Blade Runner*, *Galaxy Quest*, *Gattaca*, *The Matrix*, *Men in Black*, and *Star Trek: The Original Series* (Figure 3.7). Note that in *Star Trek* and *Blade Runner*, all interfaces other than the one pictured here use sans serif type. Only *Gattaca* uses serif typefaces throughout. With that in mind, the ratio between sans serif and serif typefaces might be closer to 100:1.

FIGURE 3.7a–e
*Star Trek: The Original Series* (1968); *Gattaca* (1997); *Blade Runner* (1982); *Until the End of the World* (1991); *The Matrix* (1999).

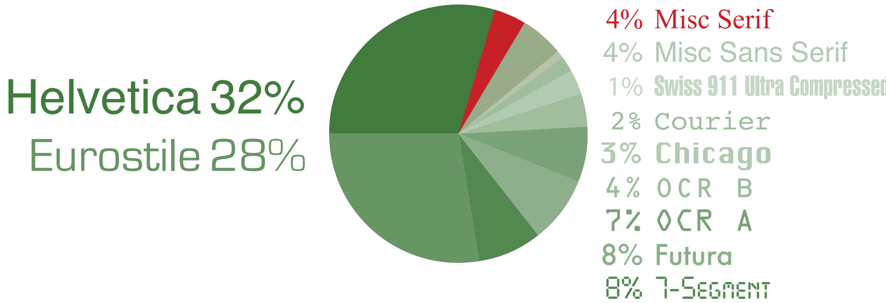




**FIGURE 3.8**
**The typefaces seen in the survey are overwhelmingly sans serif.**

When we could identify specific typefaces, the majority were either Helvetica (or a derivative like Arial) or modular typefaces like Eurostile or Microgramma. The next third divides between Futura, OCR A, and LED-type faces. OCR B, Chicago, and Courier appeared in more than one property. Swiss 911 Ultra Compressed, the typeface used in the *Star Trek* LCARS interface, is underrepresented here because we counted it as a single property. Based on screen time, this one typeface might well eclipse all of the others. After counting typefaces per property, we get the results shown in Figure 3.8.

**LESSON SANS SERIF IS THE TYPEFACE CHOICE OF THE FUTURE**

Given the propensity of sci-fi to use sans serif typefaces, designers working on projects meant to have a futuristic or sci-fi feel choose sans serif typefaces. If designers wish to build directly on the cache of sci-fi, Helvetica and Eurostile are strong candidates that viewers are accustomed to seeing.

Typography in interfaces largely conforms to standards of the real-world systems being mimicked, with one primary exception. Cinematic interfaces must be read by audiences much more quickly than their real-world equivalents, and the visual hierarchy often becomes much more exaggerated to draw attention to the aspects of the interface that are important to the plot (Figure 3.9). In a few cases, this makes sense in the real world if the system is truly critical or built for true novices, but in systems built for expert users we would not expect the overly large text labels.

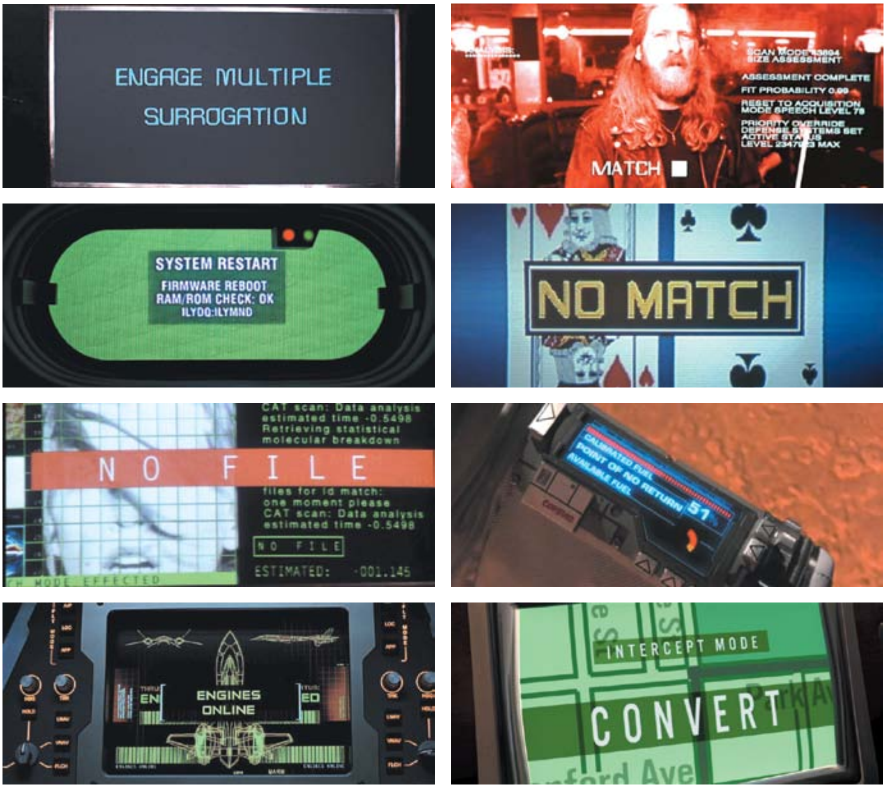




FIGURE 3.9a–i
*Logan's Run* (1976); *Terminator 2: Judgment Day* (1991); *Independence Day* (1996); *Starship Troopers* (1997); *The Fifth Element* (1997); *Mission to Mars* (2000); *X2* (2003); *The Incredibles* (2004); *Eagle Eye* (2008).

As desktop publishing and GUIs became more sophisticated in the early 1990s, more sophisticated typography appears in the survey, as well.

Typography on paper has been evolving for hundreds of years and has been optimized for its high-resolution medium. While screen-based typography has some of its own, unique requirements, as screen resolutions have increased steadily since the 1990s, the principles of print-based typography have become both more and more applicable to screens and possible to implement. For example, compare the displays in *The Island*, which use a

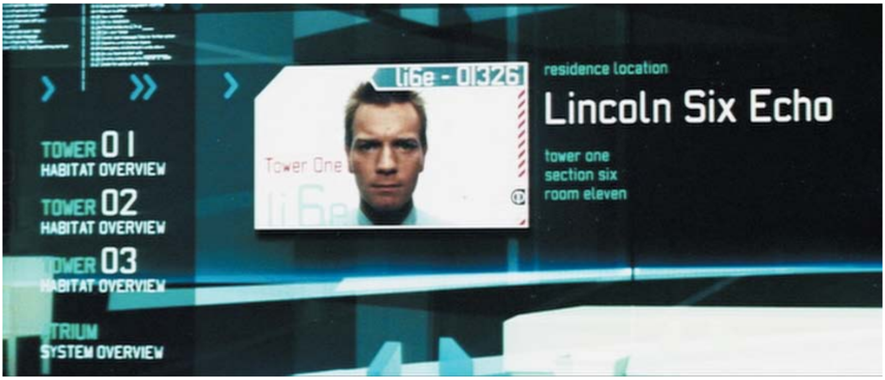



**FIGURE 3.10**
*The Island* (2005).

great deal of text, with the command-line interfaces in the prior section. *The Island* interfaces are richer and more legible partly because they use a variety of type sizes and faces to distinguish information (Figure 3.10). Most importantly, first-read information is larger and uses both upper and lowercase letters. Repetitive, second-read, and less important information uses only uppercase letters and smaller sizes. Third-read information is colored to have less contrast so that it stands out less, and fourth-read data—the least important—is very small. Sci-fi designers were maximizing the screen technology available to them and reminding us how far display technology has come.

**LESSON** **INCORPORATE TYPOGRAPHIC PRINCIPLES FROM PRINT**

The graphic style of early GUIs was partly a result of the constraints of the technology. Today, high resolutions and detailed graphic control is the norm. Without losing the new principles learned from on-screen design that deal with time, motion, and mode, designers can reincorporate the best practices from print that, for a time, had been disregarded as obsolete.

Though we don't have enough room to get into all of them here, a few obvious ones jump to mind: use strong visual hierarchies to draw the eye, and use mixed cases as well as graphically correct punctuation, diacritical marks, and ligatures. These principles can make text on screen much more legible and beautiful.

## Glow

The most prominent visual aspect of speculative technology is that it glows. From lightsabers to blasters, holograms to teleporters, most sci-fi technology emits light. It is the most common tag in our tag cloud from Chapter 1 (see Figure 1.3), and any casual overview of the survey shows its ubiquity.

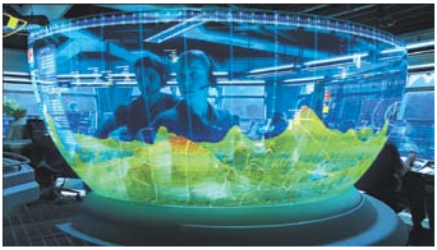
This effect includes on-screen elements as well. Type and other graphic elements, like lines in a map or diagram, are often a bright color on a dark background. Frequently a blur around these elements is added to enhance the glow effect. To push the technological aspects of the interface, diagrams and images are often rendered as wireframes instead of solid or patterned fills, creating more opportunities for high-contrast glowing (Figure 3.11).

**LESSON** **SCI-FI GLOWS**

Why does sci-fi glow? We suspect it's because things of power in the natural world glow: lightning, the sun, and fire. Other heavenly bodies glow as well—stars, planets, and the moon (especially against a black background)—and have been long associated with the otherworldly. Additionally, living things that glow captivate us: fireflies, glowworms, mushrooms, and fish in the deep seas. It's worth noting that while most of real-world technology glows, a lot of it doesn't, so its ubiquity in sci-fi tells us that audiences and sci-fi makers consider it a crucial visual aspect.

Regardless of the reasons, designers should be aware of this principle. If you want your interface or new technology to seem futuristic, it's got to glow.

FIGURE 3.11a–c
*Star Trek* (2009); *Defying Gravity* (2009); *Avatar* (2009).



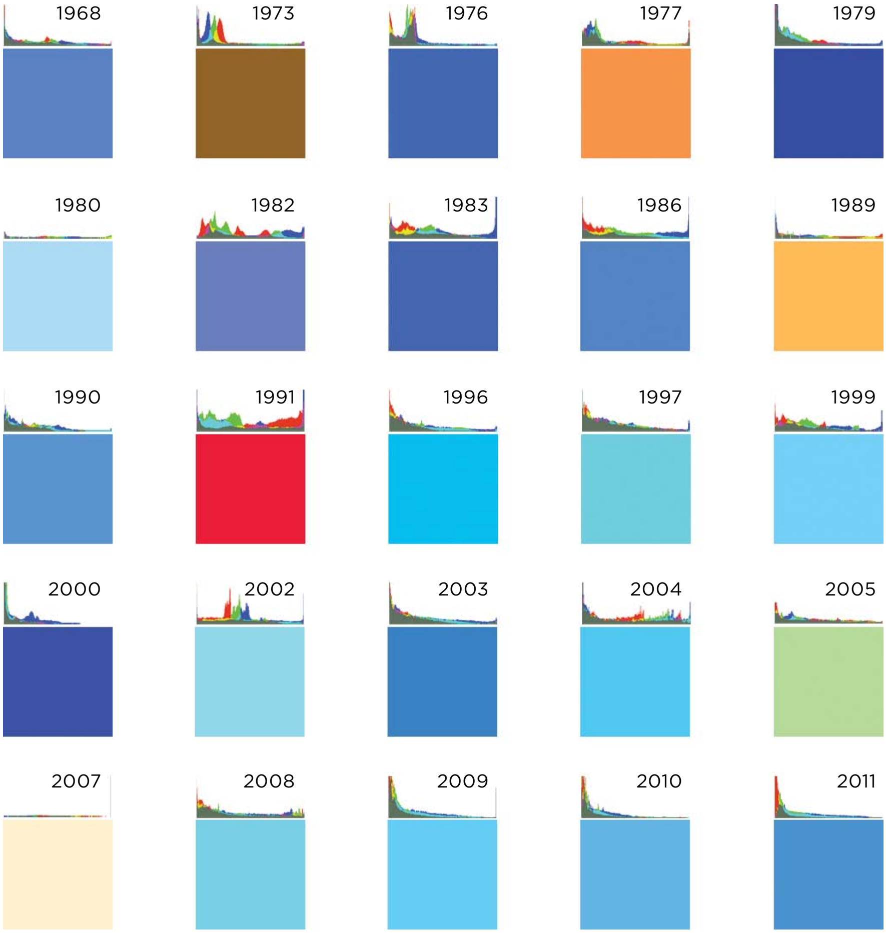



**FIGURE 3.12**
**The colors of sci-fi from the *Make It So* database show the strong tendency toward blue.**

## Color

The histograms in Figure 3.12 were made by selecting representative images for each screen-based interface in the survey, filtering out noninterface elements in the scene, aggregating them into a single image, and running a Photoshop analysis on the result. To create the color chips for each year, the same aggregate image was reduced to a single pixel, and its saturation was adjusted to 100 percent.[2] Though interesting, it should be taken with a grain

2 Almost everyone who saw this graphic in development immediately asked what happened in 1991. See our discussion of the cyborg vision from *Terminator 2: Judgment Day* in Chapter 8.

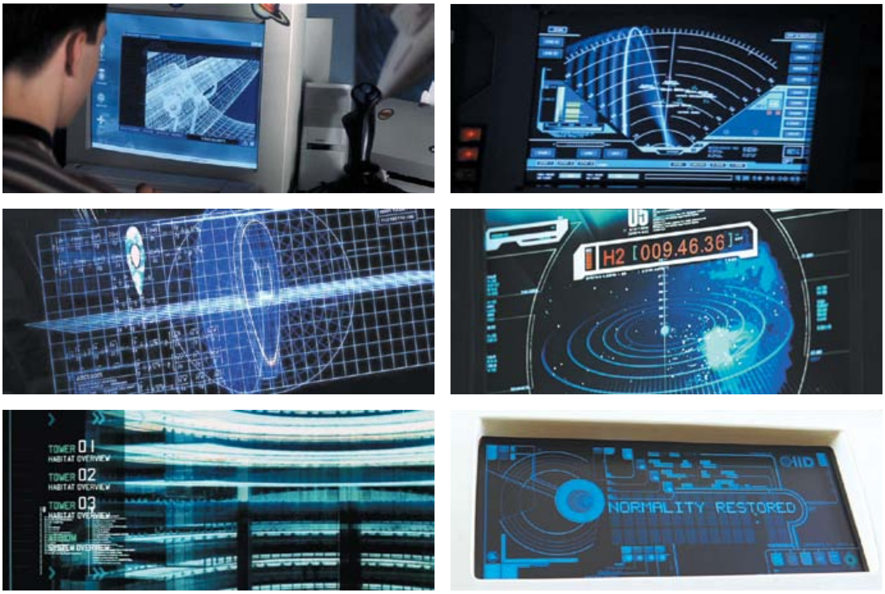
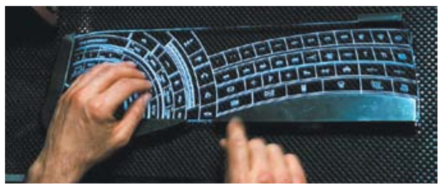



FIGURE 3.13a–g
*Galaxy Quest* (1999); *Battlestar Galactica* (2004); *Supernova* (2000); *Fantastic Four* (2005); *The Island* (2005); *The Hitchhiker's Guide to the Galaxy* (2005); *Iron Man* (2008).



of salt, because there are a number of problems in regarding these results as scientific, both in content and process. Despite these caveats, one of the things clearly shown in the chart is that sci-fi interfaces are mostly blue (Figure 3.13).

**LESSON** **FUTURE SCREENS ARE MOSTLY BLUE**

Why are sci-fi screens mostly blue? Mark Coleran, a noted production designer on many films, tells us that it's partly a technical reason: tungsten lights are the most common ones used on sets, and they're very warm in color. As filmmakers compensate for this in post-processing, blue colors are affected the least. Maintaining the vibrancy of other colors is tricky at best. Even if blue colors shift across this process, it's hard to notice because the human eye is least sensitive to the blue-yellow color axis. Trying to compensate for this color shift in the actual screen designs on set can result in garish interfaces that upset directors and actors, so it's often easier to just stick to blue.

Is there also a psychological reason? It could just be that blue is the most popular color worldwide, as polls by companies like AkzoNobel[3] and Cheskin[4] seem to verify time and again. It could be that interfaces are places for work, and blue is often associated with coolness and calm. It could also be that blue is comparatively rarer in nature than other colors (with the exception of the sky), and it underscores the technology-ness of the technology. Or, it might be the opposite, since everyone sees the sky at some point no matter what climate they live in. Blue is often the color most associated with business, and it was often used in some of the earliest screen interfaces in the real world (as in the blue screen of death).

Regardless of the reason, as with typeface and glow, designers should be aware of this trend. If you're looking to establish a futuristic interface, shades of blue are an easy bet.

The majority of screen interfaces in sci-fi adhere to the conventions of blue glow, but the exceptions tend to be found in the most unique interfaces. The second most common interface color seen in the survey is red (Figure 3.14).

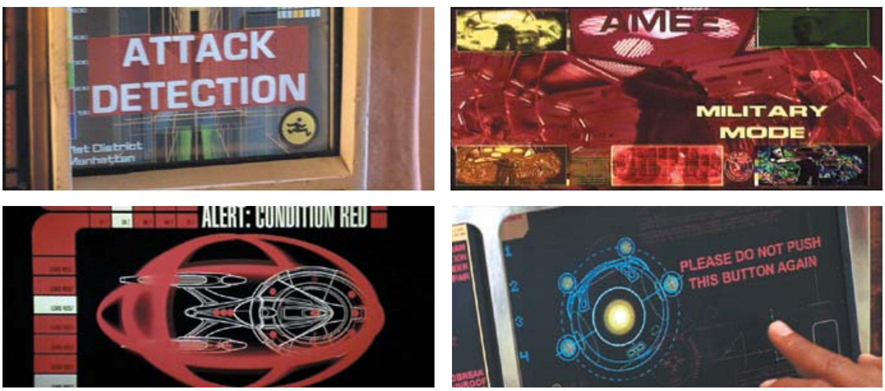



**FIGURE 3.14a–f**
*The Fifth Element* (1997); *Red Planet* (2000); *Star Trek: Nemesis* (2002); *The Hitchhiker's Guide to the Galaxy* (2005); *Iron Man 2* (2010).

3 AkzoNobel. (2012). Color futures 12. Retrieved from www.colourfutures.com/

4 Cheskin, MSI-ITM & CMCD Visual Symbols Library. (2004). Global market bias: Part 1. Color: A series of studies on visual and brand language around the world. Retrieved from www.added-value.com/source/wp-content/uploads/2012/01/9__report-2004_Global_Color.pdf

**LESSON RED MEANS DANGER**

As common as blues are as a baseline for interfaces, red is common as an alert to danger, errors, or failure—including death. This reflects the largely consistent use of red in Western countries for stop signs and warnings of all types, so it's best not to attempt to counter this learned association and try to communicate danger in other ways, unless you're prepared for user error and lots of user retraining.

Green is the third most common interface color in the survey. It is the color of hackers who work in command-line "green screens," directly reflecting the two decades that monochrome cathode ray tube (CRT) displays were the main ways to interact with computers. Wireframe 3D shapes and radar are almost always shown in green. Occasionally green is a contrast to red to clearly distinguish safe and dangerous states such as "locked" and "unlocked" (Figure 3.15).

In *Transformers,* a US military interface adheres to the glow lesson in the section above but uses green as the predominant color, instead of blue (Figure 3.16). The interface still looks technological but also slightly less typical than it would if it used blue.

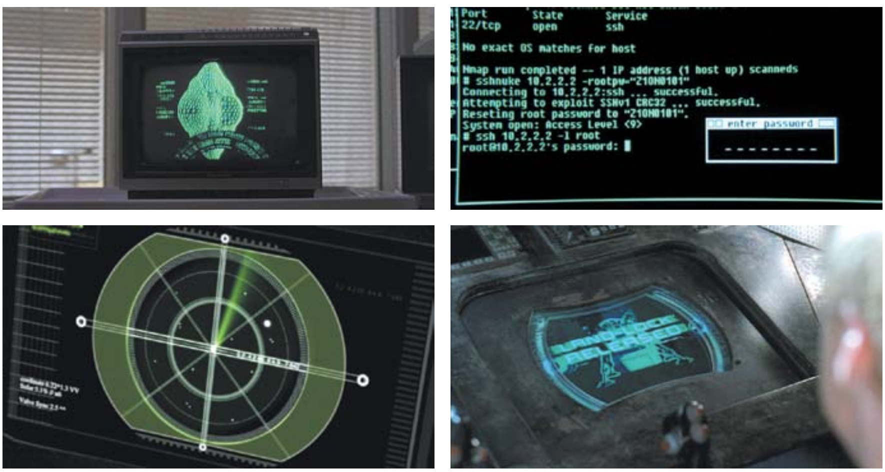



FIGURE 3.15a–d
*Flight of the Navigator* (1986); *Matrix Reloaded* (2003); *Battlestar Galactica* (2004); *Firefly*, "Safe" (Episode 5, 2002).

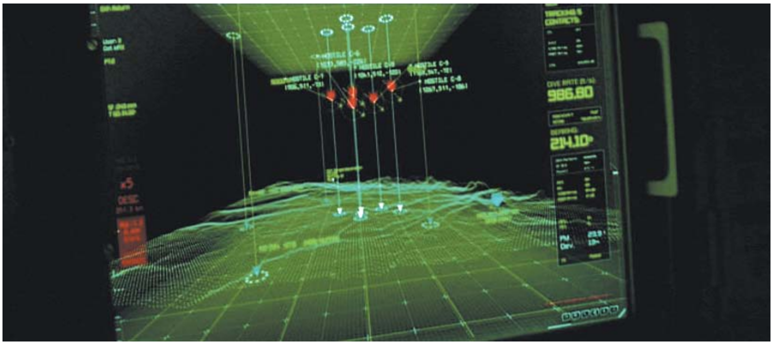


FIGURE 3.16
*Transformers* (2007).


FIGURE 3.17a–d
*Blade Runner* (1982); *Star Wars Episode I: The Phantom Menace* (1999); *2001: A Space Odyssey* (1968); *Mission to Mars* (2000).

Yellow and orange often serve as attention-directing highlights, or for caution messages that are distinct from more severe warnings (Figure 3.17).

Purple is the rarest interface color seen in the survey, possibly because the color has been technically hard to reproduce in the media of film and television. No trends of use can be observed in the samples from the survey.

To differentiate the interfaces in the *Star Trek* prequel, *Enterprise*, from those later in the timeline, the designers used a predominantly gray color scheme to make the interfaces feel much closer to our own times than the more advanced ones further in the future. This effect is aided by rectangular windows and simple geometric buttons on these screens (Figure 3.18).


FIGURE 3.18a,b
Comparing interfaces in *Enterprise* (2001) and *Star Trek: Deep Space Nine* (1993), separated by 200 years in the property's timeline.

**LESSON** **GRAY MAKES INTERFACES LOOK LIKE AN EARLY-GENERATION GUI**

Using a theme of gray elements on screen often makes an interface look less sophisticated and reminiscent of early-generation GUIs, before rich color screens were affordable and widespread.

### *Original Uses of Color*

Blue and glow are common, but we also see examples of interfaces that don't use these conventions.

In *The Matrix Reloaded,* we see one example of an all black-and-white interface (Figure 3.19). The Zion city control room exists in an all-white virtual space. The operations controllers there work with a black-line, 3D virtual touch interface arrayed in front of them. To make the "virtualness" even more apparent, these controllers are dressed all in spotless white as well. The overall effect is techy without resorting to typical conventions. This control "room" is part of the matrix and not a real space, so the convention of seamless white is used to indicate that everything in it, including the people, are virtual. The gray touch interface, as well as its translucency overlaid onto the scene, only reinforces this distinction from reality.

One interface from the *Torchwood* TV series features a monitoring interface that uses red and pink highlights supported by other highly saturated colors (Figure 3.20).

In *Star Wars Episode I,* the pod-race interface used by Anakin Skywalker glows, but with a predominantly orange interface with green and purplish-pink highlights. Included is some mostly yellow "filler" text in an alien language (Figure 3.21).

FIGURE 3.19
*The Matrix Reloaded* (2003).

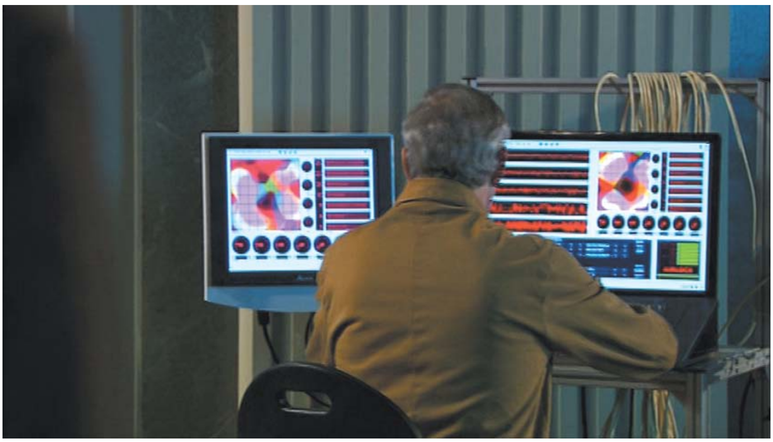


FIGURE 3.20
*Torchwood* (2009).

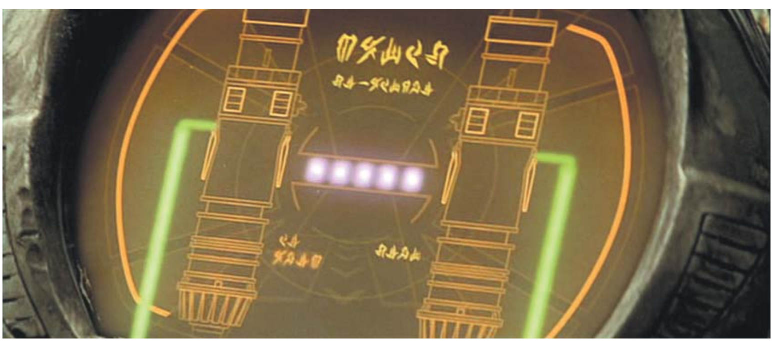


FIGURE 3.21
*Star Wars Episode I: The Phantom Menace* (1999).

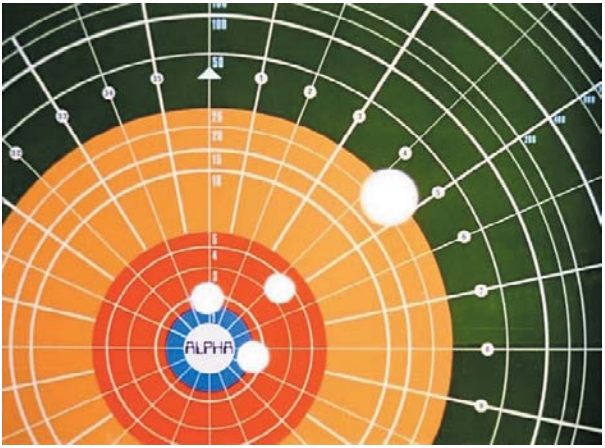



FIGURE 3.22
*Space: 1999* (1975).

A last example that goes against the blue and glow conventions comes from *Space: 1999*, in which a display within the moon base uses several bright, graphic colors with white lines and shapes to delineate measurements and white circles to track data (Figure 3.22). The overall effect looks nothing like the typical screen interfaces we see.

**LESSON** **TO CREATE A UNIQUE INTERFACE, AVOID SINGLE, COMMON COLORS AND THE GLOW EFFECT**

Bucking convention is often a successful path to creating a unique and memorable impression. Use uncommon colors or color combinations in the interface that don't stick to the too-common blue and glow conventions to differentiate your interface from more typical ones.

We must note an exception to these color trends. The LCARS interface, with its highly consistent palette, uses lots of yellows, oranges, blues, and purples throughout (see Figure 3.18b). This choice of using uncommon colors, added to the rest of the LCARS standards, makes a unique, memorable, and extensible interface.

### *Color Coding*

Color coding is used in the larger franchises to help audiences distinguish the technology of the different civilizations. For example, in the later *Star Trek* series, starting with *Star Trek: The Next Generation* (1987–94), Borg technology is green (Figure 3.23a), Starfleet's is the LCARS palette (Figure 3.23b), Klingon technology is red (Figure 3.23c), and so on. Even the transporter streams of these different cultures have differentiated tints and appearance so that audiences can tell who is beaming in or out.

When we see a green glow on a ship, we know it's Borg, even with little other information to go on. Similarly, when devices or ships appear on screen for the first time, their origins are often conveyed through color.

As interface designers, we also can use this power of differentiation and identity. Of course, color doesn't need to convey this information alone. Other visual elements can assist, as well as the shape of the display screen, discussed below.

### LESSON USE COLOR CODING TO HELP SIGNAL CONNECTIONS OR CATEGORIES

When information is presented statically, designers have many tools at their disposal to suggest structure: visual hierarchy, grouping, lines, and so on. These help users understand parts of the interface, their relative importance, and the relationships between them. When information is distributed across time, these visual aids are less effective. In these cases, use color to reinforce related types of information. This relies on the judicious assignment of color to category. To increase this effect, combine color with other visual cues, such as typography, shape, repetition, texture, and differentiated motion.

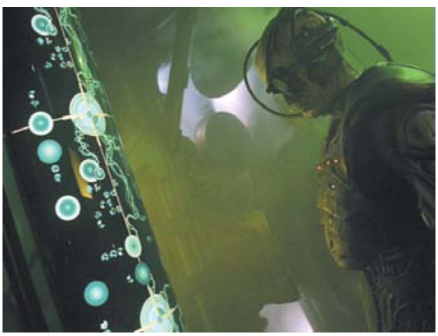


FIGURE 3.23a–c
*Star Trek: The Next Generation* and *Star Trek: Voyager* (1986–2002).

## Display Shape

Nonrectangular computer screens are an entirely sci-fi concept, because OLED or LCD displays that stray from rectangular shapes still exist only in the lab. (Radar screens and oscilloscopes had circular screens, but these aren't GUIs.) The instances of nonrectangular screens we see throughout the survey helps make the interfaces look both futuristic and alien (Figure 3.24).

**LESSON** **USE NONRECTANGULAR-SHAPED SCREENS TO MAKE THEM LOOK ADVANCED**

Because all screen technologies in use today are rectangular, masking the full display or using graphics to create a nonrectangular effect can make an interface appear more advanced.

FIGURE 3.24a–e
*Star Wars Episode I: The Phantom Menace* (1999); *Men in Black II* (2002); *Firefly*, "The Message" (Episode 12, 2002); *Star Wars Episode IV: A New Hope* (1977); *Doctor Who*, "Rose" (Season 1, Episode 1, 2005).

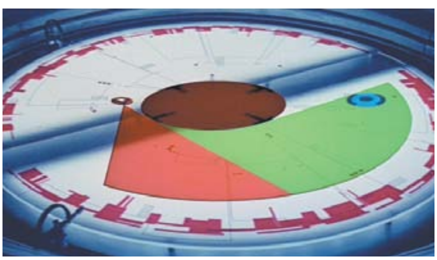


FIGURE 3.25a,b
*Things to Come* (1936, colorized version).

## Layers and Transparency

Transparency has been a part of sci-fi displays almost from the beginning, mostly as physical, transparent screens.

### *Transparent Displays*

Though these may seem like a contemporary idea, they are seen as early as 1936 in the film *Things to Come,* an adaptation of a Jules Verne novel in which John Cabell, a leader of a technocratic city of engineers, activates a completely clear screen to show his granddaughter the history of the city and how it grew out of the ashes of a decades-long world war. The video and the images themselves are somewhat translucent when viewed on this screen, as we see from the reverse shot (Figure 3.25).

We see similar screens throughout the survey. Memorable examples from more recent sci-fi include *The Fifth Element*, *Avatar*, *Mission to Mars*, *Minority Report*, and *Dollhouse* (Figure 3.26).

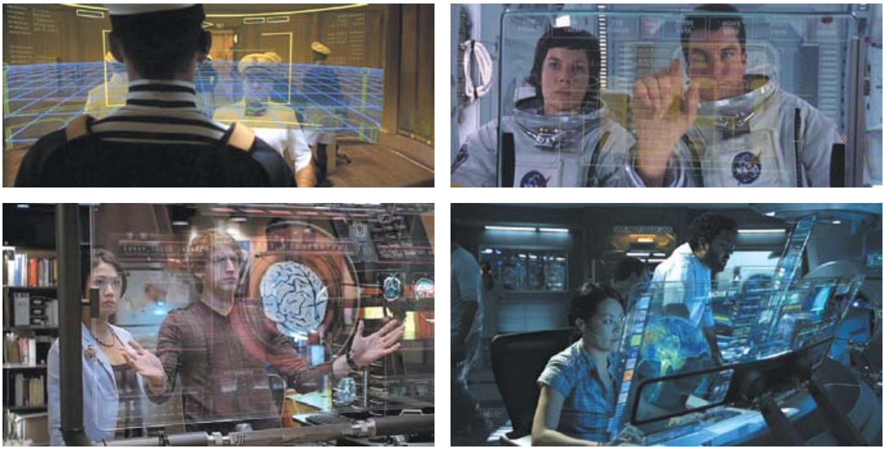
Part of the reason for the popularity of translucent displays in contemporary sci-fi may be that it allows directors and cinematographers to shoot actors through the screens, creating an interesting layered look that shows the actor's face and what *they're* looking at, simultaneously.

These are distinguished from heads-up displays (see Chapter 8) in that the content on translucent displays is independent of the background behind it, where heads-up displays are intended to augment content behind it. Transparent displays whose content doesn't do any augmentation might be useful to allow the user an ambient awareness of their surroundings, but introduces visual noise, discussed below.

### *Interface Layers*

We also see examples of interfaces that use data transparency to layer multiple levels of information on the screen, often for the purpose of conveying complexity and sophistication.

FIGURE 3.26a–e
*Minority Report* (2002); *The Fifth Element* (1997); *Mission to Mars* (2000); *Dollhouse* (2009); *Avatar* (2009).



In the film *Eagle Eye* (on the edge of sci-fi, but the most illustrative example), the interface seen for the ubiquitous "national security" ARIIA system has overlaid fields filled with a translucent, darkening color on which text and data are rendered more legible than if the field was clear. In this case, transparency is used to focus the user's attention on what is most critical while preserving some of the data that gives it context (Figure 3.27). It allows some information to have high contrast and other information to blend together, as appropriate.


FIGURE 3.27a–c
*Eagle Eye* (2008).

The 2009 reboot of *Star Trek* featured interfaces that combined information-dense, transparent layers of information with lots of moving information displays, giving the impression of overwhelming sophistication and complexity (Figure 3.28).

In *District 9,* when Wikus steps into the alien battle suit, he is presented with a multilayered 3D interface with translucent, multicolored icons and data in the alien language (Figure 3.29). It's a rich interface, involving both gestural and heads-up display. (See Chapters 5 and 8 for more examples of these.) The information it presents is disorienting to him, partly because he doesn't understand the language, but also because the visual field is so dizzyingly busy.

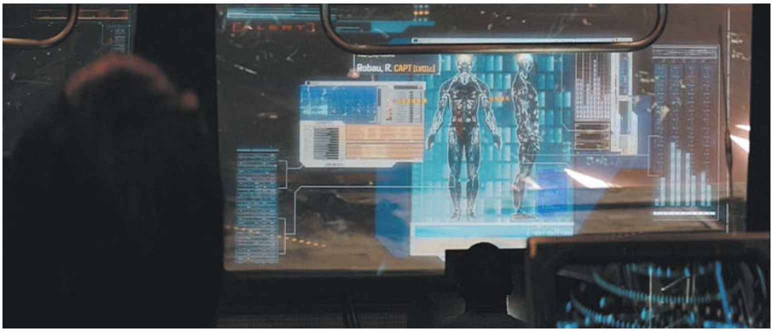


FIGURE 3.28
*Star Trek* (2009).

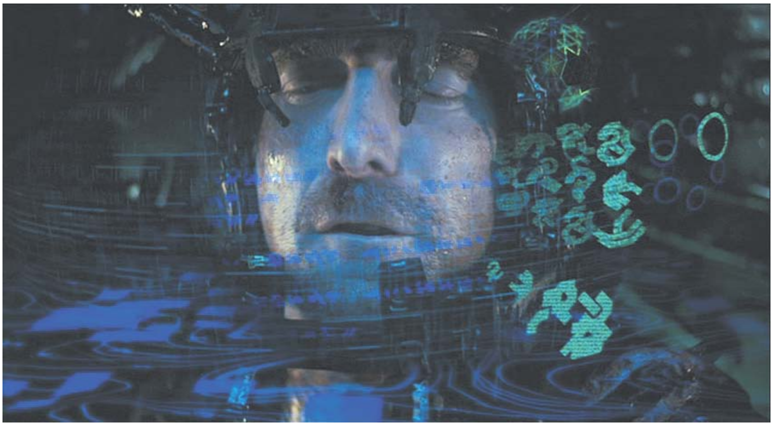


FIGURE 3.29
*District 9* (2009).

Transparent displays and interface layers, indeed, offer expert users large amounts of information with which to make decisions, which can be a useful thing. But the amount of clutter might just as easily make the data that much harder to perceive or interpret. When transparency is combined with glowing data, the effect can be beautiful but even more disorienting.

**LESSON** **USE TRANSPARENCY TO ORDER IMPORTANT INFORMATION WHILE PRESERVING CONTEXT**

Transparency can blend layers of information together to show relationships or alignment. High opacity or fully opaque backgrounds should be used to draw users' attention to critical information whereas high transparency can be used to show more general, less important connections between sets of information.

**LESSON** **AVOID THE CONFUSION CAUSED BY TOO MANY OVERLAPPING, TRANSPARENT LAYERS**

As described above, transparent layers can help organize and prioritize information, but too many become confusing and distracting. There's no optimal number of layers or level of transparency, but to make key information distinguishable, one guideline is that it should have a strong value contrast from its background. The Americans with Disability Act[5] provides a guideline of 70 percent difference for "detectable warnings," though if you are not concerned with universal accessibility you might comfortably halve that to 35 percent or higher depending on how fast the user is expected to perceive the information.

## 2½D

It's common to see elements within interfaces—particularly windows and fields in gray—with characteristics that make them look more like physical, dimensional objects. These characteristics have been ubiquitous in real-world computer software since the 1990s, and they appear often in sci-fi as well: beveled edges on windows, frames, and buttons; gradations across the "flat" surface of objects to give them a sense of being illuminated by lights in 3D space; reverse effects to make buttons and tabs look "debossed" into the surface when pushed; rulers scored with shaded lines across their surface, and so on. In some cases, text is rendered with light and dark edges to make it look etched into a surface (Figure 3.30).

5 US Department of Justice. (1991). 1991 ADA Standards for Accessible Design. Retrieved from www.ada.gov/stdspdf.htm


FIGURE 3.30
*The Matrix Revolutions* (2003).

Many of these effects are accessible for audiences because most people have seen and used them before in real-world interfaces, and additionally because these things work with people's sense of objects in the real world: real-world buttons can be pushed, and since this looks like a button, pressing it should activate it. There is some debate in the design community about the place of these skeuomorphs, but one thing is certain: these real-world references provide a fast cue to what can be done in an interface.

**LESSON USE FAMILIAR, REAL-WORLD CONTROLS FOR QUICK UNDERSTANDING**

A beveled appearance, drop shadow, or other simulation of physical attributes can make the interaction for on-screen controls more apparent and easier to understand as they appear like the physical controls they mimic. If the on-screen control doesn't function similarly to the physical control, however, greater confusion will result from the mismatch.

## Grouped Controls

We see considerable variation in the groupings of controls like menus and toolbars. Current GUIs typically have commands grouped into menus at the top of appropriate application windows, but sci-fi offers some alternatives that remind us that this is merely a popular choice and not the only way to handle commands.

The frame graphics in the LCARS interfaces serve to visually group controls of supposedly similar or related functions. This helps the crew parse the complexity of screens to find needed controls quickly and reliably. (For more detail about the LCARS, see the case study on page 68.)

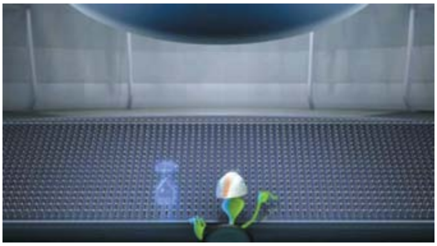



FIGURE 3.31a,b
*Alien* (1979); *Lifted* (2006).

Visual grouping needn't be limited to GUIs, however. Although several sci-fi properties intentionally make displays and controls indistinguishable from one another with rows and banks of nondescript lights and switches—as in the original *Alien* or the animated short, *Lifted*—some sci-fi properties use layout, color, and grouping to make the mechanical controls of interfaces more clear and understandable (Figure 3.31).

The TV series *Space: 1999* used this grouping principle for physical controls well, even though there are no touch screens or large display panels. Throughout Moonbase Alpha, all the controls are mechanical, but the panels they are attached to use considerable white space and colored backgrounds to group them together. Dark backgrounds are common, and color is used throughout, but in a way that suggests order and color coding. We don't know what all of the controls are meant to do but the colored bands and groupings do tell us which go together (Figure 3.32). The Aesthedes computer (discussed in Chapter 2) similarly groups controls into related functions that make the interface much easier to understand and use (see Figure 2.9). Though an ultimately unsuccessful computing platform, it is a good example of this grouping technique used well.


FIGURE 3.32a,b
*Space: 1999* (1975).

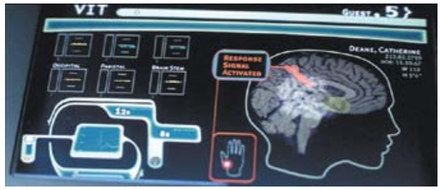




FIGURE 3.33a–c
*The Cell* (2000).

Very few sci-fi interfaces are created by professional interface designers. Some are actually real products rarely seen by most audiences, as in the case of the spatial file system in *Jurassic Park*. Others come out of research labs, like the gesture-based interface and language in *Minority Report*, which is based on work from the MIT Media Lab. Only recently have professional interaction designers been asked to consult on sci-fi interfaces.

One example is the film *The Cell,* for which interaction designer Katherine Jones was hired to create the interfaces. The screens are the control system for a brain/consciousness interface system, allowing two or three people to enter the consciousness of each other. These screens are carefully considered with few extraneous visuals elements and clear cues for interactivity. They stand out as an example of great on-screen grouping (Figure 3.33).

### OPPORTUNITY EXPLORE ALTERNATIVE WAYS TO GROUP AND ACCESS CONTROLS

One of the purposes of looking to sci-fi for inspiration and lessons is that it often shows us examples of alternative approaches to interfaces that we don't usually see. This doesn't mean that these different approaches will always be successful, but it's a duty of design to explore new arrangements of controls, displays, and interactions in order to evolve best practices and to find novel solutions that work better for users.

WIMP (windows, icons, menus, and pointers) conventions are so ubiquitous that it's often easy to forget that this is just one way to deal with the large number of functions users might need to access at any time. With alternate inputs like voice command and gestural recognition as well as new outputs like 3D and augmented reality, designers should be careful not to simply transfer metaphors from early GUI days, but to question them fundamentally and redesign where warranted.

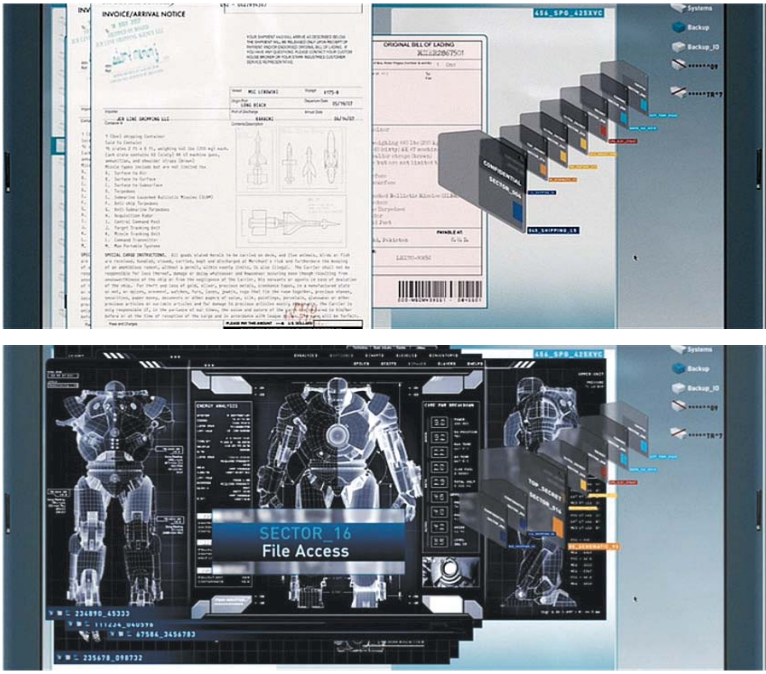



FIGURE 3.34a,b
*Iron Man* (2008).

## File Management Systems

When a sci-fi character needs to find a specific file or piece of data, or duplicate a file, they must access a computer file management system.

As with many interfaces in sci-fi, much of what is visible in these interfaces is gibberish—words and symbols designed to fill the screen and meant to zoom by too quickly to be read—making these screens problematic to analyze with real-world principles. Additionally, many movies and TV shows wish to avoid showing actual file systems like Mac OS or Microsoft Windows, though those same systems need to be familiar enough so that no explanation is needed. Still, the few examples of these types of sci-fi file management systems provide some useful lessons.

One example of such a system comes from *Iron Man.* When Tony Stark's assistant, Pepper Potts, is secretly searching for and copying files from Tony's computer at work, the files are represented with a slight 3D effect and translucently laid on top of each other. In this interface, the file currently being copied is larger in size than the rest of the group. This is the only indication of progress. At the same time, the contents of the file itself are shown on the screen (Figure 3.34).

**LESSON** **HELP DRAW USER ATTENTION THROUGH SCALE**

When presented with a lot of data or many options, only a few of which are meaningful, helping users quickly identify the important ones is crucial. Varying the size of file representations such that the important ones are larger lets users rely on visual comparison, so they can pick them out quickly.

A particularly lovely example of a novel file management system comes from the film *The Final Cut*. In it, the main character, Alan Hakman, is a video editor, hired by the family of a man who has recently died. His job is to create a tribute based on footage of his memories recorded directly from the man's implanted personal recording device.

The editing machine he uses displays the vast amount of footage as visual stills representing snippets of life experience and arranges them along a timeline (Figure 3.35). There's more to the arrangement than merely a timeline, for the stills are stacked in sets, on top of each other, and grouped vertically. Transparency is used to create a sense of depth among the clips as well. Together, these effects create a stream of memories that Hakman traverses to find the ones relevant to the portrayal he creates.

In a later scene, we see a different interface for his system that shows the edited clips he's selected to use in the final presentation. Here, the clips are grouped, labeled, and layered, but transparency is used only for the label, not the clips (Figure 3.36). Like many sci-fi films, this one doesn't explain the details of the interface, but the depiction offers us hints to visual techniques we can use to organize, relate, and display large amounts of data in a way that makes it easier to use.

FIGURE 3.35
*The Final Cut* (2004).

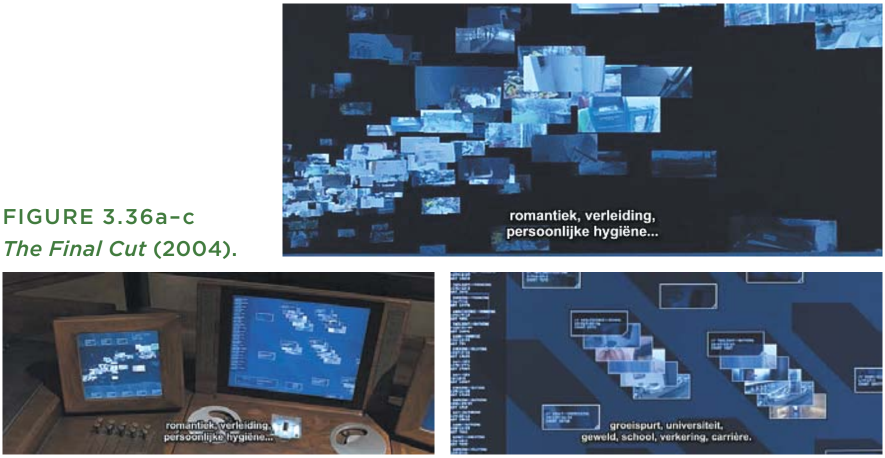



FIGURE 3.36a–c
*The Final Cut* (2004).

In addition to the *Jurassic Park* example that opened the chapter, there are several, imaginative representations of 3D file systems in sci-fi. All of these seem more advanced than common 2D interfaces because they add a dimension for organizing files and data not present in 2D interfaces. Of course, whether these are truly more effective or not depends on many details of their design.

In the film *Gamer,* the title character Simon has a room dedicated to his gaming and computer use with a volumetrically projected interface that surrounds him in a 360-degree, floor-to-ceiling virtual womb. Different files and content are accessed with different interfaces. In one, a 3D globe highlights geographical information of interest to him (Figure 3.37a). In another, a set of still images is clustered into a layered, 3D cloud (Figure 3.37b). In another, we see layers of messages to him from people all over the world (Figure 3.37c). We don't see all of these interfaces in use, but the layout is unique, interesting, and would take advantage of a user's full field of vision, body position memory, and spatial memory. These various interfaces surround him in simulated three-dimensional space even though most of the interfaces shown are two-dimensional.

In the film *Cowboy Bebop*, scale is used to simulate depth within the 3D system. In the movies *Hackers* and *Johnny Mnemonic*, one-point perspective is used to simulate this axis in an almost architectural way. In these last two examples, only text is used to portray code and/or file names, whereas in *Cowboy Bebop,* images and icons are used exclusively to portray the content of files, almost as screenshots of the file itself (Figure 3.38).


FIGURE 3.37a–c
*Gamer* (2009).

FIGURE 3.38a–c
*Johnny Mnemonic* (1995); *Hackers* (1995); *Cowboy Bebop* (2001).

### LESSON THREE-DIMENSIONAL DATA MAKES USE OF USERS' SPATIAL MEMORY

Because we all live in a 3D world, we're already comfortable navigating 3D space. Most current file systems only arrange data in, at most, two visual dimensions (and very often only one dimension within a 2D window, as in a list view), with parent-child containers like folders and files. Using the third dimension may help users navigate and arrange more data in a smaller area and find it again more effectively. With physical objects, it's common for people to remember where things are spatially, using the surroundings as reference. Likewise, this skill can translate to data objects within a 3D file system.

However, this only works if the spatial arrangement is consistent and doesn't change every time it is used. In addition, the layout can be more confusing for users who aren't spatially adept. If a user is the sort to frequently lose their keys, it would be problematic.

It's also important that file details, such as file names or key words, aren't obscured. As the *Jurassic Park* example at the beginning of this chapter shows, the extra dimension can introduce as many new problems as it might solve, making it tricky to do well. The most successful examples we see are those that use the dimensions to orient files and data according to attributes of some kind and not merely another dimension in which files seem randomly distributed, as in the *Cowboy Bebop* example above.

## Motion Graphics

There have always been blinking lights and buttons in sci-fi, but with touch screens and flat-panel displays, animation of the interface itself is becoming more common. By "motion graphics," we mean the interface itself, rather than the content it enables. For example, a folder icon that animates open when a file is dragged on top of it is an interface element, whereas the video that displays in a window in YouTube is not. In sci-fi, the data shown on display screens in *Star Trek: The Original Series* (see Figure 3.7a) is content as opposed to interface, whereas the folders in the *Iron Man* example above (see Figure 3.34), blinking and marching as their contents are copied, are part of the interface.

For example, in *Star Trek*'s LCARS interface, the frames and buttons of the interface rarely change as the user interacts (Figure 3.39a). A screen might be redrawn, with a new interface, to change its function (like opening a new application), but it's rare for animation to be incorporated into the use of the system. Video, charts, and animated content are sunk mostly into a content area of the overall LCARS interface. In contrast, screens in the film reboot *Star Trek* are more complex and often use animation within the interface itself (Figure 3.39b).


FIGURE 3.39a,b
*Star Trek: Voyager*, "Equinox, Part 1" (Season 5, Episode 26, 1999); *Star Trek* (2009).

In the film *Lost in Space,* many of the ship's interface screens are in constant motion. Most often, this motion is tied to useful information on the screen. But even if the content or controls are static, the background displays a pattern that holds the user's attention and/or conveys system information (Figure 3.40a). For example, movement in the background of the cryogenic interface indicates that the system is on and functioning (Figure 3.40b). Similarly, the motion in the background of file transfer interfaces indicates that the transfer is still processing while the foreground motion graphics indicate how much of the transfer has taken place (Figure 3.40c). The animations make the systems seem more dynamic. Their movement creates a very different effect than, say, the near-motionless LCARS interface.

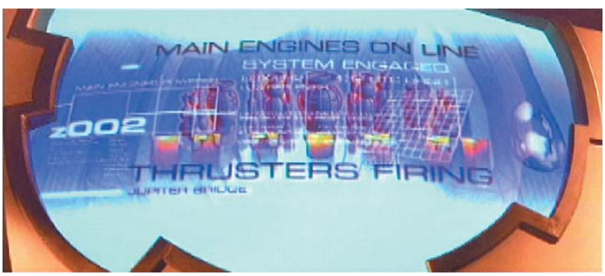
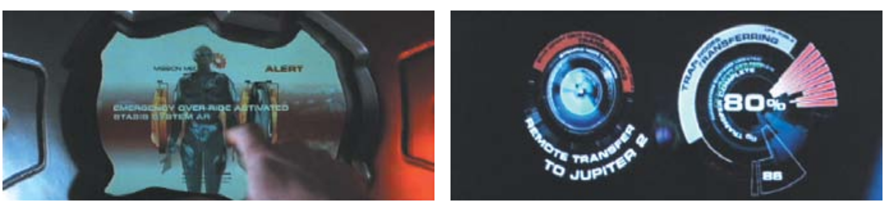



FIGURE 3.40a–c
*Lost in Space* (1998).



**LESSON** **USE MOTION TO DRAW ATTENTION, CAUTIOUSLY**

The human vision system has a separate track for drawing our attention called the *superior colliculus.* It is optimized to detect sudden light, sudden motion, and appearing/disappearing objects very quickly with no conscious processing. Because of this system, moving graphics demand our attention very quickly.

As in the *Lost in Space* examples above, movement in the background of the interface can imply the system is active more than still imagery and graphics. But take great care, as this is an autonomic response that can distract the user from her present task. If she feels the forced switch of attention was not worth it, she'll become annoyed with the system, and rightly so.

**LESSON** **USE MOTION TO CREATE MEANING**

Motion graphics are more eye-catching and novel than static screens. Though they can add a sense of modernity, they can do more. They can add another layer of information: Whether the system is working or not, the current load on the network, or the system's confidence in the thing being developed, just to name a few examples. They can also imply the relationship of parts when transitioning between them: something is a superset or a subset of something else; things are similar or different to other things. Sci-fi rarely has the time to explain such nuances to its audience, but the real world has more time for the richness of an interface to unfold. For example, the transitions in programs like PowerPoint or Keynote are often gratuitous but, on occasion, are selected specifically because they describe a relationship between information that is clarified by the transition and not merely decorated by it.

## Visual Style

Perhaps one of the most distinguishing aspects of sci-fi interfaces is their visual style—the combination of design elements like typography, color, shape, textures, layout and grouping, and even transparency that make a particular set of interfaces cohesive and unique. When done well, this visual style becomes a recognizable element across a film or series—almost as recognizable as some of the characters.

Some of the makers of the earliest sci-fi films and TV shows, such as *Metropolis* and *Flash Gordon,* consciously created a visual manifestation of "the future" using specific visual elements. They did this with industrial as well as graphic design, and the results were critical to how audiences imagined and felt about the future, whether utopian or dystopian. The interfaces in these shows reinforce the style. A crowded, dirty, or frenetic interface speaks to a world set against the protagonists. Similarly, a calm, easy-to-use, or elegant interface tells audiences and users that, in the future, technology will make their lives easier.

For this section, we've chosen to focus on examples of movies or TV shows with strong visual styles that are not just well made but also help tell the story of the sci-fi worlds in which they appear.

### *The Hitchhiker's Guide to the Galaxy*

The interface of the fictional electronic guidebook *The Hitchhiker's Guide to the Galaxy*, from the film of the same name, has a bold and humorous style that matches the feel of the film. Its backgrounds are full-screen, highly saturated color with a rainbow-colored interface system in which chosen topics slide out to the right from their peer groupings. Color is used to differentiate categories but doesn't seem to carry consistent meaning otherwise. This interface's many diagrams and animations are all in keeping with this flat, graphic style, with little hue variation within the subject category. It speaks of a world that is bold, friendly, a bit absurd, and unpanicked (Figure 3.41).

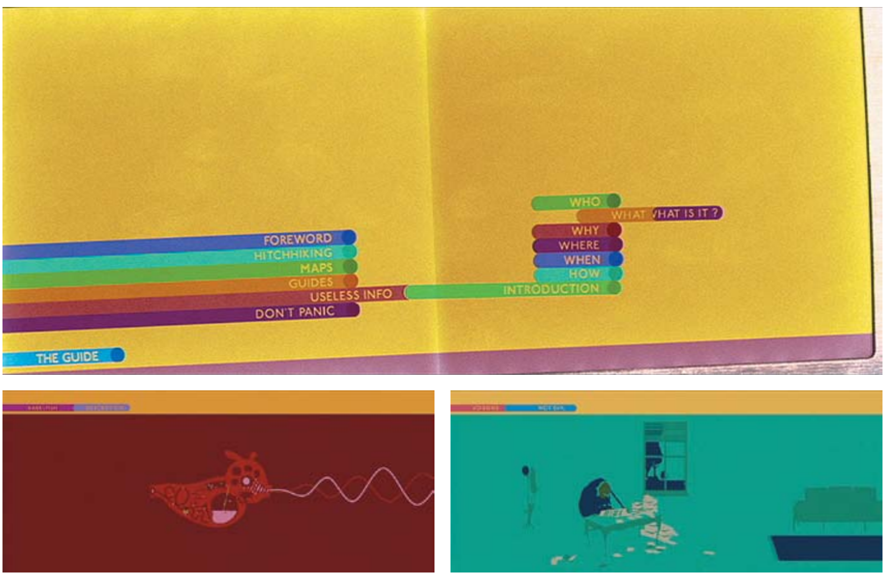



FIGURE 3.41a–c
*The Hitchhiker's Guide to the Galaxy* (2005).

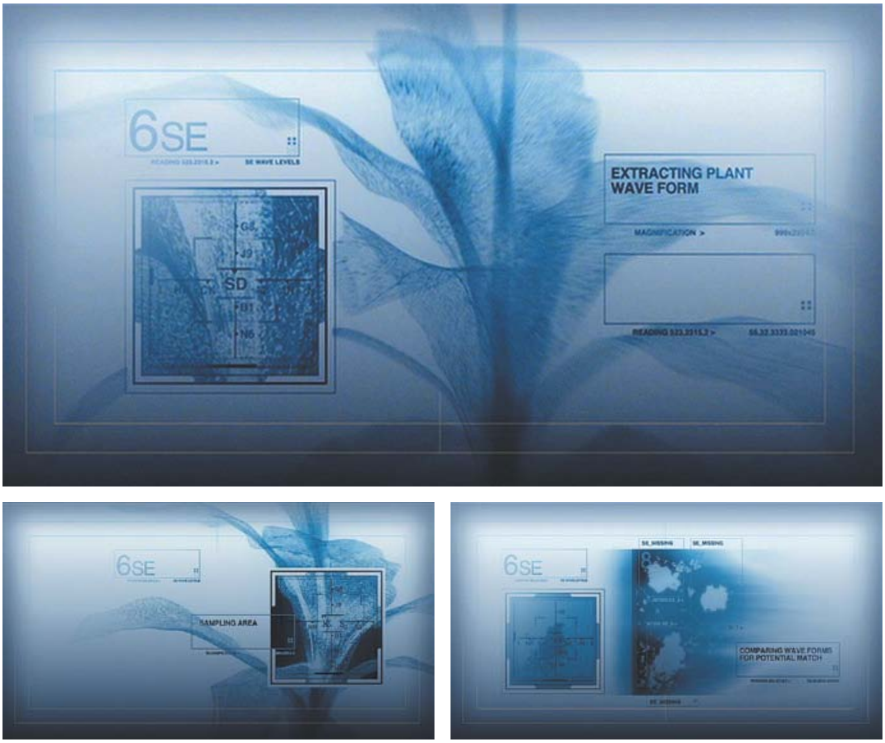



FIGURE 3.42a–c
*Final Fantasy* (2001).

## *Final Fantasy*

The adherence to a reference hue is used to a completely different effect in the animated film *Final Fantasy.* Here, only value is used to render the interface for analyzing a flowering plant, with large, subtle background images, overlaid text, boxes, and floating "windows." Transparency and gradation, as well as fine detail, create a completely unique feel of haunted technology (Figure 3.42).

## *The Chronicles of Riddick*

In the cockpit of one of this film's ships we see a variety of physical controls and visual displays, including three central screens that project color graphics onto round plates of glass. The visual style uses flat and gradient areas of color (mostly blues and gray) with typography playing the primary role. Circles are the dominant graphic element in the interface, with an informational overlay of text and numbers, creating a technologically Spartan feel (Figure 3.43).


FIGURE 3.43a–c
*The Chronicles of Riddick* (2004).

## *The Incredibles*

In the animated film *The Incredibles*, the graphics and text are simple, clear, and sparse. Little filler is used, especially when Mr. Incredible accesses the villain's database to learn more about his evil plans. The use of flat graphic silhouettes and the Eurostile typeface are similar in style to *Star Trek*'s (see the LCARS case study on page 68), but the graphic elements are set against a light blue and very light gray background, giving it the feel of a blueprint. As in several of the interface examples above, the colors are limited to a specific primary hue, except for the occasional, attention-grabbing, highly saturated red. This combination of elements gives the interface an appearance that is credible, distinctive, and original, reinforcing this alternate universe where superheroes became real in 1950s America (Figure 3.44).

In the preceding examples, many of the elements used in the interfaces are not original. For example, Eurostile is a common sci-fi typeface, as are circular screens. Highly saturated palettes and wireframe models similarly appear in many films. It is the particular combination of these, used consistently, that gives these interfaces a unique style and makes them recognizable.

A chapter on visual style would be incomplete if it didn't address the *Star Trek* LCARS interface.


FIGURE 3.44a–c
*The Incredibles* (2004).

## Case Study: *Star Trek*'s LCARS

One of the historically more significant shifts in sci-fi visual design occurred when *Star Trek* replaced controls based on mechanical, lighted buttons in the original TV series with the backlit touch panels in its first sequel series, *Star Trek: The Next Generation.* The new interface was striking not just for its visual distinctiveness but also for its comprehensiveness, extensibility, and influence.

As mentioned in Chapter 2, the reason for this change was the TV series' budget: the creators simply didn't have the funds to recreate displays and controls made from so many separate buttons across the vast surfaces of the *Enterprise*'s bridge. Production designer Michael Okuda and his team needed a much less expensive alternative. They looked to techniques such as those used in *Logan's Run* nine years earlier, which featured sheets of plastic printed with graphics and backlit (Figure 3.45).

Once Okuda's team decided on this technique, it freed them from the cost and constraints of physical interfaces, opening up tremendous design opportunities. Whereas this technique was used only for displays in *Logan's Run*, however, in *Star Trek: The Next Generation* it was used for controls as well, presaging touch-screen technology.

FIGURE 3.45
*Logan's Run* (1976).

The result is the computer interface called LCARS (Library Computer Access and Retrieval System). It consists of a black background with a condensed sans serif typeface (SWISS 911 Ultra Compressed BT) used throughout. It features rounded-corner background graphics in flat, pastel blues, purples, and oranges with areas of brighter, higher intensity color for both graphics and text. These swooping background graphics form frames along a grid, providing a structure into which buttons, labels, informational diagrams, and video are placed. This graphic system supported a wide variety of applications, diagrams, controls, and Starfleet technologies (Figure 3.46).

The LCARS interface was so durable that it was used consistently across three *Star Trek* TV series and four films. It even inspired two thematic transformations, to its "past" and its "future," helping to reinforce the evolution of technology in this universe.

To differentiate the interface of the prequel, *Enterprise,* a different visual language was created for the touch-screen displays mixed with physical controls (Figure 3.47). These displays were less integrated into panels and surfaces than those seen in the LCARS interface. The *Enterprise* interface may have been inspired by the LCARS interface (and foreshadow it), but it isn't technically part of it. The virtual portion of this interface used low-saturation color frames but buttons with more saturated colors, as well as a 2½D shading effect on the on-screen controls that mimicked physical buttons.

The *Enterprise* graphical language is almost entirely rectangular, and all data and controls are contained within closed, rectangular windows that do not overlap. There are very few round elements (though several of the window frames have a round "anchor" in the upper left corner), and a few rectangular buttons overlap their frames. These elements gave this series' interfaces a distinct yet related appearance while introducing limited touch-screen capability.

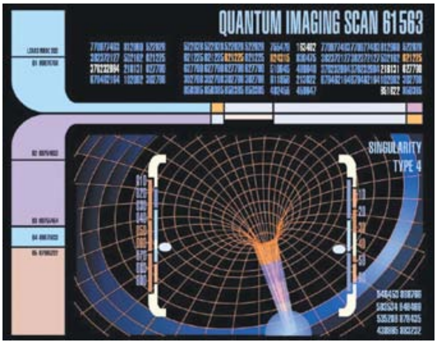
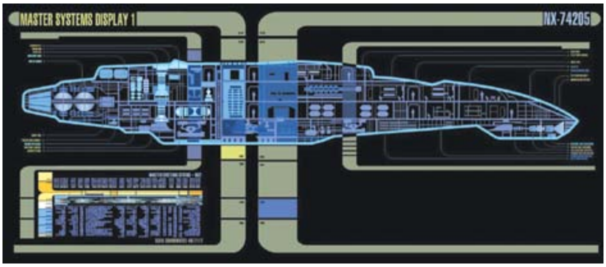




FIGURE 3.46a–c
LCARs interface from *Star Trek: The Next Generation* (1987).





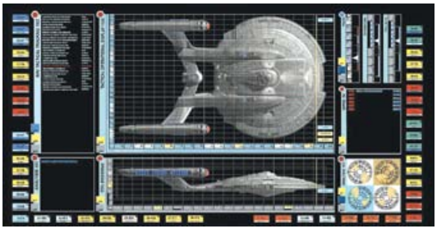


FIGURE 3.47a–c
Enterprise 001 interface from *Enterprise* (2001–2005).

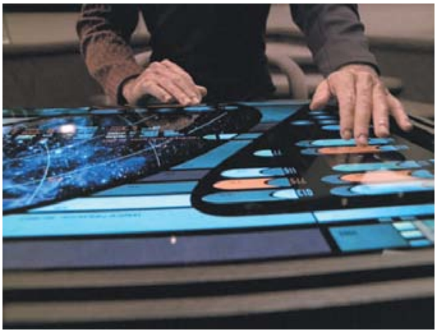



FIGURE 3.48a–c
TCARS interface from *Star Trek: Voyager*, "Relativity" (Season 5, Episode 24, 1999).

A future variant of the LCARS interface comes in the fourth TV series, *Star Trek: Voyager*. In the "Relativity" episode, a Starfleet ship from the future uses a modified LCARS interface called TCARS (Temporal Computer Access and Retrieval System; Figure 3.48). The TCARS interface has notable differences, although its lineage is clear: the black background panels persist, as do the touch screens. But the framing graphics use curved shapes based on long ovals and a predominantly blue hue. Several buttons have curved sides, based on ovals and not circles. In some screens, round elements establish radial grids instead of the perpendicular grids seen in the LCARS interfaces. In addition to the flat frame graphics, several are given dimensionality with shading, although with a softer effect than in *Enterprise*.

These changes are enough to indicate the almost 200-year evolution of the TCARS interface from the fundamental elements of the LCARS interface. It serves to help audiences understand this leap in time without being confronted with something too unfamiliar.

In addition to the LCARS interface found in Starfleet ships in *Star Trek,* many of the same underlying elements are used in the interfaces of other races seen throughout the 24th century, across the series (*Star Trek: The Next Generation*, *Deep Space Nine*, and *Voyager*) as well as the films associated with them. The large touch-screen surfaces with black backgrounds persist, but the colors, frame shapes, layouts, and typefaces are usually changed to make them look somewhat distinct. The overall effect is to make them all feel current with each other, of similar technology, but specialized to the cultures that use them (Figure 3.49).

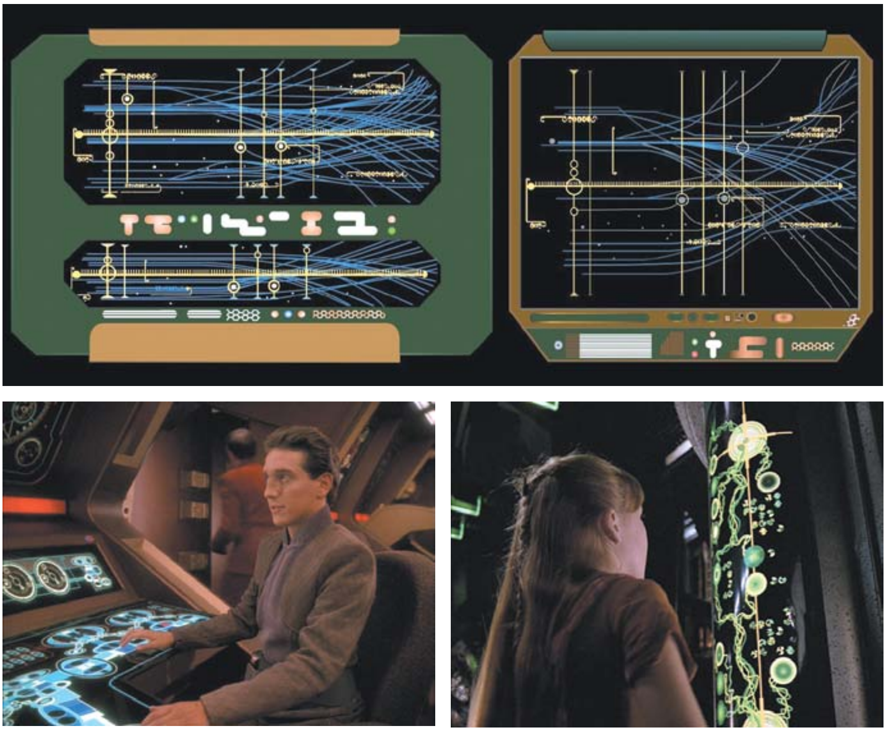


FIGURE 3.49a–c
Kremen interface from *Star Trek: Voyager* (1997); Bajoran interface from *Star Trek: Deep Space Nine* (1998); and Borg interface from *Star Trek: Voyager* (1999).

**LESSON** **CREATIVE COMBINATIONS OF EVEN COMMON STYLISTIC CHOICES CREATE A UNIQUE APPEARANCE**

One of the most powerful ways to differentiate an interface, whether for sci-fi or real life, is to create an original color scheme, typographic treatment, and arrangement of displays and controls. This is no surprise to graphic or visual designers, but many clients (and directors) shy away from being original because they are leery of presenting their users or audiences with something too unfamiliar. However, as long as the visual elements are appropriate, don't create confusion, and facilitate understanding, this is one of the best ways to create a unique or differentiated product brand or interface experience.

## Visual Interfaces Paint Our Most Detailed Pictures of the Future

Because television and film are such visual media, there is a great opportunity to study particular visions of the technology of the future. Even slight modifications to elements such as color, shape, symbolism, and typography can create drastically different screens than those we're used to seeing in real life today.

These examples and the lessons throughout this chapter give us a vocabulary for remaking our real-world interfaces in order to make them look more futuristic. This could be useful in differentiating them from others, or to purposely relate them to sci-fi and the future.

In addition, these lessons help us see that the boundaries of visual interface design are wider than we might have realized. Even if we don't intend for our interfaces to look like something from sci-fi, exploring these boundaries can help us discover and develop visual styles that are different than standard mobile, application, or computer interfaces, yet still look "real."

CHAPTER 4

# Volumetric Projection

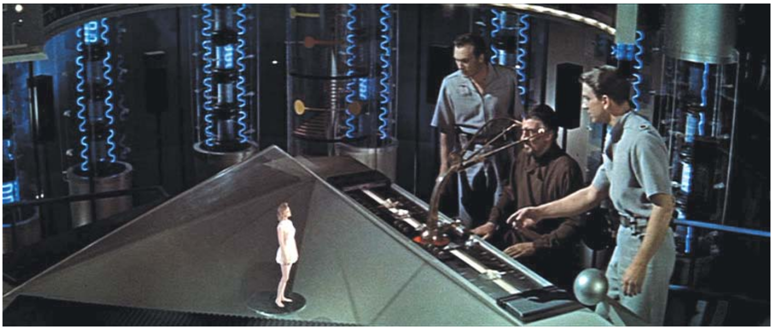


FIGURE 4.1
*Forbidden Planet* (1956).

The swirling, luminescent smoke slowly settles into a form within the Krell transparent display case, taking the shape of a small version of Dr. Morbius's daughter. The figure smiles and shifts position. "That's Altaira!" Adams exclaims. Morbius explains calmly, "Simply a three-dimensional image, Commander." Despite this explanation, Adams looks on in amazement at the figure standing before him (Figure 4.1).

This earliest example of a volumetric projection (VP) found in our survey was a modification of a very old illusion called *Pepper's ghost*, in which a bright, out-of-sight image is reflected off of a clean pane of glass in relative darkness, making the reflected image appear as if it is floating in space. It was thrilling for audiences and started the long love affair sci-fi makers have had with the use of VP.

What makes these displays so appealing to sci-fi makers is that they are so cinemagenic. They are shape, light, and motion in a medium that works best with shape, light, and motion. Because they are not restricted to 2D screens, VPs can be put anywhere in a scene the sci-fi maker needs them to be. And because they're not real-world technologies, they are a quick, established way to signal a highly futuristic technology in a sci-fi story in a manner that is also useful to forward the plot.

## What Counts?

"Volumetric projection" is a mouthful. Why not just call it what everyone else calls it—a hologram? Part of the reason is that that term already belongs to another kind of image. Remember those slightly 3D, multicolored shapes etched onto a silver substrate, as seen in the weird ending of *Logan's Run* (Figure 4.2a)? Or just look at a credit card—more likely than not there's a small hologram on it. This sophisticated printing technology has already laid claim to the term *hologram*, and these kinds of images are not like what we see projected in films.

FIGURE 4.2a,b
What doesn't count as a VP: *Logan's Run* (1976); *The Last Starfighter* (1984).

Another potential name might be *3D display*, but that term, too, has its problems. The ability to render objects on a 2D screen as if the objects were three-dimensional could be called 3D. It certainly was when computer-generated graphics first came on the scene, as in *The Last Starfighter* (Figure 4.2b). The term is further complicated by stereoscopic technologies that help a viewer perceive a display as if it were 3D, which are also sometimes included in descriptions of "3D displays," but that's not the same as VP either.

The most specific term to describe what this chapter is about is *volumetric projection*—those massless, moving 3D images that are projected into space, which anyone can see with their own eyes from any direction without the aid of special viewing devices, such as glasses. This is really a long way of saying, "You know, like the Princess Leia 'Help me, Obi-Wan Kenobi' message in *Star Wars*" (Figure 4.3). That's certainly the most famous VP in sci-fi, and the most canonical.

And although *Star Wars* is responsible for establishing the use (and the general appearance; see next section) of VP as the de facto communication medium in sci-fi, it's by far not the only example of it. VP is everywhere in sci-fi. It is such a staple of the genre that we don't have room to mention every movie or TV show that features it, much less to give an example of every type of VP display.

FIGURE 4.3
*Star Wars Episode IV: A New Hope* (1977).

As in most other chapters in this book, some technologies skirt the boundaries of the technology discussed. Explaining why we include some, but not others, helps to identify the parameters of the topic. You may be wondering whether the *Star Trek* holodeck counts as VP. Savvy readers may have caught the inclusion of the term *massless* in our definition. But because nearly all of the holodeck's projections can have a perfectly detailed force field that gives them a sense of mass and solidity, this pushes them into a unique category. Therefore, the holodeck isn't considered in this chapter. (But you will find it discussed as a case study in Chapter 11.)

## What Do Volumetric Projections Look Like?

When we look at the bulk of the examples, the first thing that strikes us is how similar they are. They tend to be translucent monochrome with a hint of blue, the whites glow a bit, and there are scan lines and the occasional flicker. The examples in Figure 4.4 show how strongly this style has remained in place since *Forbidden Planet*.

Some examples take pains to add rays of light to the display to emphasize its dimensionality and point back to its source (Figure 4.5).

FIGURE 4.4a–g
*Total Recall* (1990); *Lost in Space* (1998); *The Matrix Reloaded* (2003); *Serenity* (2005); *Chrysalis* (2007); *Iron Man 2* (2010); *Tron: Legacy* (2010).



FIGURE 4.5a–c
*Minority Report* (2002); *Star Wars Episode III: Revenge of the Sith* (2005); *District 9* (2009).



FIGURE 4.6a–c
*Starship Troopers* (1997); *Star Wars Episode II: Attack of the Clones* (2002); *Avatar* (2009).

In some cases, the colors are supersaturated. This is most often the case when the VP is a wireframe model and the context is one of information display (Figure 4.6).

In the rare cases in which the projection is not translucent, it's often because a trick is being played either on a character in the story or on the audience. One example is from *Back to the Future Part II*, when Marty McFly is surprised by a giant VP shark that "eats" him to advertise the fictional holofilm *Jaws 19* (Figure 4.7a). Another is from the TV series *Firefly* when a brawler goes flying through a barroom "window" that only suffers a brief flicker instead of shattering (Figure 4.7b). This break in audience expectation says, "Ha! You thought it was real, but you forgot this is sci-fi!"

FIGURE 4.7a,b
*Back to the Future Part II* (1989); *Firefly*, "The Train Job" (Episode 2, 2002).

This trick helps underscore why VPs need these visual traits in the first place. When you show something on screen that looks and moves like the real thing, how is an audience to know it's just a projection and *not* the real thing? How do you know, in a sci-fi world where the rules are by definition not the same as the real world, that this isn't some tiny clone of Leia who has just teleported in to speak to Luke? Of course, some of this is handled in context with dialogue, but the narrative overhead is reduced if the technology can be seen rather than explained. So, multiple cues help establish the virtualness of the VP beyond question.

**LESSON DIFFERENTIATE THE VIRTUAL**

If a VP is informational and too realistic, the image, sound, or data in it may need to be altered so that users don't confuse it with reality. If for some reason the VP can't be altered, it should reveal its virtualness with a simple interaction, such as a question or the wave of a hand.

**LESSON SHARE THE JOKE, AFTER A BEAT**

If a VP is meant to deceive an audience, verisimilitude is important to its effectiveness. When through a simple interaction the user encounters the ruse, don't reveal the trick instantly. Waiting a beat builds up the joke so its reveal has more impact.

Most of these cues adopt the visual artifacts of extant media. The peaked whites and bluish monochrome references black-and-white television. The scan lines and flicker reference broadcast television signal. More recent VPs adopt the edge-lit appearance of the electron micrograph. The use of projection rays references the projection light in a cinema. By adopting these visual conventions, the makers build on the audience's existing associations, helping them understand even more quickly and thoroughly that an object is only a projected image.

**LESSON** **VPs SHOULD CONFORM TO THE PEPPER'S GHOST STYLE**

The visual language of VP is established and narratively necessary. When this technology becomes commonplace in the real world, designers will have to break its dictates very carefully, or run into problems with understanding and acceptance by an audience trained across decades of sci-fi.

## How Are Volumetric Projections Used?

The ways in which VPs are used vary more than their appearance. They are used for video messaging, navigation, tactical planning, advertising, entertainment, medical imaging, user interfaces, brain exercise, industrial design, and even alien abduction training, as seen in the 2006 Pixar short *Lifted*. The most common of these are communications, navigation, and medical imaging.

### Communications

Communications technology can be distinguished in several ways. One helpful distinction is whether the communication is synchronous or asynchronous. *Synchronous* technologies have the communicators interacting in real time, both attending the communication simultaneously, as on a telephone call. Most of the communications examples in the survey are synchronous (see Chapter 10). *Asynchronous* communications involve a sender encoding their communication in some medium, such as a letter, video, or audio recording, and then sending it to the receiver. The words *asynchronous* and *synchronous* are an eyeful, so we'll talk about the more friendly *message* and *call*, respectively. These two types overlap quite a bit, but where they don't is mostly in the composing, editing, and sending of messages.

Most VPs in the survey are messages: the sender looks at the recording device, and the message is played back like a movie. But if it is a call, the speaker often looks directly at the recipient as if they were in the same space. This works for the TV or movie audience—after all, we'd be wondering what they were looking at if they weren't looking at the recipient—but on closer inspection, when the size or position of the VP is different than the sender would be in real life, it raises the significant problem of scaling and positioning. Let's take a look at this problem in detail, because although it appears to be about VP, its lessons can apply to any kind of video telephony.

Take, for example, Darth Vader's projection in *Star Wars Episode V: The Empire Strikes Back*, when it appears in one of the AT-AT cockpits. The VP appears in miniature, probably to prevent a life-size image from blocking the stormtrooper pilot's view (Figure 4.8).

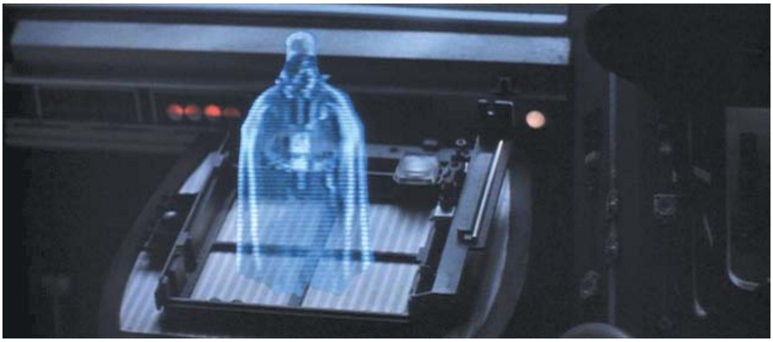
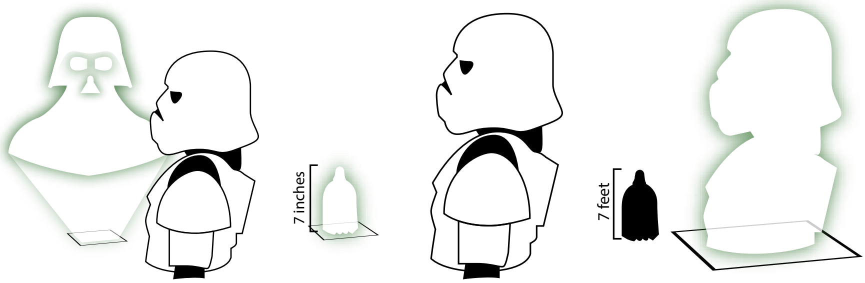


FIGURE 4.8
*Star Wars Episode V: The Empire Strikes Back* (1980).




Though this seems ideal from a "naturalness" perspective, it may be neither possible nor desirable. For instance, it would block the stormtrooper's view.

Scaling may solve some problems from the stormtrooper's position . . .

. . . but poses some strange problems from Vader's position. He wouldn't be physically or hierarchically comfortable with this.

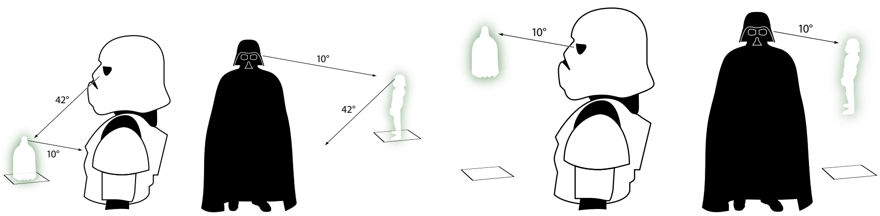
FIGURE 4.9
Neither simple cropping nor scaling solves the gaze-matching problem.

For the stormtrooper, this miniaturization works well. He can glance down at a dashboard-component-size Vader when necessary. But what is Vader himself seeing? If the stormtrooper were to be scaled inversely—which would be necessary in order for Vader to make eye contact—Vader would need to be looking up at a figure scaled to gigantic proportions (Figure 4.9).

To respect their relative status and make Vader physically comfortable using the communications system, he would need to be looking downward as well. Presuming the VP camera does not dynamically reposition itself to stay in the sight line of the speaker, the social need to look into each other's eyes introduces a *gaze-matching* problem. (This problem is called *gaze monitoring* in academic research.) As each looks at the eyes of the VP before him, he would appear to the other to be looking downward, as if avoiding eye contact. This is unacceptable, because it provides incorrect social cues of shyness, shame, subordination, or lying.

Another possible way to solve the problem is to float the projections so that they are positioned at a level that matches normal gaze angles (Figure 4.10).

Though this technique is used a few times in the *Star Wars* movies, in these cases care is taken not to show the free-floating VP sender's feet. In *Revenge of the Sith*, Obi-Wan is seen piloting a spaceship and conversing with a VP of Senator Organa. The filmmakers solved the floating person problem by cropping the movie frame so that the audience doesn't see Organa's feet (Figure 4.11). But in the real world, interface designers may not have this editing trick available to them, and in any case, floating projections may be detrimental in terms of secrecy or occlusion.




Letting both participants glance downward would mismatch their gazes.

Placing the scaled projection at a natural gaze position requires the VPs to float in midair, awkwardly and possibly inconveniently.

**FIGURE 4.10**
**Scaling combined with floating partly solve the gaze-matching problem.**

**FIGURE 4.11**
***Star Wars Episode III: Revenge of the Sith* (2005).**

So is scaling and repositioning in person-to-person VPs a nonstarter because of the gaze-matching problem? Not entirely. We just need to use apologetics to figure out how to make what works in the films work in real life.

### LESSON VP SYSTEMS SHOULD INTERPRET, NOT JUST REPORT

What if the VP technology is more complicated than it appears? Whereas a camera passively conveys whatever information it picks up, the VP system is more like a scanner that blends photographic and computer-generated rendering for its output. It would work like this: the camera captures the sender's movements, and then the system uses that information to construct a model of the sender that can be subtly altered. When it renders the sender's image for the receiver, it automatically adjusts body and eye positions so that eye contact can be made and gaze feels natural. When the real-world user matches the gaze of his VP co-communicator, his VP avatar on the other end of the call would match gaze with the real-world recipient, even if it requires adjusting the position and gaze of the avatar.

It would have to be smart enough to recognize other social cues and let those pass through appropriately, such as lowering eyes in deference or rolling eyes in contempt. This way the position and scale of the VP can be adjusted, as the situation requires, while still maintaining natural social interactions. This is just as important in video conferencing, because the camera is rarely in the middle of the image we're given. Until we can situate the camera in the screen, at about eye level, we will need some kind of computational support to make the interaction look and feel more natural.

This may be just what is happening when Sidious issues the infamous Order 66 in *Revenge of the Sith*. A comparison of the images shows a mismatch in the speakers' positions: Commander Cody looks down into the eyes of a miniature VP Sidious, who is looking up at him, and the real Sidious is looking horizontally at the projection of Cody, who looks horizontally back at him (Figure 4.12).

The creation of software sensitive enough to understand, alter, and represent gestural nuance without altering its meaning is a daunting task, to say the least. But as interface designers tackle similar problems in the real world, perhaps simpler steps can be taken first, such as simply repositioning the direction of the eyes. If such socially aware and capable systems cannot be made, there is another more direct way to solve the gaze-matching problem.

FIGURE 4.12a,b
*Star Wars Episode III: Revenge of the Sith* (2005).

FIGURE 4.13
*Star Wars Episode III: Revenge of the Sith* (2005).

**LESSON** **POSITION VPs EYE TO EYE**

As mentioned above, the first rule of placement for *Star Wars* VPs seems to be "don't float people, and hide their feet from sight if you do." But given the constraints of space, this may make the avatars quite small and, in long conversations, strain the necks of communicators looking downward. To avoid this prolonged strain, adjust the height of the VP "stage" and the position of the user such that representations can meet one another's gaze comfortably, and speak "eye to eye" (Figure 4.13).

## Reinforcing Social Hierarchy

Another aspect of the *Star Wars* VPs becomes apparent when we compare those used by the Empire and those used by the Jedi. The Empire's VPs are almost always shown scaled, with superiors scaled larger than their subordinates (Figure 4.14a). The Jedi council, in contrast, reinforces its egalitarian principles by making sure that, where possible, VPs in live deliberations are sized to appear as they would in real life (Figure 4.14b).

FIGURE 4.14a,b
*Star Wars Episode V: The Empire Strikes Back* (1980); *Star Wars Episode III: Revenge of the Sith* (2005).

**OPPORTUNITY SCALE AVATARS ACCORDING TO THEIR IMPORTANCE**

Once the problems of gaze matching are solved, scaling becomes a possible variable in communications displays. What scale is appropriate depends on the context. It could be something fixed, such as hierarchy or seniority relative to the meeting; for example, the White House press secretary may be larger than the reporters in a virtual briefing. Or it could be something dynamic, such as indicating popularity in a public contest or the current speaker in a business meeting.

## Navigation

Another common use of VP is to show navigation of objects or people through space. These scenes hint at some of the promise of VPs—namely, that they can be seen from all sides, allowing representation of the full spatial context to increase the chances of solving spatial problems. Unfortunately, many of these scenes are written for characters to discuss the difficulties of reaching a destination and to telegraph plot points, rather than for problem solving or multiuser interaction (Figure 4.15).

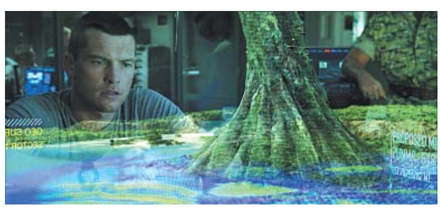


FIGURE 4.15a–c
*Lost in Space* (1998); *The Matrix Reloaded* (2003); *Avatar* (2009).

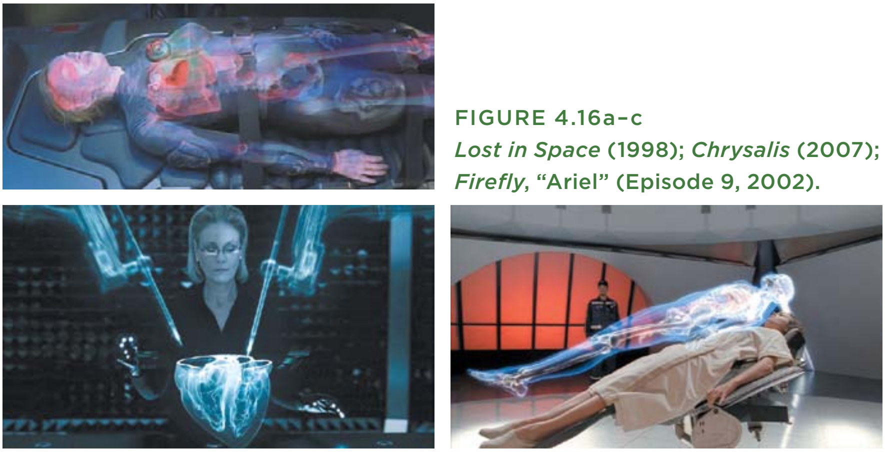


FIGURE 4.16a–c
*Lost in Space* (1998); *Chrysalis* (2007); *Firefly*, "Ariel" (Episode 9, 2002).

## Medical Imaging

The third most common use of VPs is for medical imaging, to provide noninvasive, real-time views of internal systems (Figure 4.16). Edge-lit, translucent, and color-coded rendering allows multiple organs in complex physical relation to be identifiable and observable. Medical imaging showcases the only collocated use of VP, with the projection and the thing being projected in the same space. These medical examples, like the communications ones described above, showcase a different promise of VP—that is, the re-representation of reality in a way that is more convenient for observation, study, and understanding. (See more about sci-fi medical interfaces in Chapter 12.)

# Real-World Problems

VP is not going away in sci-fi. It's too established and cinemagenic. But there are problems with it in the real world that aren't addressed fully by sci-fi. We discuss the main issues below.

## Confusion

As mentioned above, there is a risk of confusion when people see something that looks three-dimensional but is massless. They will naturally presume it's real. The Pepper's ghost visual style adopted by sci-fi certainly helps telegraph this difference, but if designers begin to stray from this style, it may cause confusion until some other takes its place.

## Eyestrain

The Pepper's ghost style has its own problems, however. Translucency may be a quick signal of masslessness, but it also introduces issues of eyestrain. The additional light coming from behind the VP forces the user's eyes to work harder to distinguish between the light sources, especially if the user is looking at the projection for data.

## Cropping

Objects exist in 3D contexts, but the surroundings may not be of interest to the user. For example, in the above scene from *Firefly* (see Figure 4.16b), River is reclining on a hospital bed, but that bed is rightly not included in the VP because the doctor is not concerned with it. In some cases, as in the *Lost in Space* and *Avatar* examples above (see Figures 4.15a, c), the context surrounding a particular planet or location may be critical to understanding the information.

But at other times, just a hint of the context is useful. In *Attack of the Clones,* Yoda listens to Obi-Wan's VP report from Geonosis. In this projection, rain can be seen passing within Obi-Wan's silhouette, but not outside of it, even though we see the projection from different directions (Figure 4.17). Without this subtle context clue, Yoda might misconstrue Obi-Wan's stance as discomfort in delivering the message, or interpret his yelling as excitement rather than trying to hear himself above the noise of the rain.

If systems can't interpret the context smartly, as they do in the *Star Wars* examples, they will need to crop objects in the scene. This could slice objects awkwardly or cause moving objects to appear and reappear.

FIGURE 4.17
*Star Wars Episode II: Attack of the Clones* (2002).

FIGURE 4.18
*Lifted* (2006).

## Occlusion

If a 3D crop *includes* the walls or ceiling of a room, or other large objects in the environment, these things may occlude the items of primary interest in a volumetric scene. Translucency or edge highlighting may help the user to ignore these extraneous objects, as seen in the Pixar short film *Lifted*, but this introduces issues of eyestrain as mentioned above (Figure 4.18).

## Overuse

Because VP is still out of reach for most audiences to experience firsthand, sci-fi makers may lean on its cachet and inappropriately present information in three dimensions that would better be presented in two. These examples are, fortunately, few and far between, but they nonetheless may set inappropriate expectations that 3D is good for anything.

In one such example from *The Matrix Reloaded*, workers in Zion Control monitor security and manage access through the city's gates. They do this in a virtual reality where information panels float in a confused, overlapping 3D space around them. Though not technically VP, it is easy to imagine that most of this interface would be physically and visually easier to use in a 2D format, or at least one that appeared two-dimensional from the operator's perspective, as seen in *Avatar* (Figure 4.19).

FIGURE 4.19a,b
*The Matrix Reloaded* (2003); *Avatar* (2009).

## Volumetric Projection Has Been Defined by Sci-Fi

VP has the main benefit of presenting information in a way that matches how humans sense most of the things in the world around them—in three dimensions. Our binocular vision, stereophonic hearing, and use of motion parallax are major inputs to understanding and interpreting the information that is contained in 3D space. VPs promise to bring this capability to bear in our digital interfaces.

But until volumetric displays in the real world become cheap and ubiquitous, most of us will design for and experience it in sci-fi. Perhaps its continued presence there will help push it forward in ways that will make its eventual adoption in the real world smooth and usable.

CHAPTER 5

# Gesture

FIGURE 5.1
*The Day the Earth Stood Still* (1951).

Returning to the interior of his mysterious spaceship, Klaatu waves his hand in front of a panel outside the ship's interior chamber and the door opens. He approaches a panel of transparent controls and waves his hand again. In response, the controls illuminate, disks begin to spin, and a circular screen pulses with a soft light. He begins a voice recording in his strange, alien tongue, "Imrae Klaatu naruwack. Macro puval baratu ludense empliccit . . ." (Figure 5.1).

This scene from *The Day the Earth Stood Still* shows the first gestural controls in the survey.

## What Counts?

Gestural controls allow users to provide input to a system with the free motion and position of their fingers, hands, and arms. Some systems require the gestures to be performed while in contact with a 2D surface, such as a touch screen, though most do not. Some require the user to wear gloves to help the system identify finger positions, though most do not. Nearly all involve volumetric projection, though a few, like the one Klaatu uses, do not. Because gestural interfaces are designed for "direct" manipulation, they almost always lack intermediary interface elements such as mice, pointers, and cursors.

Given this, there are three technologies that don't quite count.

The first is the exosuit, such as the loader from *Aliens* or the armored personnel units from *The Matrix Reloaded* (Figure 5.2). Do they count as gestural interfaces?

Certainly, the wearers of these exosuits gesture to move the arms and legs of the suit. But the interface for each is a set of mechanical controls, and this distinguishes them. They are, in effect, complex and highly ergonomic


FIGURE 5.2a,b
*Aliens*, detail (1986); *The Matrix Reloaded* (2003).

levers, switches, and potentiometers, but not what the interaction design community currently calls a gestural interface.

The second edge case is the holodeck from *Star Trek*. Its users gesture within its virtual worlds, interacting with the system while being completely unencumbered. Should it be considered? The objects and characters in its virtual worlds are for all practical purposes real to the user, and so the technology is no more or less "gestural" than the real world. To control the holodeck itself, crew members use a combination of spoken commands and a touch-screen wall panel called the *arch* (Figure 5.3). For these reasons, the holodeck cannot be classified as a purely gestural interface, so it isn't considered among the other examples here.



FIGURE 5.3a–c
*Star Trek: The Next Generation*, "Encounter at Farpoint" (Season 1, Episode 1, 1987).

FIGURE 5.4a–c
*Avatar* (2009).

The third case is the re-embodiment technology in *Avatar*. Although it is similar to the holodeck, and Jake Sully does gesture in his Na'vi body, these movements have no special meaning for controlling an interface. Since Jake's real body is lying motionless in a chamber while he's big and blue, it is more as if he has changed shape than used an interface (Figure 5.4).

A fourth case bears consideration: touch-screen-based gestural interactions. These are gestures that the user performs on a 2D surface such as a video display (as on current smartphones and tablets). In *Iron Man 2*, Tony Stark uses touch gestures to do a quick background search on a job applicant and zoom in to a sexy photo he finds (Figure 5.5). Though such interfaces are more limited in the types of gestures that can be performed and there are a great deal fewer of them in the survey than the free-form variety, they certainly do count as gestural interfaces and are considered in this chapter.

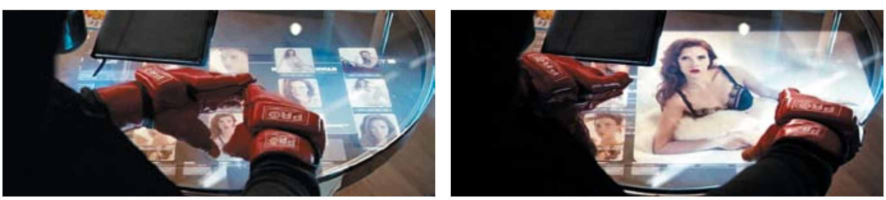


FIGURE 5.5a,b
*Iron Man 2* (2010).

## The Canonical Gestural Interface: *Minority Report*

One of the most famous interfaces in sci-fi is gestural—the precog scrubber interface used by the Precrime police force in *Minority Report* (Figure 5.6). Using this interface, Detective John Anderton uses gestures to "scrub" through the video-like precognitive visions of psychic triplets. After observing a future crime, Anderton rushes to the scene to prevent it and arrest the would-be perpetrator.

This interface is one of the most memorable things in a movie that is crowded with future technologies, and it is one of the most referenced interfaces in cinematic history.[1]

It's fair to say that, to the layperson, the *Minority Report* interface is synonymous with "gestural interface." The primary consultant to the filmmakers, John Underkoffler, had developed these ideas of gestural control and spatial interfaces through his company, Oblong, even before he consulted on the film. The real-world version is a general-purpose platform for multiuser collaboration. It's available commercially through his company at nearly the same state-of-the-art as portrayed in the film.

Though this chapter references *Minority Report* a number of times, two lessons are worth mentioning up front.

FIGURE 5.6a,b
*Minority Report* (2002).

1 In a quick and highly unscientific test, the authors typed [sci-fi movie title] + "interface" into Google for each of the movies in the survey and compared the number of results. "Minority Report interface" returned 459,000 hits on Google, more than six times as many as the runner-up, which was "Star Trek interface" at 68,800.

### LESSON A GREAT DEMO CAN HIDE MANY FLAWS

Hollywood rumor has it that Tom Cruise, the actor playing John Anderton, needed continuous breaks while shooting the scenes with the interface because it was exhausting. Few people can hold their hands above the level of their heart and move them around for any extended period. But these rests don't appear in the film—a misleading omission for anyone who wants to use a similar interface for real tasks. Although a film is not trying to be exhaustively detailed or to accurately portray a technology for sale, demos of real technologies often suffer the same challenge. The usability of the interface, and in this example its gestural language, can be a misleading though highly effective tool to *sell* a solution, because it doesn't need to demonstrate every use exhaustively.

### LESSON A GESTURAL INTERFACE SHOULD UNDERSTAND INTENT

The second lesson comes from a scene in which Agent Danny Witwer enters the scrubbing room where Anderton is working and introduces himself while extending his hand. Being polite, Anderton reaches out to shake Witwer's hand. The computer interprets Anderton's change of hand position as a command, and Anderton watches as his work slides off of the screen and is nearly lost. He then disregards the handshake to take control of the interface again and continue his work (Figure 5.7).

**FIGURE 5.7a–d**
***Minority Report*** **(2002).**

One of the main problems with gestural interfaces is that the user's body is the control mechanism, but the user intends to control the interface only part of the time. At other times, the user might be reaching out to shake someone's hand, answer the phone, or scratch an itch. The system must accommodate different modes: when the user's gestures have meaning and when they don't. This could be as simple as an on/off toggle switch somewhere, but the user would still have to reach to flip it. Perhaps a pause command could be spoken, or a specific gesture reserved for such a command. Perhaps the system could watch the direction of the user's eyes and only regard the gestures made when he or she is looking at the screen. Whatever the solution, the signal would be best in some other "channel" so that this shift of intentional modality can happen smoothly and quickly without the risk of issuing an unintended command.

## Gesture Is a Concept That Is Still Maturing

What about other gestural interfaces? What do we see when we look at them? There are a handful of other examples of gestural interfaces in the survey dating as far back as 1951, but the bulk of them appear after 1998 (Figure 5.8).

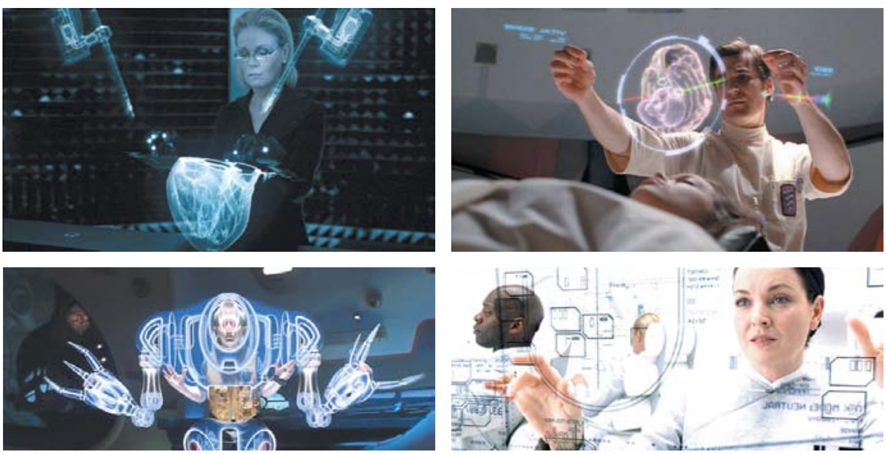


**FIGURE 5.8a–e**
*Chrysalis* (2007); *Firefly*, "Ariel" (Episode 9, 2002); *Lost in Space* (1998); *The Matrix Reloaded* (2003); *Sleep Dealer* (2008).

Looking at this group, we see an input technology whose role is still maturing in sci-fi. A lot of variation is apparent, with only a few core similarities among them. Of course, these systems are used for a variety of purposes, including security, telesurgery, telecombat, hardware design, military intelligence operations, and even offshored manual labor.

Most of the interfaces let their users interact with no additional hardware, but the *Minority Report* interface requires its users to don gloves with lights at the fingertips, as does the telesurgical interface in *Chrysalis* (see Figure 5.8a). We imagine that this was partially for visual appeal, but it certainly would make tracking the exact positions of the fingers easier for the computer.

## Hollywood's Pidgin

Although none of the properties in the survey takes pains to explain exactly what each gesture in a complex chain of gestural commands means, we can look at the cause and effect of what is shown on screen and piece together a basic gestural vocabulary. Only seven gestures are common across properties in the survey.

### 1. Wave to Activate

The first gesture is waving to activate a technology, as if to wake it up or gain its attention. To activate his spaceship's interfaces, Klaatu passes a flat hand above their translucent controls. In another example, Johnny Mnemonic waves to turn on a faucet in a bathroom, years before it became common in the real world (Figure 5.9).

FIGURE 5.9a–c
*Johnny Mnemonic* (1995).

## 2. Push to Move

To move an object, you interact with it in much the same way as you would in the physical world: fingers manipulate; palms and arms push. Virtual objects tend to have the resistance and stiffness of their real-world counterparts for these actions. Virtual gravity and momentum may be "turned on" for the duration of these gestures, even when they're normally absent. Anderton does this in *Minority Report* as discussed above, and we see it again in *Iron Man 2* as Tony moves a projection of his father's theme park design (Figure 5.10).

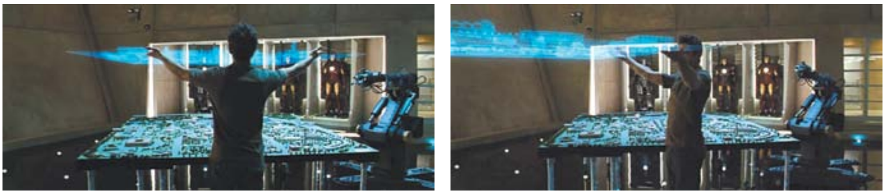


FIGURE 5.10a,b
*Iron Man 2* (2010).

## 3. Turn to Rotate

To turn objects, the user also interacts with the virtual thing as one would in the real world. Hands push opposite sides of an object in different directions around an axis and the object rotates. Dr. Simon Tam uses this gesture to examine the volumetric scan of his sister's brain in an episode of *Firefly* (Figure 5.11).

FIGURE 5.11a,b
*Firefly*, "Ariel" (Episode 9, 2002).

## 4. Swipe to Dismiss

Dismissing objects involves swiping the hands away from the body, either forcefully or without looking in the direction of the push. In *Johnny Mnemonic*, Takahashi dismisses the videophone on his desk with an angry backhanded swipe of his hand (Figure 5.12). In *Iron Man 2*, Tony Stark also dismisses uninteresting designs from his workspace with a forehanded swipe.

FIGURE 5.12a–c
*Johnny Mnemonic* (1995).

## 5. Point or Touch to Select

Users indicate options or objects with which they want to work by pointing a fingertip or touching them. *District 9* shows the alien Christopher Johnson touching items in a volumetric display to select them (Figure 5.13a). In *Chrysalis,* Dr. Brügen must touch the organ to select it in her telesurgery interface (Figure 5.13b).

FIGURE 5.13a,b
*District 9* (2009); *Chrysalis* (2007).

## 6. Extend the Hand to Shoot

Anyone who played cowboys and Indians as a child will recognize this gesture. To shoot with a gestural interface, one extends the fingers, hand, and/or arm toward the target. (Making the *pow-pow* sound is optional.) Examples of this gesture include Will's telecombat interface in *Lost in Space* (see Figure 5.8c), Syndrome's zero-point energy beam in *The Incredibles* (Figure 5.14a), and Tony Stark's repulsor beams in *Iron Man* (Figure 5.14b).

FIGURE 5.14a,b
*The Incredibles* (2004); *Iron Man* (2008).

## 7. Pinch and Spread to Scale

Given that there is no physical analogue to this action, its consistency across movies comes from the physical semantics: to make a thing bigger, indicate the opposite edges of a thing and drag the hands apart. Likewise, pinching the fingers together or bringing the hands together shrinks virtual objects. Tony Stark uses both of these gestures when examining models of molecules in *Iron Man 2* (Figure 5.15).

Though there are other gestures, the survey revealed no other strong patterns of similarity across properties. This will change if the technology continues to mature in the real world and in sci-fi. More examples of it may reveal a more robust language forming within sci-fi, or reflect conventions emerging in the real world.

FIGURE 5.15a,b
*Iron Man 2* (2010).

**OPPORTUNITY** **COMPLETE THE SET OF GESTURES REQUIRED**

In the real world, users have some fundamental interface controls that movies never show, but for which there are natural gestures. An example is volume control. Cupping or covering an ear with a hand is a natural gesture for lowering the volume, but because volume controls are rarely seen in sci-fi, the actual gesture for this control hasn't been strongly defined or modeled for audiences. The first gestural interfaces to address these controls will have an opportunity to round out the vocabulary for the real world.

**LESSON** **DEVIATE CAUTIOUSLY FROM THE GESTURAL VOCABULARY**

If these seven gestures are already established, it is because they make intuitive sense to different sci-fi makers and/or because they are beginning to repeat controls seen in other properties. In either case, the meaning of these gestures is beginning to solidify, and a designer who deviates from them should do so only with good reason or risk confusing the user.

## Direct Manipulation

An important thing to note about these seven gestures is that most are transliterations of physical interactions. This brings us to a discussion of direct manipulation. When used to describe an interface, direct manipulation refers to a user interacting *directly* with the thing being controlled—that is, with no intermediary input devices or screen controls.

For example, to scroll through a long document in an "indirect" interface, such as the Mac OS, a user might grasp a mouse and move a cursor on the screen to a scroll button. Then, when the cursor is correctly positioned, the user clicks and holds the mouse on the button to scroll the page. This long description seems silly only because it describes something that happens so fast and that computer users have performed for so long that they forget that they once had to learn each of these conventions in turn. But they are conventions, and each step in this complex chain is a little bit of extra work to do.

But to scroll a long document in a direct interface such as the iPad, for example, users put their fingers on the "page" and push up or down. There is no mouse, no cursor, and no scroll button. In total, it takes less physical and cognitive work to scroll with the gesture. The main promise of these interfaces is that they are easier to learn and use. But because they require sophisticated and expensive technologies, they haven't been widely available until the past few years.

In sci-fi, gestural interfaces and direct manipulation strategies are tightly coupled. That is, it's rare to see a gestural interface that isn't direct manipulation. Tony Stark wants to move the volumetric projection of his father's park, so he sticks his hands under it, lifts it, and walks it to its new position in his lab. In *Firefly,* when Dr. Tam wants to turn the projection of his sister's brain, he grabs the "plane" that it's resting on and pushes one corner and pulls the other as if it were a real thing. *Minority Report* is a rare but understandable exception because the objects Anderton manipulates are video clips, and video is a more abstract medium.

This coupling isn't a given. It's conceptually possible to run Microsoft Windows 7 entirely with gestures, and it is not a direct interface. But the fact that gestural interfaces erase the intermediaries on the physical side of things fits well with erasing the intermediaries on the virtual side of things, too. So gesture is often direct. But this coupling doesn't work for every need a user has.

As we've seen above, direct manipulation does work for gestures that involve physical actions that correspond closely in the real world. But, moving, scaling, and rotating aren't the only things one might want to do with virtual objects. What about more abstract control?

As we would expect, this is where gestural interfaces need additional support. Abstractions by definition don't have easy physical analogues, and so they require some other solution. As seen in the survey, one solution is to add a layer of graphical user interface (GUI), as we see when Anderton needs to scrub back and forth over a particular segment of video to understand what he's seeing, or when Tony Stark drags a part of the Iron Man exosuit design to a volumetric trash can (Figure 5.16). These elements are controlled gesturally, but they are not direct manipulation.

FIGURE 5.16a–c
*Minority Report* (2002); *Iron Man* (2008).

Invoking and selecting from among a large set of these GUI tools can become quite complicated and place a DOS-like burden on memory. Extrapolating this chain of needs might very well lead to a complete GUI to interact with any fully featured gestural interfaces, unlike the clean, sparse gestural interfaces sci-fi likes to present.

The other solution seen in the survey for handling these abstractions is the use of another channel altogether: voice. In one scene from *Iron Man 2*, Tony says to the computer, "JARVIS, can you kindly vacuform a digital wireframe? I need a manipulable projection." Immediately JARVIS begins the scan. Such a command would be much more complex to issue gesturally. Language handles abstractions very well, and humans are pretty good at using language, so this makes language a strong choice. (See Chapter 6 for further discussion.)

Other channels might also be employed: GUI, finger positions and combinations, expressions, breath, gaze and blink, and even brain interfaces that read intention and brainwave patterns. Any of these might conceptually work but may not take advantage of the one human medium especially evolved to handle abstraction—language.

**LESSON** **USE GESTURE FOR SIMPLE, PHYSICAL MANIPULATIONS, AND USE LANGUAGE FOR ABSTRACTIONS**

Gestural interfaces are engaging and quick for interacting in "physical" ways, but outside of a core set of manipulations, gestures are complicated, inefficient, and difficult to remember. For less concrete abstractions, designers should offer some alternative means, ideally linguistic input.

## Gestural Interfaces Have a Narrative Point of View

Gestural interfaces can be distinguished by their narrative point of view. Interfaces such as the one Tony Stark uses to design the Iron Man exosuit and *Chrysalis*'s telesurgical interface are *second person*, with the user manipulating states of objects or data. The survey shows several examples of gestural interfaces that are *first person*, in which users control a device, such as a robot, as if they were embodying the thing.

In *Lost in Space*, Will uses a handheld device to control the family robot and remotely "joins" the adults investigating a potentially deadly spacecraft. When metallic, spidery aliens attack the group, Will realizes he needs faster control than the handheld can provide. He drops it and switches to a gestural control that is a first-person interface. It allows him to stand within a translucent, color-coded volumetric projection of the robot and control its direction, speed, gaze, arms, and weapons systems (see Figure 5.8c).

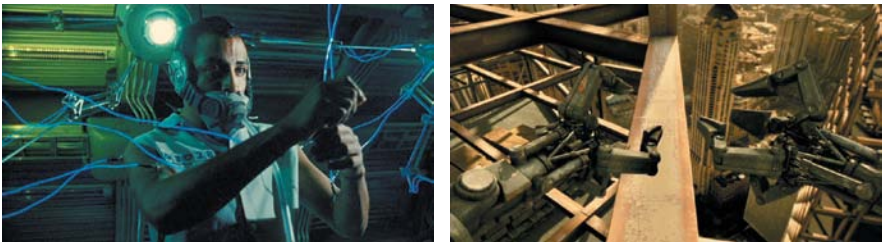


FIGURE 5.17a,b
*Sleep Dealer* (2008).


FIGURE 5.18a,b
*Sleep Dealer* (2008).

In the movie *Sleep Dealer*, Memo lives in Tijuana, Mexico, but does construction work remotely in San Diego using a "wetware" interface (Figure 5.17a) to control a small robot (Figure 5.17b). His gestures control its movement, gaze, and arms, as well as a welding arc.

In this same film, Rudy works for the US Air Force using a similar wetware interface (Figure 5.18a) to gesturally control drone attack planes that patrol Mexican territory looking for rebels (Figure 5.18b).

An interesting and unusual example appears in *Johnny Mnemonic*, when in a video call the deceptive businessman Takahashi gesturally controls the computer-generated image of a person he's had killed. To do this, he holds his hand above a scanner and moves it as if it was the mouth of a puppet. The computer interprets this gesture and moves the lips of the avatar as a result. It also disguises his voice to sound as if he were the dead man. It is a unique example in that the avatar is mapped to a body part rather than to Takahashi's entire body (Figure 5.19).

For the most part, these first-person interfaces might be considered more natural than the second-person gestural interfaces. The remotely controlled robots are an extension of the user's body, with clear mapping between the user and the avatar.

FIGURE 5.19a–c
*Johnny Mnemonic* (1995).

Complications arise from the mismatch of the thing being controlled and the body doing the controlling. In some cases, the human can do something that the machine can't. Neither of the robots mentioned above could jump, for example, though there's nothing to stop their controllers from doing just that. This is a relatively simple problem, as the system can simply ignore the input.

What's more troublesome is when the robot can do something for which the human doesn't have an easy analogue. In *Lost in Space*, we see the robot retreating from the spidery aliens. Will extends his hands in the direction of the spiders to fire the robot's weapons at them. Cutting back to a view of the robot, we also a see laser shooting from the robot's head. How does Will control that?

It's simple to come up with an apologetic explanation—that the laser is simply following his gaze, or it is controlled by systems usually controlling the entire robot. But the mismatch is a good illustration of the core problem of first-person interfaces. What would Will do if he wanted to control the fire of that third laser? His hands and legs are otherwise engaged. Some other channel of input must be engaged to address this additional control.

The problem becomes even more complex when the robot is less anthropomorphic. In *Sleep Dealer*, Rudy's gestural interface controls a drone aircraft. What's the gestural analogue of dropping bombs? Or an Immelmann turn (Figure 5.20)? These things don't have intuitive analogues.

Rudy could use a gestural throttle, of course, but this just illustrates the limits and challenges of a full first-person gestural interface. It can't do everything that the robot can, and therefore needs additional interface layers.

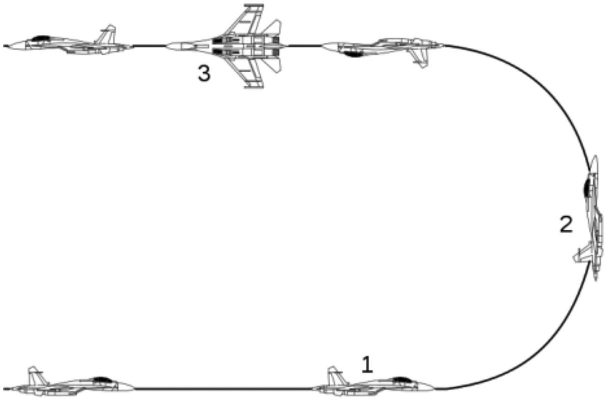



FIGURE 5.20
An Immelmann turn.

### OPPORTUNITY DESIGN A THIRD-PERSON GESTURAL INTERFACE

*Third-person* gestural controls allow control of the behavior of a thing from without. This could be as simple as a camera above and just behind an avatar. Many video games, and virtual worlds such as *Second Life*, adopt this convention to allow for a better view of the avatar's environment. A third-person perspective can also describe a bird's-eye view that would, for example, allow a general looking at a live, sand-table view of a battlefield to control an army of robots by means of gestures and commands.

The written documentation for the *Minority Report* Precrime scrubber explains that to select a new camera angle, users indicate with their left hand the thing to be viewed, and use their right hand to describe the position and frustum of the camera. Though this is a third-person gesture, it is not apparent from watching the movie, and the survey didn't find any other examples of a third-person gestural interface.

### LESSON CHOOSE A NARRATIVE POINT OF VIEW THAT MAKES SENSE

First-person gestural interfaces work best as an extension of the user's body when the controlled device is anthropomorphic. Otherwise, an additional layer of interface is required and might call on another point of view altogether. Sometimes, giving the user the ability to swap between views may accommodate different tasks.

## Gestural Interfaces: An Emerging Language

Gestural interfaces have enjoyed a great deal of commercial success over the last several years with the popularity of gaming platforms such as Nintendo's Wii and Microsoft's Kinect, as well as with gestural touch devices like Apple's iPhone and iPad. The term *natural user interface* has even been bandied about as a way to try to describe these. But the examples from sci-fi have shown us that gesturing is "natural" for only a small subset of possible actions on the computer. More complex actions require additional layers of other types of interfaces.

Gestural interfaces are highly cinemagenic, rich with action and graphical possibilities. Additionally, they fit the stories of remote interactions that are becoming more and more relevant in the real world as remote technologies proliferate. So, despite their limitations, we can expect sci-fi makers to continue to include gestural interfaces in their stories for some time, which will help to drive the adoption and evolution of these systems in the real world.

CHAPTER 6

# Sonic Interfaces

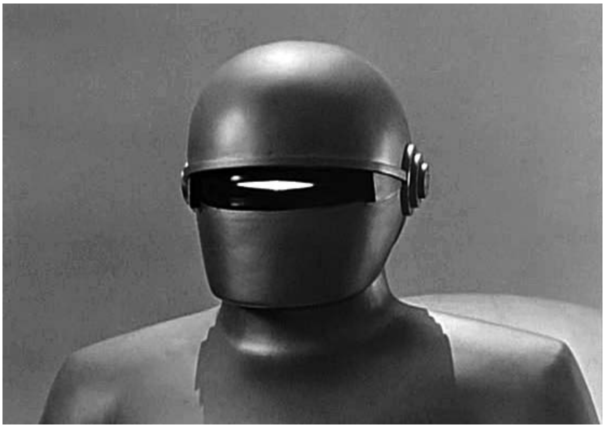


FIGURE 6.1
*The Day the Earth Stood Still* (1951).

After the alien Klaatu is shot by a nervous soldier, his robot companion, Gort, appears menacingly from within the landed spacecraft. Its visor slowly rises to reveal a disintegration beam, which Gort uses to begin destroying all weapons in sight, including artillery and a tank. Klaatu, wanting to de-escalate the situation, turns to Gort and shouts, "Gort! Declet ovrosco!" In response, Gort stands down, ceasing the counterattack (Figure 6.1).

Gort isn't the first piece of technology in sci-fi to have a conversational interface. That honor belongs to the wicked robot Maria from *Metropolis*, but as it is a silent film, we do not get to hear the commands delivered to her. In the case of *The Day the Earth Stood Still*, we can study the tone, pace, and responses in real time without having to interpret from lip reading and intertitles. This makes it easier to study this primary example of a sonic interface.

## What Counts?

Sound becomes part of the interface when it is an input or output for a system's state and function. Note that this is distinguished from simple audio content, such as the music from a radio. We've broken out sonic interfaces into two broad categories: sonic output and voice interfaces.

## Sound Effects

We commonly encounter systems that use sounds for output: status, alerts, and responses. For example, our telephones play a distinct tone for each button pressed in the numeric keypad. Alarm clocks buzz to wake us up. Cars chime to remind us to buckle our seat belts. We see similar system sounds throughout sci-fi, as well. Audiences have come to expect some kind of audio interface because it helps us understand the action in a film or TV show.

## A Brief Experiential History

The ringing of a telephone was one of the first sonic interfaces common in people's lives, but even though the telephone appeared in the late 1800s, it remained one of the few sound interfaces until well into the 1950s. Though they produced sound to deliver content, even radio and television didn't deliberately employ sound in their interfaces until much later. Sound effects of this time were analog and mostly confined to appliances such as alarm clocks, buzzers on ovens, and bells on timers.

From the production side of things, beeps and buzzes, chimes, and tones can be added to a soundtrack along with all of the other sounds necessary in a TV show or movie, such as the click of a button or the creak of a door. The art of adding such sounds is called *Foley* after Jack Foley, a sound engineer who launched the field in 1927, and is surprisingly more complex than one might initially think. For example, almost every sound other than actors' voices in a movie is added after the filming is complete,[1] and many sounds are created using objects that differ from those being portrayed. Despite this complexity, sound plays such a strong role in conveying a sense of realism and futuristic technology that studios have included simple effects in sci-fi as part of sonic interfaces since the advent of talking pictures.

1 And sometimes even the actors' voices are recorded in a studio and put back into the soundtrack of the film. These must be precisely synchronized with the original speech and actors' lips.

For example, when we hear the specific double beep with rising tone in *Star Trek,* we know the system is hailing someone. Similarly, when we hear the same tones reversed we know that the communication is over and the channel is now closed. If the same beep were used in each case, it would confuse us and the characters as to whether the channel was still opened or closed.

**LESSON** **ASSIGN ONE SYSTEM SOUND PER SYSTEM EVENT**

Users need to be able to differentiate system sounds to understand their meaning. Systems that use multiple sounds and sound sequences to communicate system messages will require some learning, but ultimately they communicate more information. In addition, the sounds need to be used consistently with specific actions in order to be associated with those actions.

The later *Star Trek* episodes used nearly twice as many different systems sounds, sequences, and voice responses as the first series. This differentiation could speak to the sophistication of the ship's systems in specifying audio output with more precision, the care the production designers took and the increased sophistication of the tools available to them, and the audience's increasingly sophisticated expectations and understanding of system sounds in the interface. Regardless, because many of our expectations are set or influenced by what we see in media, developers must consider more sophisticated sound solutions in their interfaces.

## Ambient Sound

The ambient clacking of moving parts within a mechanical computer, like reels turning to access a section of tape memory, can be considered part of an interface because the clicks indicate that the system is working, even though this sound is mostly a by-product and not a designed signal.

In sci-fi, we find numerous examples of computer systems making such sounds, particularly to signal to audiences that they're working to process a large set of data. When Scotty, the chief engineer of the *Enterprise* on *Star Trek*'s original series, remarks that he can tell that the ship's engines aren't tuned correctly because the hum they are producing is slightly off, he is calling attention to such sounds. But this doesn't have to be an accidental by-product. With digital technologies, we can include this information deliberately.

**LESSON** **CONVEY AMBIENT SYSTEM STATE WITH AMBIENT SOUNDS**

Different ambient sounds can unobtrusively inform a user that a system is operating and indicate its current state in broad strokes. Ambient sounds need to strike a balance between being the sonic focus and being too far in the background. If the sounds are completely unobtrusive, they aren't useful. To be effective, they must not come to attention until it's required, like when a system problem arises. This means the level of sounds must be calibrated, beforehand or dynamically, so that background sounds can come forward to a user's attention.

## Directional Sound

Humans naturally hear in three dimensions. Our ears are extremely sensitive, capable of discerning microsecond differences between the sound waves reaching each of our ears. Systems that produce sound directionally can enhance our understanding of where a sound source is in space, its direction, and its speed. Because our sense of directionality is fast and subconscious, it must be done precisely when replicated technologically, but the effects provide information to users that are immediately understandable and actionable. An apologetics example helps explain its power.

FIGURE 6.2
*Star Wars Episode IV: A New Hope* (1977).

When Luke and Han climb into their gunner stations aboard the *Millennium Falcon*, they strap themselves in, turn on the targeting computer, and put on headphones. As TIE fighters speed by, we hear the roaring approach of their engines, the piercing blasts of the laser cannon fire, the fading zoom as they speed away, and, if the stormtroopers are less lucky, the boom as their ship explodes (Figure 6.2). Few people pause to consider the physics of the situation, but where are these sounds coming from? After all, there is no air in space to convey sound waves between the exploding TIE fighter and the *Falcon*. Of course we could excuse this as a convention of film, a way that the filmmakers engage the audience in the firefight. But if it helps the audience, wouldn't these same sounds help the gunners, too? What if this wasn't a filmmaker's trick but a powerful feature of the weapon system itself? Let's presume that the *Falcon*'s sensors are tracking each TIE fighter in space and producing the roars and zooms directionally to provide a layer of ambient data that helps the gunner track opponents, even when there are several targets or they are out of sight. This makes the sound effects a powerful sonic aspect of a mission-critical system.

**OPPORTUNITY** **CONSIDER USING SPATIAL SOUND FOR NONSPATIAL INFORMATION**

Hearing people don't have to learn to locate sounds in space directionally. It's a built-in capability. Designers can use this to place information, even when it's not "naturally" spatial, in the space around the user. For example, if an interface for monitoring stock market portfolios used sounds to draw attention to trading activity that was likely to affect the portfolio, these signals could be made to seem closer than sounds used to indicate other activity. A user might need to be trained for the meanings behind arbitrarily assigned directions, but thereafter they would provide contextual clues to help inform more concrete tasks.

Directional sound is a little tricky to portray to more than one user in a space and works best when the sound delivery is spatially constrained, such as with headphones or in a small area occupied by one person. When more than one person inhabits a space, their individual capabilities, orientations, and locations need to be processed so accurate sound can be sent to each one separately, which may be prohibitively complicated for most multiuser systems.

## Music Interfaces

We see only two interfaces in the survey that use music as a part of the interface as well as part of the content. The first example is *Close Encounters of the Third Kind,* in which a specific tonal sequence forms a welcome message—one of acknowledgment and understanding. The five tones are G, A, F, F (an octave lower), and C. This musical phrase is implanted telepathically into a few people who encounter smaller alien spacecraft as an invitation to visit the massive mother ship that arrives at the climax of the film. When the mother ship appears at Devil's Tower, the US Army greets it with the same tones played on a specialized electronic organ (Figure 6.3).

It is a simple musical interface, with a user playing a standard synthesizer keyboard. As each note sounds, a corresponding colored light illuminates on a huge array. This is the visual part of the alien language, which is vital for complete communication.

The other example is an interface from *Barbarella* that uses music as a weapon. Like in *Close Encounters of the Third Kind,* the music is part content, part interface. Here, the evil scientist Durand-Durand straps Barbarella into a seat within his musical torture device called the Excessive Machine. Each note he plays on the keyboard simultaneously performs nefarious sexual acts on its victims, in an attempt to pleasure them to death. Though the exact cause and effect is demurely hidden from view, it is worth noting for the synergy of the playing, the music, and the intent (Figure 6.4).

FIGURE 6.3a–c
*Close Encounters of the Third Kind* (1977).

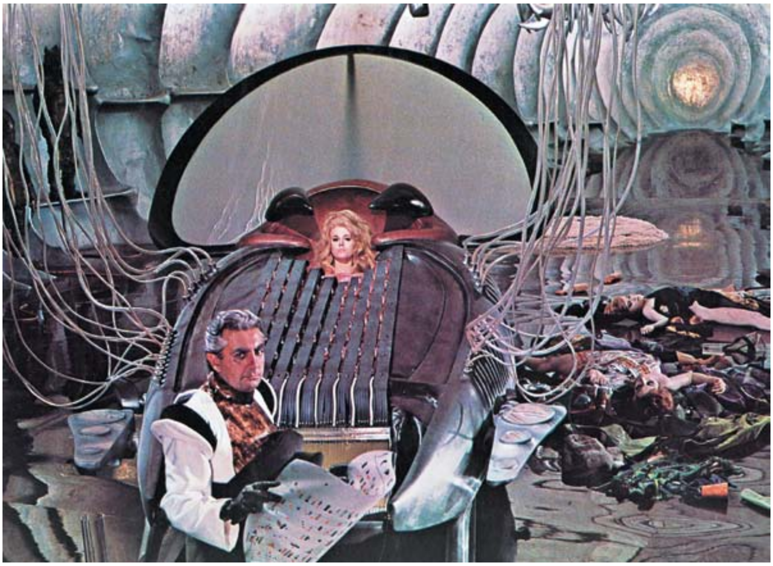


FIGURE 6.4
*Barbarella* (1968).

**OPPORTUNITY** **MAKE MUSIC IN THE INTERFACE**

What if interfaces could use music for indicating system status? It would not be without its challenges: encoding meaning into the music, handling users' preferences for different styles of music, and processing data aesthetically so that its patterns are intelligent and not cacophonous. But once solved, it might be a way to receive system information—particularly ambient information—that is pleasant and not widely explored.

## Voice Interfaces

Where sonic interfaces really strike a chord is with voice interfaces. They are found throughout sci-fi, and over time their frequency has been increasing, for a number of reasons:

- Voice interfaces are easy for writers to imagine and audiences to understand because they rely on our innate language abilities.
- Voice interfaces are easy to create and portray. For input, actors speak into a system and it responds accordingly. For output, a voice actor can provide the output, and the track incorporated as part of the Foley editing.
- Voice interfaces still seem advanced, especially when they have fully conversational capabilities.

Voice interfaces have a range of sophistication:

- Simple voice output provides spoken information for listeners.
- Voice-identification systems, most often used for secure access, responds to specific words or numbers for security and can sometimes include voiceprint analysis.
- Limited-command voice interfaces might only respond to a few words and phrases and a small set of commands, making it easy for systems to isolate and identify the correct meanings. These can be coupled with voice-identification systems, in some cases.
- Conversational interfaces are capable of parsing everything spoken by a speaker. This is a humanlike level of language understanding. Conversational voice interfaces include both language recognition and voice synthesis.

In current, real-world interfaces, these four categories are fairly distinct. In sci-fi, however, we find examples with a combination of these systems. As technology progresses, this may point the way toward a greater mixing within real-world interfaces, as well.

## Simple Voice Output

The most basic of voice interfaces are those that provide information spoken as a prerecorded or synthesized voice.

One of the most familiar of the simple voice outputs in sci-fi is the warning countdown. In movies including *Alien*, *Star Trek*, and *Galaxy Quest*, when scuttling procedures are initiated, a Klaxon sounds as red lights provide a general warning. While attention getting, these mechanisms only tell that there is a critical problem, not exactly what that problem is or what is to be done about it. To provide that information, a female voice repeatedly announces that the self-destruct is under way, and that people have a certain amount of time to evacuate to a safe location.

**LESSON** **PUT INFORMATION IN THE CHANNEL IT FITS BEST**

Should a bit of system information be conveyed through audio or spoken language? Though every piece of content needs to be considered in its particular context of use, a good rule of thumb is to put peripheral information in peripheral channels. Since Captain Kirk could feel confident that his communicator was on when he heard voices coming from it, and off when he heard nothing or got no response, the double beeps that signal opening and closing communications can be considered peripheral and can be signaled as system sounds instead of a voice that would convey the same information. Conversely, if the system needs to convey that 10 seconds remain before the whole place is gonna blow, it could be conveyed as a rising tone, but the information is important enough that the discreteness and omnidirectionality of language is required.

## Voice-Identification Interfaces

There are many examples in which characters speak to a computer in order to gain access to a restricted area, dangerous function, or sensitive content. Although voice-authorization technology is available in the real world, it's been a mainstay of sci-fi for several decades. The earliest example in the survey is in *Star Trek* (the original series), as Kirk sets the auto-destruct sequence for the *Enterprise* in the episode "Let That Be Your Last Battlefield" (Season 3, Episode 15). Some of these systems check for specific spoken data, such as a password or code. Others check for a voiceprint, which includes some combination of vocal qualities such as timbre, tone, and spectrum. These sci-fi interfaces are simple and offer simple confirmation.

A few other unique voice security interfaces warrant examination. In the film *Lost in Space,* weapons are vocally secured. When John Robinson picks up a gun, he speaks the command "Deactivate safety!" to unlock it. Instantly, his voiceprint is checked and the command carried out as he begins to fire the weapon (Figure 6.5). We learn later that the gun can be disabled for certain people—particularly for the untrustworthy Dr. Smith. In another scene, Don West locks the room used to imprison Dr. Smith with a simple, forceful "Lock!"; we can reasonably assume that the room won't respond to Dr. Smith himself should he try to use a voice command to unlock it.

This system check for voiceprint is common and, in sci-fi, is occasionally thwarted by heroes and villains alike to gain access to restricted areas. Some use recordings of authorized people, others assemble passphrases from recordings of authorized people, and others, since this is sci-fi, are simply able to mimic the person's voice directly. For example, in the film series *X-Men*, Mystique is a metamorph capable of transforming into any other person. In *X2*, to gain access to a government computer system,

FIGURE 6.5
*Lost in Space* (1998).

she transforms into a senator's assistant and uses her voice for access. In *Star Trek: The Next Generation*, the android Data is also able to mimic others' voices well enough to bypass voice security measures.

**LESSON** **REQUIRE MULTIFACTOR AUTHENTICATION**

If there are ways to mimic or replicate authorized voices and security is important, adding at least one other form of identification, such as a retinal scan, typed password, or face recognition system, would strengthen security over one form of identification alone.

A humorous example of a problem with a voice-identification system comes from the 2009 *Star Trek* reboot film when Ensign Pavel Chekov tries to authenticate himself to the system in his heavy Eastern European accent: "Ensign authorization code: nine-five-wictor-wictor-two!" He gets increasingly frustrated as it repeatedly fails. If this interface were a voiceprint, Chekov's accent would be part of the match. This simple joke highlights just a bit of the difficulty present systems have parsing spoken language and predicts that it won't get much better in 300 years.

**LESSON** **ACCOUNT FOR VARIATION IN ACCENTS**

Even within the same language, there is considerable variation in pronunciation across different dialects and idiolects. If a system isn't able to recognize common or even individual variation in such characteristics as intonation, pronunciation, diction, and rhythm, it may inadvertently deny access to those who should have it. Designers need to be sure and include this in their requirements for such systems.

## Limited-Command Voice Interfaces

In *Blade Runner,* Deckard investigates a set of special photographs recovered from a hotel room. Though these photographs appear two-dimensional, they contain 3D information captured at the moment the image was taken. To examine them, Deckard inserts the photos into an "Esper machine," a television-like device he has in his living room. It works like this: After the picture is inserted, the screen reveals a blue grid, behind which a scan of the photo appears. He stares at the image in the grid for a moment and speaks a series of instructions that are short and direct: "Enhance, stop . . . Move in, stop . . . Pull out, track right, stop . . . Enter and pull back, stop . . . Track 45 right, center and stop . . . Enhance 34 to 36 . . . Pan right . . . Pull back, stop. Wait a minute. Go right" (Figure 6.6).

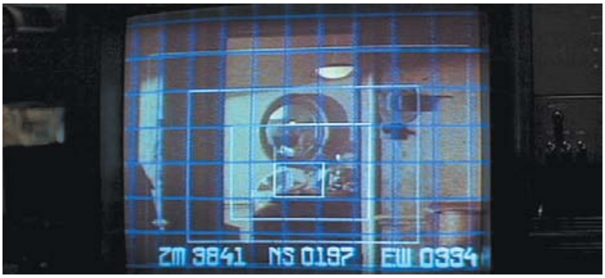



FIGURE 6.6
*Blade Runner* (1982).

In response, the Esper zooms and pans the photo on the screen and shows three sets of numbers at the bottom of the screen: ZM 0000 NS 0000 EW 0000. The NS and EW—presumably north–south and east–west coordinates, respectively—immediately update to his spoken commands. (Attentive audience members will note that later numeric commands do not match what is shown on screen.) The only time he uses a full sentence that sounds somewhat conversational is at the end of the scene: "Give me a hard copy right there." In response, the machine prints the part of the image shown on the screen.

This kind of reduced vocabulary makes it much easier for systems to respond to voice instructions. They only need to look for specific patterns and can ignore many variables and vocal characteristics that might stump a system required to respond to grammar or a larger vocabulary. Such limited-command voice systems are already common today, and they are at the heart of hands-free automobile technology such as OnStar, mobile technology such as Apple's Siri, and the oft-maligned voice-response telephone support systems.

**LESSON** **REDUCE VOCABULARY TO INCREASE RECOGNITION**

The smaller the vocabulary that a voice recognition system needs to understand, the more confidently it can identify keywords. More constrained contexts help this. The Esper machine in *Blade Runner*, for example, only needs to recognize a few commands for spatially exploring a photographic scan. If he was far enough from the microphone that only "ack right" registered, the system could assume he meant "track right." If you are developing a limited-command voice interface, consider reducing the glossary that a user must memorize to the smallest feasible size.

**LESSON** **IGNORE WORDS NOT PART OF THE RECOGNIZED VOCABULARY**

Many current systems are designed in such a way that if you add words and phrases that aren't part of its vocabulary, the system fails to recognize the words it does understand. Although the examples mentioned above focus on the use of limited vocabulary, we have to imagine what would happen in the case of a character using more than the specific, expected vocabulary. For example, if Deckard commanded the Esper machine with "Pull out and track right to the cell two over, please," we wouldn't expect the system to be stumped. But that's true of many nonconversational voice systems today.

Some users cannot easily distinguish between limited voice-command systems and conversational systems, so owing to their social training, they speak to these systems conversationally. If the system isn't specifically designed to ignore this extra input, in the way Google searches ignore words like *the*, *to*, and *of*, the system will attempt to treat the extraneous (though polite) content as important.

One unusual vocal interface found in our survey is the "weirding module" seen in the film *Dune* (Figure 6.7). The Atreides clan uses these vocal weapons to amplify specific words and vocalizations, then focus and project them as energy. Part of the device is worn around the neck, with two silver cylinders placed on either side of the throat, and the other is a box held in the hands and used to position the direction of the energy. Paul Atreides quickly masters the device, and when he escapes to live with the Fremen, he teaches them how to make and use these devices as well. Eventually, they learn that his Fremen name, Muad'Dib, is the most powerful vocalization possible for the device. In this example, the spoken words are both content and the interface for activation.

FIGURE 6.7
*Dune* (1984).

**LESSON** **CHOOSE COMMAND WORDS THAT ARE REPRESENTATIVE OF THE ACTION**

The more obvious the system commands, the easier the interface will be to learn and use. But be wary of words that have multiple meanings or are easily confused within the context of use. For example, a self-driving car could be designed to respond to the words “left” and “right,” but without a qualifier like “turn” they could inadvertently change course while a political discussion ensues between passengers. Even then, the possibility of disastrous misinterpretation exists, which is why many current systems (like Siri) and sci-fi systems (like the *Enterprise’s* computer) use a moniker to signal when the system should take notice for a command (see below for more on this).

## Conversational Interfaces

Truly natural language interfaces still represent the pinnacle of vocal interfaces, and the real world hasn’t gotten there quite yet. Modern voice response systems may seem conversational, but these are actually elaborate limited-response interfaces that include polite niceties and respond to key words. To be a truly conversational interface, systems need to handle the full complexity of conversational language, including unexpected requests and responses.

For example, when J. F. Sebastian returns to his apartment at the top of a vacant building in *Blade Runner*, he is greeted by two handmade automaton toys: a clown and a bear (Figure 6.8). When they approach he says to them, “Evening fellas,” to which they respond “Home again, home again, jiggity jig. Goooood evening J. F.!” Their manner conveys that this is a routine interaction between them, which might make us suspect they were simply checking for his voiceprint. But when they see his guest, Pris, they look nervously at her, and he explains to them in casual language that she is a friend and to be trusted. This interaction suggests they have greater conversational capabilities than was at first apparent.

**FIGURE 6.8**
***Blade Runner*** **(1982).**

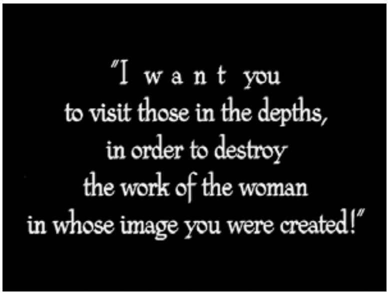



FIGURE 6.9
*Metropolis* (1927).

Nearly every mechanical robot, android, and gynoid in sci-fi has a fully conversational interface. As mentioned above, as early as 1927 we see the robot Maria in *Metropolis* responding to spoken instructions given to her by Joh Frederson (Figure 6.9).

In contrast, artificial intelligences like HAL didn't display conversational interfaces until at least four decades later. Audiences immediately accepted that human-shaped machines could speak but could not believe a nonhumanoid machine could master language until much later. Once the idea was out there, nearly all nonhumanoid artificial intelligences were given the ability to speak: Max from *Flight of the Navigator*, Deep Thought from *The Hitchhiker's Guide to the Galaxy,* even the user-friendly, godlike galaxy that Bender encounters while floating in deep space in the *Futurama* episode "Godfellas."

Computers on Federation ships in the *Star Trek* films and TV series have fully conversational interfaces (voiced by the beloved voice actress Majel Barrett Roddenberry across six series, four films, and seven video games). In *Star Trek*, the ship's computer system parses natural speech and responds, in kind, with natural (if sometimes slightly formal) language.

The ship's computer must be addressed with a control phrase to get its attention, namely by saying "Computer." Many limited-command interfaces work the same way. Perhaps this was so audiences could tell when a character is addressing the machine instead of addressing another character, but it also helps the system know when it should pay close attention and will be expected to understand and respond. Though the system is alerted by a control word or phrase, with both HAL and the *Enterprise* computer, the rest of the interface is conversational. This is, of course, consistent with conversational dynamics in public or when many actors are present. We often need to call out the name of whom we're addressing when in conversation around others.

**LESSON** **MAKE IT EASY FOR THE INTERFACE TO KNOW IT IS BEING ADDRESSED**

If users are having conversations that aren't intended for the system, there's a risk that the system will try to mistakenly act on what it hears. This could be frustrating for users who have to retroactively undo some accidental action or wonder why the computer is not responding.

Ideally, the system itself should be sophisticated enough to determine when commands are intended for it in the same way people do: by monitoring the user's gaze, inferring from the content of conversation, and asking when it is uncertain. But in cases in which a user needs to be discrete or the technology isn't sophisticated enough, give the user controls.

If such conversations are common, this could be handled with discrete modes, such as "listen to me" and "don't listen to me," activated with a manual control, a screen control, or voice commands.

If such conversations with the computer are the exception, a simple escape phrase can set the temporary attention for the duration of the conversation. People are social animals and are used to addressing each other by name, so a good tactic is to let the user set a temporary "listen to me" mode by addressing it by name. A common way this is done is for the system to listen for an alert word or phrase, such as its name, as HAL does in *2001: A Space Odyssey*, or a more generic term, like the word *computer* in *Star Trek*.

Alternately, if conversations with people are the exception, the system can be designed such that when the user begins a statement with a person's name to disregard it. This way if Picard needs to say, "Data, shut down," he doesn't accidentally disable the entire ship.

Once a *Star Trek* crew member gets the computer's attention, the conversational interface mirrors human conversation greatly. It can parse complex grammar, nuanced word senses, commands split between users, colloquialisms, and cultural references. It understands hundreds of languages and dialects and can shift seamlessly between them. This kind of sophistication makes for an exceedingly powerful and natural interface, but it is difficult (some have argued, impossible) to build, and expectations for its use are as high as they would be for a human.

**LESSON** **CONVERSATIONAL INTERFACES SHOULD FOLLOW HUMAN SOCIAL CONVENTIONS**

If a system seems to have full conversational capability, users' expectations will be that it can follow basic human rules of conversation. These include acceptable pacing, the role of politeness and honorifics, speech disfluencies such as "umm" that signal to the listener that they should hold on while the speaker is thinking, rules for interruption, nonlexical conversational sounds and discourse markers such as "mm-hmm" and "wow" that confirm that the listener is still engaged and in agreement, and the four so-called Gricean maxims.[1]

1 These four maxims are quantity (speakers provide as much information as necessary but not too much), quality (speakers are truthful), relation (speakers don't stray too far from the subject), and manner (speakers are clear and brief).

Advanced conversational interfaces need to be aware of these sorts of social rules, understand them, and respond in socially appropriate ways in order to fulfill their role as considerate, if subservient, conversationalists.

## Sonic Interfaces: Hearing Is Believing

Sonic interfaces seem less sci-fi than many other technologies we explore in this book because we commonly encounter many types of sonic interfaces in our lives today, such as system beeps and limited-voice interfaces. Users may prefer and expect the naturalness of truly conversational interfaces, but these are still difficult to build convincingly outside of sci-fi. User expectations of successful sonic interfaces increase significantly across the spectrum described here.

Simple system sounds need to be clearly heard and understood, but we don't have greater expectations for them. The more a voice is present in the interface, the more users expect that voice to represent the social characteristics of another person. This is especially true of the human quality of the voice used (the more representational, the higher the expectations). There aren't many lessons at either end of this spectrum because the first are so simple and the last use human conversation as their model.

As Marshall McLuhan famously observed, "We are simply not equipped with earlids." We evolved to constantly monitor sounds as evidence of the truth of the things around us, and to pay attention to them for meaning. Sci-fi has long recognized this characteristic, harnessing it to make its speculative technologies believable, useful, and inspirational. Almost from the beginning, sci-fi has filled our ears with the promise of technology with which we could fully converse, using the full power that language brings. Though we're still a long way away, we can listen carefully for those things that work and make our technology sing.

CHAPTER 7

# Brain Interfaces

FIGURE 7.1
*Buck Rogers*, "War of the Planets" (c. 1939).

Buck tightens the chinstrap on the tall mind-control helmet placed on Killer Kane's head (Figure 7.1). Kane's face goes blank and expressionless. Buck says, "You'll take orders from me now, Kane," before walking him to the space radio and instructing him to broadcast the command, "This is the Leader Kane. Withdraw all outer atmosphere patrols to their flying fields," thereby ending the War of the Planets.

Thought is invisible. And the thing that houses our thoughts, the brain, is hidden in the protective bone box of our skulls. Even if we could see our brain when our thoughts are racing at 100 miles an hour, it would look like it's just sitting there. But audiences and sci-fi makers alike are aware of the importance of this organ as the seat of thought, and of the central role that thought and memory plays in human life. This proves an irresistible lure for the imagination of speculative technologies, but it also poses a creative challenge to sci-fi makers: How do you make interactions with this most invisible and unmoving of materials apparent to the audience?

## Physically Accessing the Brain

To indicate to an audience that a device is accessing a user's thoughts, designers first have to show that the technology has access to the brain.

### Invasive Brain Interfaces

The most direct way is to show technology plugged into a person's brain or nervous system, but this sort of invasive connection naturally triggers negative reactions from most people. For most of us, seeing a foreign object sticking out of a person's head or neck indicates a dire medical emergency or, at the very least, something seriously wrong. Though some sci-fi makers seek to capitalize on this sort of body horror, most do not.


FIGURE 7.2a,b
*The Matrix* (1999).

FIGURE 7.3
*Dollhouse*, "Epitaph: Return" (Season 2, Episode 13, 2010).

In *The Matrix* films, for example, a menacing and sharp plug is inserted into the base of the skull to allow that person to "enter" the Matrix (Figure 7.2). In another example, the final episodes of *Dollhouse* showed jacks implanted in the face that let people upload and erase information and skill modules at will (Figure 7.3).

Despite these two examples, direct-connection brain interfaces are rare. Most interfaces in sci-fi don't rely on technologies that pierce the skin.

## Noninvasive Brain Interfaces

The easiest noninvasive way to show access to the brain is by proximity. Most audiences assume that technology put near or around someone's head probably has something to do with the brain. This definition of "head" includes the forehead but usually excludes the face, perhaps because things near the face might be interpreted as having more to do with either speech or the sensory organs—eyes, ears, nose, and mouth. The face might be excluded from these kinds of connections in sci-fi simply so audiences can see the actor's expressions, but the face is a preventatively thick barrier between sensors and the brain anyway.

There are other noninvasive ways to show the connection between the brain and technology, but the need for proximity is closest to the actual science. Thoughts are complicated and ill-defined things, and what a real-world brain–computer interface technology actually measures is the faint electromagnetic waves emanating from the brain as a result of clusters of neurons firing. Because many of the brain's regions are specialized for certain types of thought, scientists must scatter many sensors around the skull to pinpoint the region sending a particular signal. Audiences and sci-fi makers have likely seen images of skullcaps with lots of small sensors and wires emanating from them, providing a real-world paradigm for speculative brain–computer interfaces.

### *Worn Devices*

Noninvasive direct-contact brain interfaces in sci-fi take two main forms: smaller devices that fit on the head, and larger machines that the user sits in.

Most brain interfaces seen in the survey are devices that are worn on the head—especially the crown (Figure 7.4). In *Metropolis*, the mad scientist Rotwang's machine uses a skullcap. In the *Buck Rogers* serial of 1939, Killer Kane controls his worker zombies by means of a tall metallic hat (see Figure 7.1). In *Brainstorm* and *Johnny Mnemonic*, the devices fit around the user's head. The *Lawnmower Man* straps a helmet onto himself and his victims. In *Flight of the Navigator,* David wears a metallic headband. The Game from the *Star Trek: The Next Generation* episode of the same name has players wearing the devices like glasses. The mind-blanking haloes in *Minority Report* are worn like earphones.

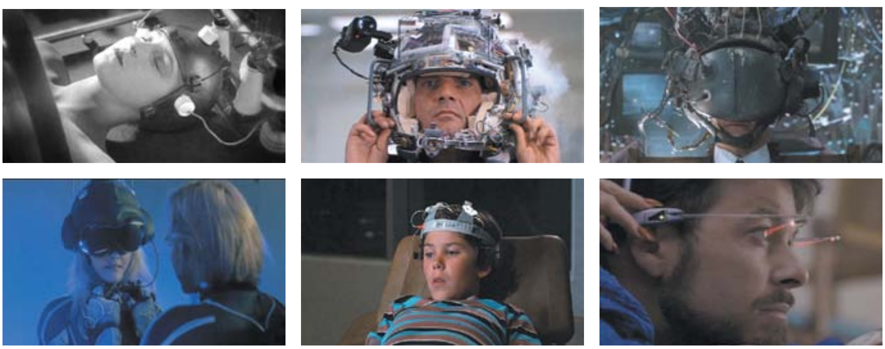


FIGURE 7.4a–g
*Metropolis* (1927); *Brainstorm* (1983); *Johnny Mnemonic* (1995); *Lawnmower Man* (1992); *Flight of the Navigator* (1986); *Star Trek: The Next Generation* (1991); *Minority Report* (2002).

Other devices are larger and require users either to sit inside or to strap themselves into them. The Krell thought-manifesting technology in *Forbidden Planet* requires users to lean forward and lower two long rods to their temples (Figure 7.5a). Both deneuralizers from *Men in Black 2* are large and require K to sit within them (Figure 7.5b, c). Agents working for the *Dollhouse* have their minds wiped and replaced while sitting in a reclining chair (Figure 7.5d). Tom Paris from *Star Trek: Voyager* flies an alien shuttle with an artificial intelligence named Alice from a seat with an affixed "neurogenic" interface (Figure 7.5e).





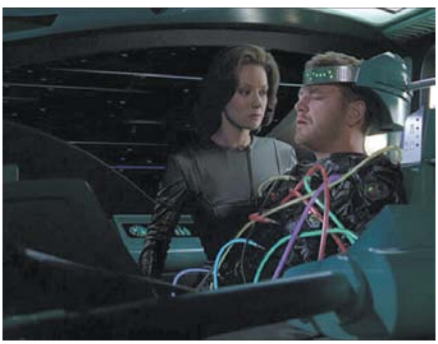


FIGURE 7.5a–e
*Forbidden Planet* (1956); *Men in Black 2* (2002); *Men in Black 2* (2002); *Dollhouse*, "Ghost" (Season 1, Episode 2, 2009); *Star Trek: Voyager*, "Alice" (Season 6, Episode 5, 1999).

## Where Do Sci-Fi Interfaces Sit?

Where do sci-fi audiences expect brain interfaces to sit?

When we overlap all of the brain interfaces from the survey onto a single head (Figure 7.6), we can see an image of the common physical location of brain interfaces. An arc over the head from ear to ear is there for stability, but it also floats away from the head when the subject is reclining. Sagittal arcs play a strictly stabilizing role for technology.

The crown is the most important location for these technologies. The forehead appears in cerebral sci-fi such as *Star Trek* and *Forbidden Planet*. More visceral sci-fi, such as *The Matrix,* focuses on the back of the head. Whole-head and cranial interfaces turn out to be closer to real-world science, which needs input from all areas of the brain.

Though the industrial design of real-world brain interfaces relies on the particular science involved, industrial designers should be aware of the expectations that have been set.

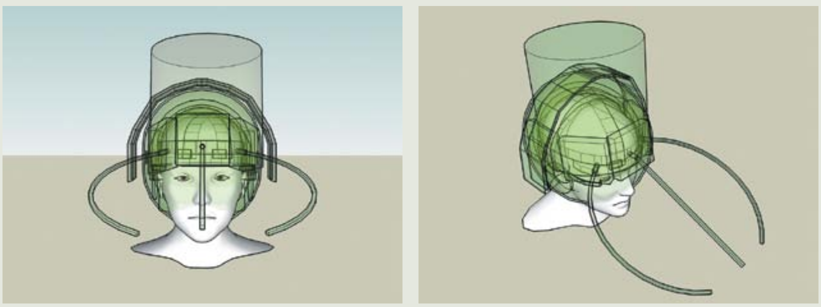


FIGURE 7.6a,b
Overlaying physical brain interfaces from sci-fi reveals some patterns.

### *Remote Connection*

Two examples show brain access from a distance, with victims usually unaware they are being manipulated.

In the final episodes of *Dollhouse*, the doll technology has advanced to a stage where any person's mind can be wiped from a distance (Figure 7.7). This throws all of civilization into terrified, anti-technology chaos.

In the *Star Trek: The Next Generation* episode "The Battle," Ferengi commander DaiMon Bok uses a highly illegal and rare Thought Maker to exact a complicated revenge on Commander Picard. The Thought Maker is a large broadcast device for painfully implanting false memories in a target. It is paired with a smaller receiver device that produces even stronger effects when near its victim (Figure 7.8). (More on this below, in "Unwilling Subjects.")

FIGURE 7.7a,b
*Dollhouse*, "The Hollow Men" (Season 2, Episode 12, 2010).

FIGURE 7.8
*Star Trek: The Next Generation*, "The Battle" (Season 1, Episode 9, 1987).

## Disabling the Mind

The survey includes a few technologies whose purpose is to disable the mind of the subject: to forbid its subject any agency, thought, or the development of new memories. These interfaces are particular to their properties, and few generalities can be made other than their proximity to the brain.

In *Buck Rogers,* this technology comes in the form of a metallic top hat with spiraling coils and dials. In *Dollhouse,* the same reclining chair that uploads experiences can be used to wipe an uploaded mind and return the doll to a harmless, dopey state. In *Minority Report,* it is a headband with a single glowing indicator at the rear (Figure 7.9).

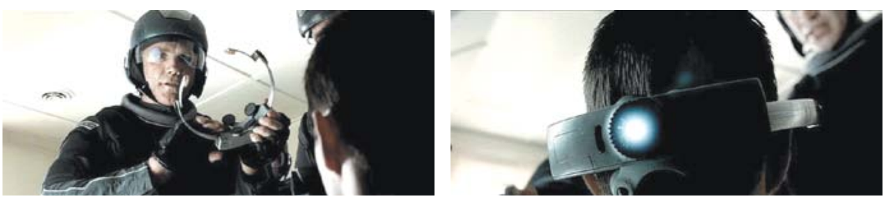


FIGURE 7.9a,b
*Minority Report* (2002).

## Two Directions of Information

We can also distinguish brain interfaces as addressing two different directions of information. Interfaces that enable *reading from the brain* treat a person's thoughts and memories as output. Interfaces that enable *writing to the brain* incorporate the user's thinking as an input.

### Writing to the Brain

Some interfaces are meant to install new information into a subject's brain. The technology takes a much different form if the subject is unwilling, so we've separated the examples along these lines.

A note about triggers: It's tempting to include interfaces that trigger preprogrammed effects in a subject's mind, such as in *The Manchurian Candidate,* where seeing a queen of diamonds playing card would turn Shaw into a sleeper agent for the KGB, or the *Dollhouse* trigger whispered over the phone to Mellie ("There are three flowers in a vase. The third flower is green"). Although the trigger signal may be delivered through any media, such as a mobile phone, there are no specialized interfaces seen in the survey for delivering these signals, so we don't include them here.

#### *Willing Subjects*

If the subject is willing (or at least unresisting, as are the dolls in *Dollhouse*), the interface is most often a reclining chair with head-mounted components.

The technology in *Until the End of the World* was originally intended by its creator to give sight to the blind through direct brain stimulation. To see the images, the blind subject rests in a reclining chair with her head in a horseshoe-shaped band of blue lights and an electrode strapped to her head (Figure 7.10a). The device that maps the mind of Joel from *Eternal Sunshine of the Spotless Mind* has a similar hard plastic halo around the head, but the subject is sitting upright as his mind is read and mapped (Figure 7.10b).

FIGURE 7.10a,b
*Until the End of the World* (1991); *Eternal Sunshine of the Spotless Mind* (2004).

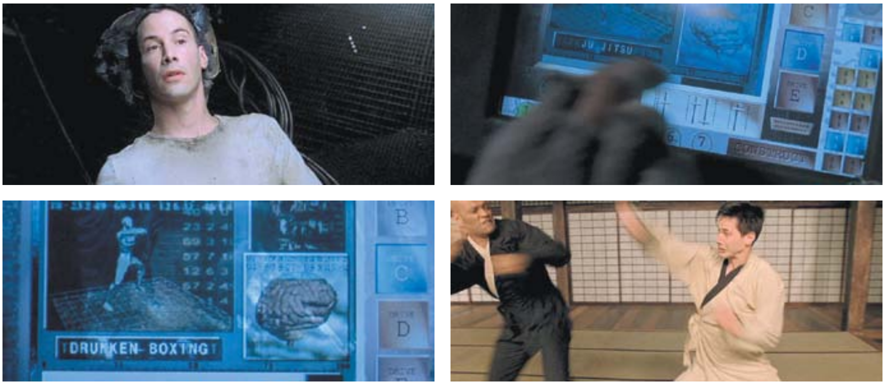



FIGURE 7.11a–d
*The Matrix* (1999).

Perhaps the best-known example of this type of brain interface is seen in *The Matrix*. Whether to access the Matrix or to train for operations, Neo and the others are “jacked in” to specialized systems. For training, skill modules such as kung fu are uploaded into their brains. The operator of this system sees animated visual icons on a control screen that show the skills module and a brain “filling up” with knowledge, serving as a rotating, 3D-rendered progress bar of sorts. Neo is able to immediately put these skills to the test inside the system’s virtual reality (Figure 7.11).

This is similar to the *Dollhouse* procedure in which new personalities and memories are uploaded into human “dolls,” but no process is shown that an operator might see. Instead we are shown a stylistic representation of the new memories rushing toward the camera as a field of images floating against a black background (Figure 7.12). *Avatar* uses similar industrial design and rushing visualizations for its similar technology (see Figure 5.4).

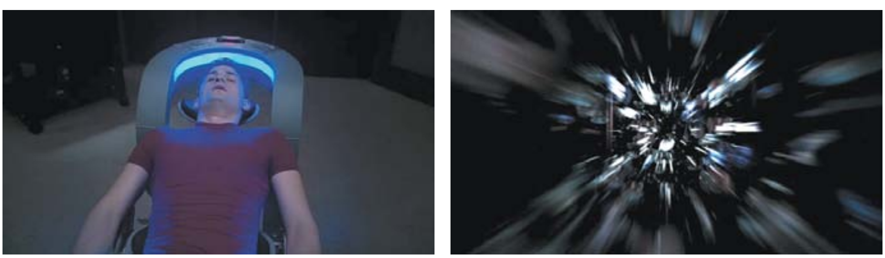
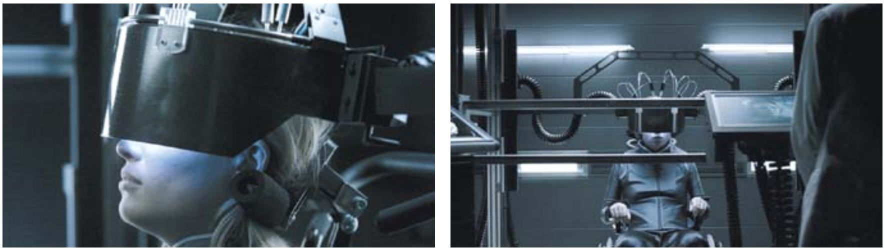


FIGURE 7.12a,b
*Dollhouse*, “Spy in the House of Love” (Season 1, Episode 9, 2009).



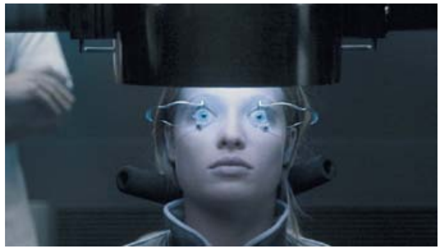


FIGURE 7.13a–c
*Chrysalis* (2007).

Another mind-writing device appears in the French sci-fi thriller *Chrysalis*. The device is meant to "shape memories," but a gangster is using it to implant memories. Though his abuse of the technology is nefarious, the unaware subjects sit in it willingly (Figure 7.13).

The central plot device of *Johnny Mnemonic* involves a technology that modifies a human brain to act as a simple repository for smuggling data over borders, while it remains inaccessible to the carrier. Uploading data is a process that involves plugging a small cable directly into the skull and donning some protective gear to avoid damage during the very painful procedure. One imagines that a reclining position would be more comfortable, but Johnny has a professional, tough-guy reputation to uphold (Figure 7.14).

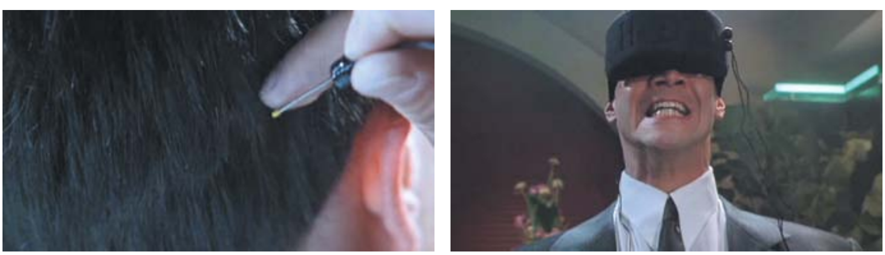


FIGURE 7.14a,b
*Johnny Mnemonic* (1995).

**LESSON** **LET THE USER RELAX THE BODY FOR BRAIN PROCEDURES**

Some sci-fi treats brain-writing technology like an MRI scan, where the procedure is interrupted by a subject's moving. If this is the way actual noncontact brain-writing technology would work (see below for why this technology is unlikely), then providing a comfortable resting position would help to avoid movement due to fatigue or discomfort.

### *Unwilling Subjects*

When the subject is unwilling, the form of the technology becomes particular to the property.

In both of the TV series *Chuck* and *StarGate SG-1*, unwilling victims are force-fed vast amounts of data in a short time. In *Chuck*, the title character is stunned into submission by a rapid-fire set of specially encoded images displayed on his home computer, embedding in his head the only copy of a vast set of US government secrets and rendering him unconscious after it is complete (Figure 7.15a). In the *StarGate SG-1* episode "Lost City," Colonel O'Neil is grabbed by a piece of fluid architecture, and alien information is painfully forced into his brain (Figure 7.15b). These examples have fast interfaces that are not apparent until they activate (to catch unsuspecting subjects off guard).

The *Star Trek: The Next Generation* episode "The Battle" revolves around the Thought Maker, a highly illegal broadcasting device for implanting thoughts into a victim's brain, even to the extent of making him or her disregard reality and instead relive events in the past. The Thought Maker itself looks something like a large, metallic brain, with a glowing red, bisected hemisphere on top and rectilinear, metallic shapes below. The similar-looking, head-size receiving device amplifies the Thought Maker's effects when it is near its victim (Figure 7.16).


**FIGURE 7.15a,b**
*Chuck*, "Chuck Versus the Intersect" (Season 1, Episode 1, 2007); *StarGate SG-1*, "Lost City" (Season 7, Episode 21, 1997).

FIGURE 7.16
*Star Trek: The Next Generation*, "The Battle" (Season 1, Episode 9, 1987).

To use the Thought Maker, DaiMon sets it on a table and rotates the red hemisphere along its equator. He also moves a slider backward along its equator, but the effect of this control is not apparent (see Figure 7.8). The farther the entire hemisphere is rotated, the more pain Jean-Luc endures and the more suggestible he becomes. DaiMon also has a screen with which he monitors the device's effects (Figure 7.17a). Its mysterious variables are displayed as irregular blue bars that angle away from a horizontal axis. The more intensely the device is working, the faster a dark-blue banding slides along the bars and the louder its whine (Figure 7.17b).

FIGURE 7.17a,b
*Star Trek: The Next Generation*, "The Battle" (Season 1, Episode 9, 1987).

A few technologies write to the brain by deleting memories, just as a computer might delete files by overwriting them. The neuralyzer from *Men in Black* is a handheld rod that flashes a bright red light toward its subject. People viewing this light without the protection of special, stylish eyewear immediately forget recent events and pass into a brief fugue state, during which they are subject to false memory suggestion through speech. The interface—one of the few user-facing brain interfaces seen closely in the survey—is a set of dials for selecting the duration of memories to erase, some lights to confirm selection and power, and a push button to execute (Figure 7.18). The devices used to alter memories in *The Adjustment Bureau* are also handheld cylinders, but one shines lines of light into the subject's eyes, and the other ends in an illuminated disk held near the subject's temple (Figure 7.19).

FIGURE 7.18a,b
*Men in Black* (1997).

FIGURE 7.19
*The Adjustment Bureau* (2011).

FIGURE 7.20
*Paycheck* (2003).

FIGURE 7.21
*Eternal Sunshine of the Spotless Mind* (2004).

Other interfaces for wiping memories look a lot like devices from *Dollhouse* and *Until the End of the World*: glowing arcs across the coronal plane of a resting subject that are connected to computers (Figure 7.20).

The device that does the memory erasing in *Eternal Sunshine of the Spotless Mind* works in the subject's sleep while a technician monitors the process. (This is different than the device in Figure 7.10b, which maps the mind.) The device itself looks like a large metal bowl covering the top of the head with wires regularly spaced across it (Figure 7.21).

## Reading from the Brain

Some brain-affecting interfaces extract information passively from their subjects. For these interfaces, a distinction between willing and unwilling subjects isn't particularly useful. For these speculative interfaces, the main challenge for designers is to show that the machines are working, what has been extracted, and when the process is complete.

In *Metropolis*, Rotwang copies Maria's mind into a robot. As the extraction occurs, electricity arcs between Maria's chamber and a sphere directly above it, and strange chemicals bubble in flasks. The helmet she wears in the chamber is a material conduit and doesn't provide any signal. We know the data—in this case, her mind—has been copied when we see the robot's stiff, metallic appearance transform until it looks and moves just like Maria (Figure 7.22).

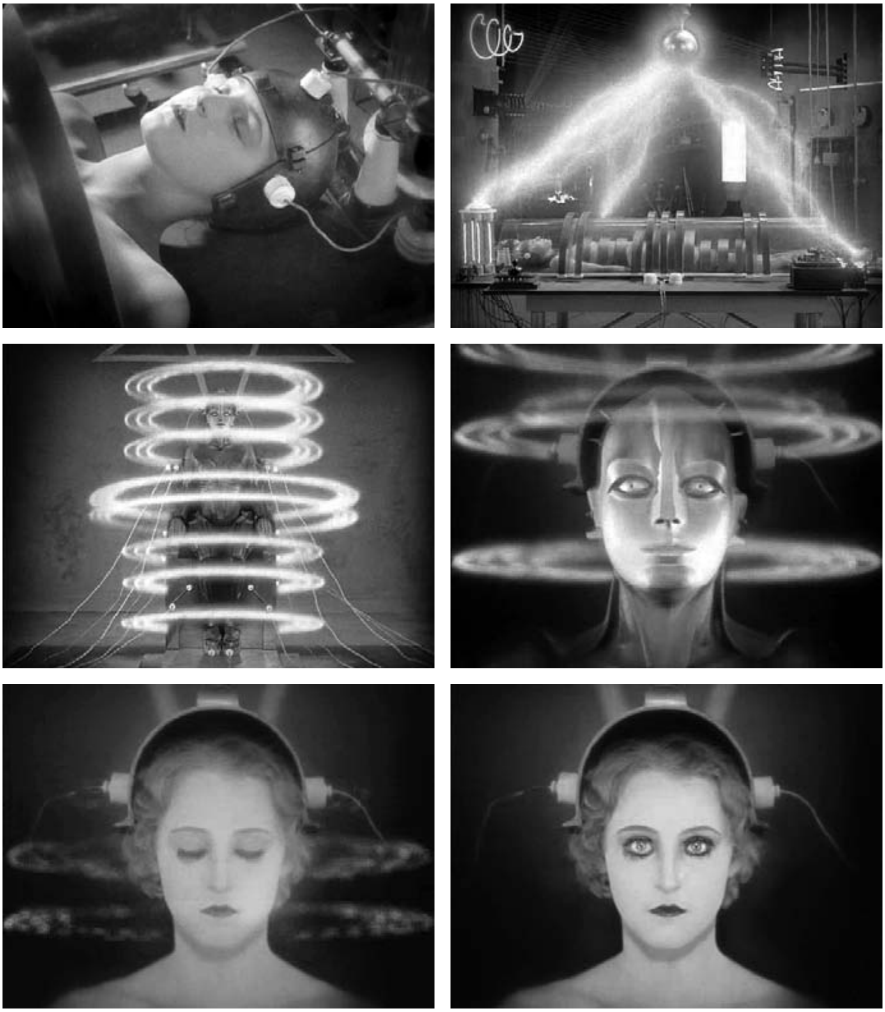


FIGURE 7.22a–f
*Metropolis* (1927).

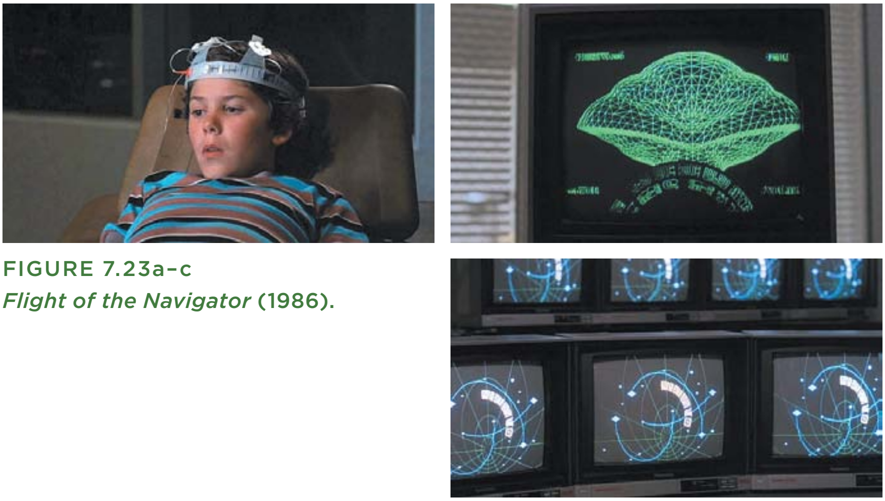


FIGURE 7.23a–c
*Flight of the Navigator* (1986).

In *Flight of the Navigator*, David has mysteriously had alien information, such as star charts and ship schematics, deposited into his brain. Luckily, the scientists at NASA can pipe this data directly out to displays as pixel-perfect, animated graphics via a brain interface strapped around his forehead (Figure 7.23).

In *Minority Report*, three psychically gifted triplets are kept sedated in a pool, and their precognitive visions are piped directly from their minds to video systems that display and record them. The audience knows the system is working because the video screens mounted in the ceiling directly above them are flashing images, and the lights in their headgear and in the pool are illuminated (Figure 7.24).

The *Dollhouse* technology allows the mind of the subject to be read and a copy of it stored digitally, so that a person's memories and skills can be uploaded to a "doll" later. The procedure requires the subject to lie back on a reclining chair with his or her head resting within a horseshoe-shaped component (see Figure 7.12a). An operator starts the copying via a nearby computer or by a few controls on the component itself. We know the device is on and working primarily by the blue glow that surrounds the head of the subject. We know it is complete when the light dims and the chair raises the subject back to a sitting position.

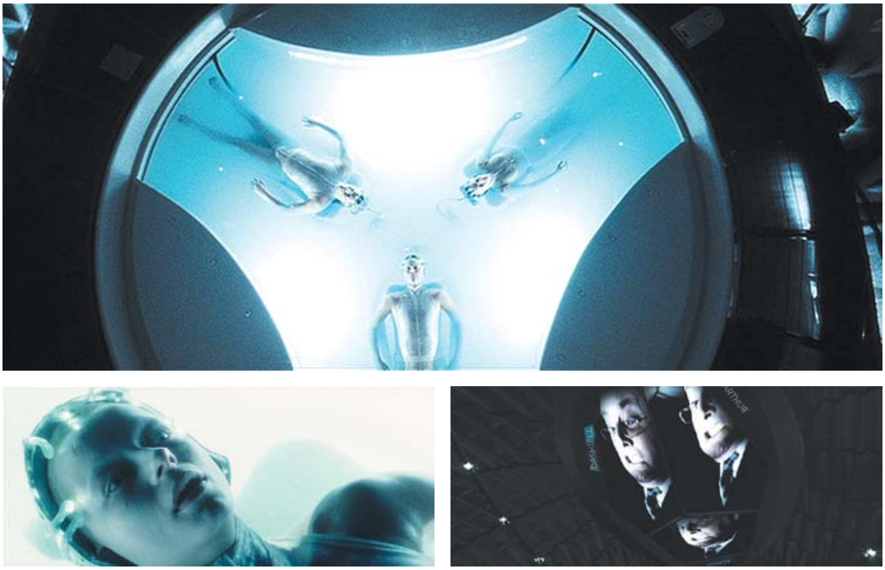


FIGURE 7.24a–c
*Minority Report* (2002).

Wim Wender's epic *Until the End of the World* features a telexperience technology that is adapted to record dreams so that they can be shared with others or watched on a video display. In the world of the film, the technology is new and experimental, and is handled in the inventor's laboratory with complicated electronic equipment. After having first recorded an event with a special binocular, brainwave-reading camera (Figure 7.25a, b), the subject must rewatch the recording and remember the event (Figure 7.25c, d). During this rewatching, the subject's brainwaves are being recorded for later transmission. The subject has electrodes taped to his or her temples and lies back in a curved headrest with an electronic grid lining it. We know it's working because of the various screens that display the moving images gathered by the procedure. We know it's done when the subject's REM state ends, which is seen on screens that monitor the health and brain activity of the subject.

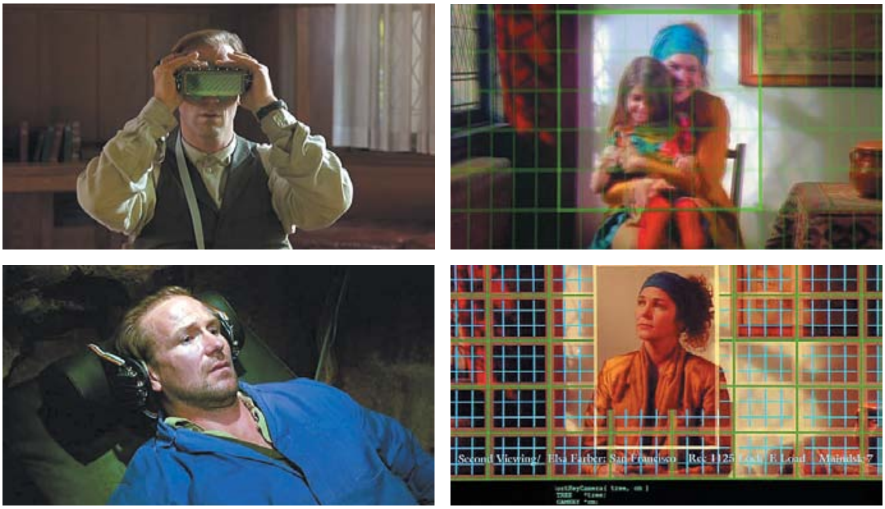



FIGURE 7.25a–d
*Until the End of the World* (1991).

**LESSON** **USE LIGHTS AND REAL-TIME RESULTS TO SHOW READING**

Interfaces that take time to read from a source should signal when they are in process and when they are complete. Sci-fi primarily uses two means to visualize the process. In the first, real-time results of a reading appear on a nearby monitor. This nicely shows what content has been detected, and can even help signal the amount of progress for a lengthy scan. In the second case, where the content is too complex to display as a visual, lights on the reading device near the subject's head illuminate and animate when the read is in progress. Either or both strategies communicate well to observers. The animated icons in various operating systems that loop during long copy procedures are one example, though few show content and most could be simpler.

## Telexperience

Three sci-fi films in the survey tackle the personal and cultural effects of technology that records someone's sensory experiences and allows someone else to fully experience them as if they were there, passively experiencing it themselves. This sort of technology is categorized somewhere between reading and writing to the brain, because recording the experience is separated in time from its later playback.

The first film, *Until the End of the World*, is discussed for its brain-reading capabilities above. The playback process is simpler. Initially the (blind) viewer lies back with her head in a ring of pulsing blue lights. Later in the film, when the technology is adapted to record and play back dreams, the resulting images can be viewed on any video screen like a movie, though it is strictly a visual, not a full-sensory, experience (Figure 7.26).

The second of these films is *Brainstorm*, which focuses on the personal and corporate abuses possible with such a technology. It also shows the iterations that the technology goes through—from clunky laboratory prototype to slick consumer accessory (Figure 7.27).

FIGURE 7.26a–d
*Until the End of the World* (1991).

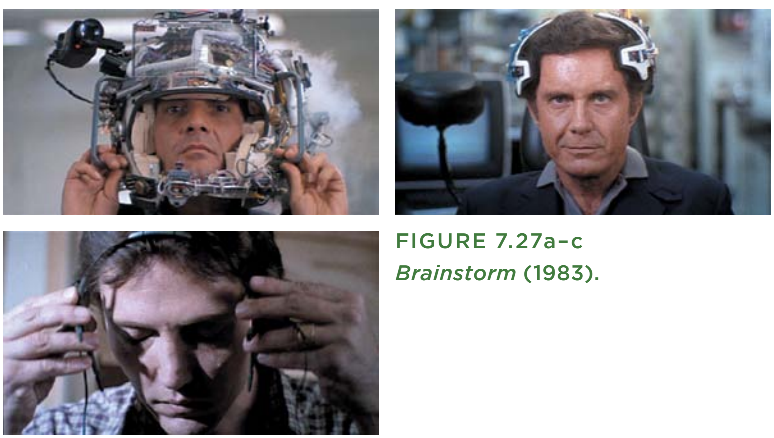


FIGURE 7.27a–c
*Brainstorm* (1983).

FIGURE 7.28
*Strange Days* (1995).

The most recent of these films is *Strange Days*, in which a peddler of virtual-reality pornography tries to catch a murderer who uses the technology in disturbingly twisted ways. In the story, the medium itself is suspect and regarded by some characters as entertainment fit only for lowlifes. So it is no surprise that the device has no external indication that it is on and is most often worn under wigs (Figure 7.28).

## Active Subjects

The other major category of brain interfaces lets a willing user control a system with thought as the primary input. Though it seems like sci-fi would be all over this, a look through the survey shows it is comparatively rare. There are a few telepresence technologies, and then a handful of one-off technologies that are particular to their plots.

Unlike the passive telexperience technologies discussed above, telepresence technologies involve an active participant who is able to act and influence the experience he or she is having.

### Virtual Telepresence

Two properties in the survey address technologies that allow users full-body immersion into virtual worlds. The first is one of the best-known sci-fi trilogies of all time, *The Matrix*.

By jacking in through the socket in the back of his head, Neo makes himself available to an operator who can transfer Neo's consciousness into the virtual reality of the Matrix. Neo, through his avatar, interacts in the Matrix with full agency as if it were a real world with full sensory stimulus and tactile feedback (Figure 7.29).

The rebellion's understanding of the digital nature of the virtual world allows them to use thought as input; to bend the rules of the simulation, performing seemingly superhuman feats to the amazement of people still trapped in the Matrix, who are unaware of its true nature and bound to its laws. While a rebel's consciousness resides in the Matrix, he or she is effectively in a coma in the real world, insensate and unresponsive (Figure 7.30).

FIGURE 7.29a–d
*The Matrix* (1999).

FIGURE 7.30
*The Matrix Reloaded* (2003).

Members of the rebellion have even created virtual spaces with the sole purpose of facilitating specialized tasks, such as training for combat or managing security access to the underground human city of Zion. The virtual interface in this environment does not need to obey any real-world rules (see Figure 5.8d).

**LESSON VIRTUAL REALITY WORLDS SHOULD DEVIATE FROM THE REAL WORLD WITH CAUTION**

The more that virtual spaces deviate from the real world, the more foreign they feel to the people inhabiting them. Our brains and bodies are fairly well adapted to living in the real world, and we have many faculties hardwired into the brain to help us: face recognition, spatial hearing, simple physics algorithms, and an aptitude for spoken language, to name a few examples. Spaces that deviate greatly fail to take advantage of these built-in faculties and require more cognitive effort to make sense of and operate within.

Like with all media, however, adhering to real-world metaphors when the functionality doesn't align can also create confusion. Don't be afraid to deviate from reality when the functions don't fit how things work in reality.

In the *Deep Space 9* episode "Extreme Measures," the effects of Bashir and O'Brien's improvised mind probe are shown cinematically—that is, the two of them are shown walking around in a spaceship looking for a physical file when, in fact, they are probing the mind of an unconscious enemy to look for vital information (Figure 7.31). When they find the "file" and wake up in the real world, we know their task is done. Note, however, that in this episode, they "wake up" several times but are still in Sloan's mind, tricked into thinking they're now back in the real world. This brings up both a common sci-fi theme with brain interfaces as well as a practical challenge when creating these virtual worlds: How do people know when they're out of the mind-created world and back in the real world?

In the film *eXistenZ*, a game system immerses players in a virtual reality where they play roles in an exciting story. In a recursive twist, the virtual-reality game involves a gaming system similar to the real-world system, but its appearance is more biological than technological (Figure 7.32).

**FIGURE 7.31a,b**
***Star Trek: Deep Space Nine*, "Extreme Measures" (Season 7, Episode 23, 1999).**

FIGURE 7.32a,b
*eXistenZ* (1999).

The real-world system uses headgear and a controller in the player's hands (Figure 7.33a). The in-game biological system has similar controls for the player's hands, but the other component is a spinal jack with a cord that looks disturbingly like an umbilical cord (Figure 7.33b, c).

This film provides the most direct comparison between two versions of the same speculative technology, one electronic and the other bioengineered. Functionally they're identical, but the biological version feels creepier—even the noninvasive handheld controller. Should such technologies become commonplace, they might not inspire such a visceral reaction, but until then, designers should be aware of how unnerving such interfaces can be.

FIGURE 7.33a–c
*eXistenZ* (1999).

**LESSON** **BIOENGINEERED TECHNOLOGY IS CREEPY**

Biology has a distinct look and behavior guided by evolutionary rules, especially when compared to man-made technology. When the aesthetics and movements of the body appear in ways that violate our understanding and experience of biology, we feel revulsion, a violation of our shared and near-universal biophilia. This effect is heightened when it appears that this "natural" material has been subverted for man-made ends. Designers should be aware of this visceral response to viscera, and either make direct use of it for creepy ends, or take pains to avoid it for any other purpose.

## Actual Telepresence

*Avatar*'s technology allows a subject's consciousness to be projected to a purpose-grown humanoid creature. The interface is an enclosed bed with a side-hinged chamber for body-monitoring sensors. The only head-related sensors are a few thin transparent lines with bright pinpoints that arc around the subject's head at a distance of a few inches. While the mind is being projected, the human body remains in a disabled state, protected in the coffin-like bed, which rests in turn inside a large metal cylinder similar to a computed tomography (CT) scanner (Figure 7.34).

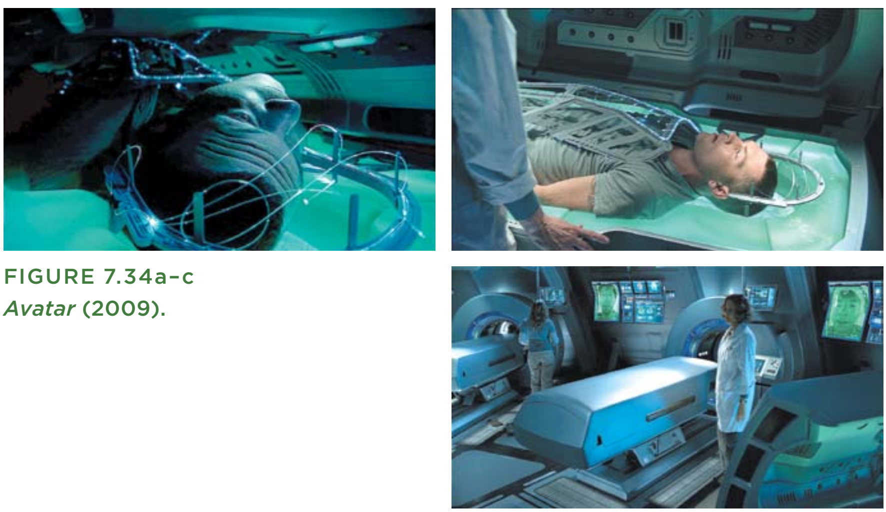


FIGURE 7.34a–c
*Avatar* (2009).

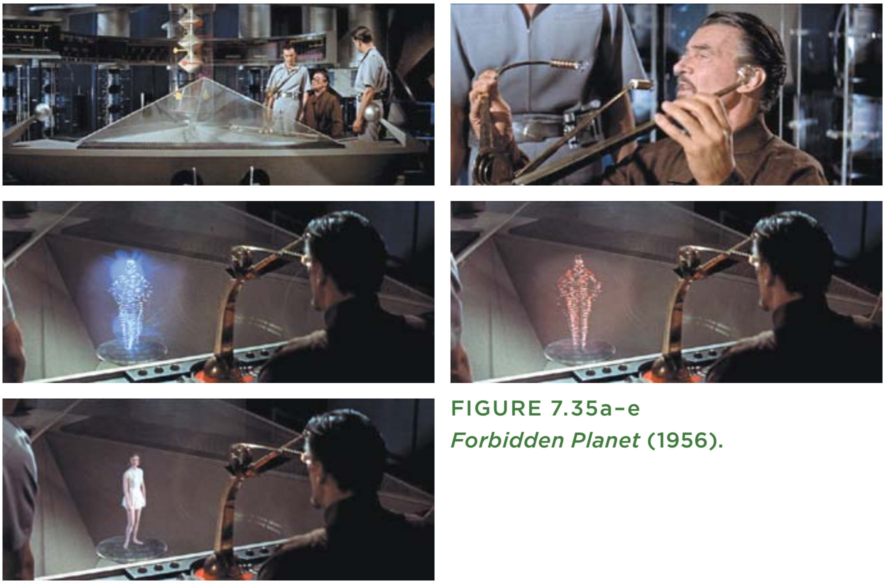


FIGURE 7.35a–e
*Forbidden Planet* (1956).

## Manifesting Thought

In *Forbidden Planet*, Dr. Morbius demonstrates the oddly named "plastic educator," a Krell device that manifests any thought the user has. (It doesn't appear to actually educate.) To use it, he sits in a chair and swivels three lit rods to touch his head, and then concentrates. As the thought becomes clearer, its manifestation resolves. Once manifested, the translucent projection moves of its own accord as the conceived object would. Morbius manifests an image of his daughter, who stands, smiles, and shifts her posture (Figure 7.35). To turn off the device and dismiss the manifestation, he lifts the rods to their original position.

## Having Virtual Sex

When Lenina makes an offer to John Spartan for "sex" in *Demolition Man*, it turns out to be a meeting of the pleasure centers of their minds. To perform the act, they sit a few feet apart and don one of a pair of headgear, then close their eyes and relax. The headgear has a small red light to indicate that it is on. Each feels pleasure and sees psychedelic, sensual images of the other. Disconcerted with the unfamiliar, virtual nature of the experience, Spartan removes the headgear before climax, so there's no indication of how the interaction ordinarily culminates (Figure 7.36). (See Chapter 13 for more on interfaces in this genre.)


FIGURE 7.36a–c
*Demolition Man* (1993).

## Piloting a Spaceship

In the *Star Trek: Voyager* episode "Alice," Tom Paris is selected by the artificial intelligence in an alien shuttle to be its "savior" of sorts. It projects an image of a human woman into his mind and, through this hallucination, convinces him that he must pilot the shuttle to a specific destination. To do so he sits in the pilot's seat and rests his head in a "neurogenic" interface. It is through this interface that he flies the shuttle. The audience knows that the neurogenic interface is on and functioning when green pinpoint lights along its surface illuminate and its retractable arm extends horizontally across the pilot's forehead. Paris has access to a touch-screen interface on the instrument panel, but all dialogue with the artificial intelligence is conducted through speech, and the piloting through the brain interface. After he has been piloting the shuttle for some time, additional glowing wires appear to grow from the chair, snaking across his body and lodging themselves in his skin, illustrating the AI's increased absorption of him (Figure 7.37).

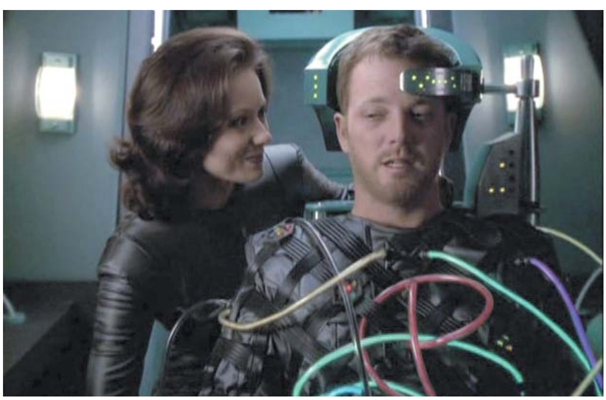


FIGURE 7.37
*Star Trek: Voyager*, "Alice" (Season 6, Episode 5, 2000).

FIGURE 7.38a,b
*Star Trek: The Next Generation*, "The Game" (Season 5, Episode 6, 1991).

### Playing a Game

To introduce Riker to The Game, Etana Jol places a small headset on his crown with thin transparent arms that wrap around in front of his eyes. To turn it on, she presses small controls on the headset above his ears. Small red beams emanate from the tip of the arms to his pupils, projecting the graphics of the game directly onto his retinas (Figure 7.38). The device reads brainwaves, allowing the player to control the 3D position of a small virtual disk. When the player moves the disk into a funnel, the level is complete, and he receives a small buzz to the pleasure center of his brain. The game turns out to be addictive, mind-altering, and somewhat infectious, as it programs players to convince others to play the game as well.

## Dismantling Two Sci-Fi Brain-Tech Myths

Because the brain-affecting interfaces discussed above are either based on bad science or so unlike any other technology that interface designers are likely to be working with, direct lessons aren't apparent. Instead, let's identify the two problematic concepts that become evident when looking at the entire collection.

### Myth: Brain-Affecting Interfaces Will Be Painful

In most of these properties, moving information in or out of the brain is painful to the subject, even when the technology is noninvasive. Subjects' heads are immobilized and their body reclined to a resting position, as if to minimize potential damage and discomfort. This frame is problematic because it isn't true for today's real-world, state-of-the-art technology, and isn't likely to be true in the future, either.

In the real world, the closest science has come to putting data directly *into* the brain is with a procedure called *transcranial magnetic stimulation* (TMI). At best, it can keep subjects alert and aware, and Australian TMI researcher Allan Snyder has shown it can improve subject's scores at math tasks. Otherwise it can dim localized faculties such as inhibition, cause involuntary jerking of muscles, or cause the subject to see white spots of light in their vision. At worst, it can cause seizures, but it doesn't give subjects bodice-ripping migraines like sci-fi would have us believe. Nor has it deposited any "information" into anyone's brain, and it is unlikely to (see the next section).

The closest we've gotten to getting data directly *out* of the brain is with functional magnetic resonance imaging (fMRI) neuron reading. And as of 2008, it was strictly a crude, 10x10 pixel copy of the visual field, certainly not a rich experience or a whole mind (Figure 7.39).[1] Furthermore, the process isn't painful.

Figure 7.39 illustrates the results of this type of reading. It shows what was read off of two subjects. The top row shows what the subjects were being shown while in the fMRI machine. The rest shows what the scientists were able to extract over multiple readings. The last row shows an average, which matches the original most closely.

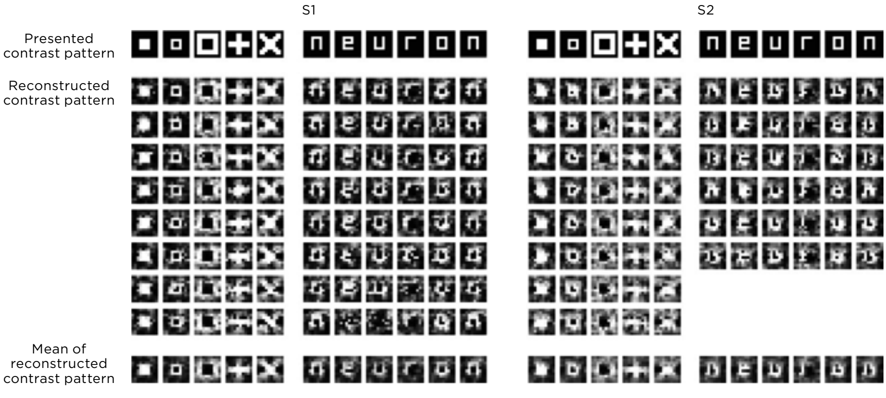



FIGURE 7.39
Scientists have so far only managed to read crude fMRI images from the brain.

1 Miyawaki, Y., et al. (2008). Visual image reconstruction from human brain activity using a combination of multiscale local image decoders. *Neuron*, *60*, 915–29.

### Myth: Knowledge Can Be Installed and Uninstalled Like Software

Some sci-fi properties show skills and information being plugged in to the hard drive of the brain (either through a jack or through the eyes) and uploaded. Just wait for the painful progress bar, and poof!—you know kung fu.

This metaphor is problematic because it runs counter to modern brain science, which says that the structure of the brain *is* the knowledge of the brain. Furthermore, this structure is holographic, meaning bits of information related to a single thought are distributed throughout the brain, and the neurons involved are also used for other thoughts. To "upload" information requires a precise physical restructuring of some significant portion of the 100 billion nerve cells in the gray matter. Neither flashes of light blasting the retina nor electrical impulses shooting through a jack will do it.

## Where Are the Thought Interfaces?

The main thing missing when we look at the brain-reading technologies is *thought interfaces*. What do we mean by this? Aren't they all thought interfaces?

Certainly there are *physical* interfaces for connecting a thinker's brain to a machine, but beyond that, there are precious few audiovisual representations and controls of the systems shown. In most cases, these technologies are really narrative tools that transport the characters to other worlds where the characters interact bodily with their surroundings and linguistically with others. The workers in Zion, for example, use floating gestural interfaces with near-perfect representations of their own bodies (see Figure 4.19a).

In *Star Trek: Voyager*, Paris seems to be flying the Alice shuttle as an extension of himself. We never see the piloting interface that is feeding him information and allowing him to modify the ship's position and systems accordingly (see Figure 7.37).

The primary function of *Forbidden Planet*'s plastic educator is clearly to read from the mind, but the thinking is the entire interaction (see Figure 7.35). When you visualize an object in the way that the machine expects, then you see an image of it. That's it.

The brain-reading technology in *Star Trek: The Next Generation*'s game is closest, but pretty rudimentary: relax to move the red puck into the blue funnel. The interface is also very basic, but there's a feedback loop there to accomplish a task and receive a reward, which pretty quickly becomes the player's goal.

**OPPORTUNITY** **VISUALIZE BRAIN-READING INTERFACES**

Given the kinds of thoughts one can have, physical position seems to be one of the most basic as a candidate for speculative brain-reading technologies. Where are the thinking tools for managing power in a starship? Or aiming weapons? Or developing and testing a complex hypothesis? They just aren't there. These more advanced uses of brain–computer interfaces would require complex interfaces, but not the simple ones seen in the survey.

Why the dearth of interfaces, given even a medium-size collection of brain technologies? Our guess is that it's too soon on the technology curve, and brain-interface technology is too young. As of this writing there are only six consumer brain–computer interfaces on the market. Two of these are toys that measure beta emissions from the brain with dry electroencephalography (EEG) sensors, which correlate to concentration and relaxation and actuate a fan to move a ball (Figure 7.40).

FIGURE 7.40a,b
Force Trainer; Mindflex game.

FIGURE 7.41a,b
Emotiv EPOC.

A more advanced and costly option is the Emotiv EPOC system. It is meant to be a general input device, like a mouse. Its 14 sensors combine with gyroscopes, and it is touted as having, after a bit of training, the ability to capture four mental states, certain thoughts and facial expressions, and head motion (Figure 7.41).

Still, even this most advanced of consumer brain–computer interfaces doesn't have general market awareness, application, or success. Most people don't know about it. This means that there is no established paradigm in the real world for sci-fi makers to build on for their speculative technologies. With little incentive for sci-fi makers to include these invisible interactions in their moving pictures, reality will have to lead the way in establishing this paradigm before we can expect to see enough of these interfaces in fiction to be able to learn lessons from them.

## Brain Interfaces: A Minefield of Myths

It's certainly possible to imagine and depict new interfaces for new kinds of thought aids. In fact, the foundations of these are already in the productivity tools we use every day—from word processors and spreadsheets that help us outline and express our ideas and model complex numerical interactions, to specialized tools such as task lists to aid our memory, Prezi presentations for modeling hierarchical thought, concept-mapping software, flowcharting software like OmniGraffle, and scientific search tools such as Wolfram Alpha. There is a lot of space to explore new interfaces that rethink how we think and aid more complex representations and development. We just need to put a little more thought into it.

CHAPTER 8

# Augmented Reality

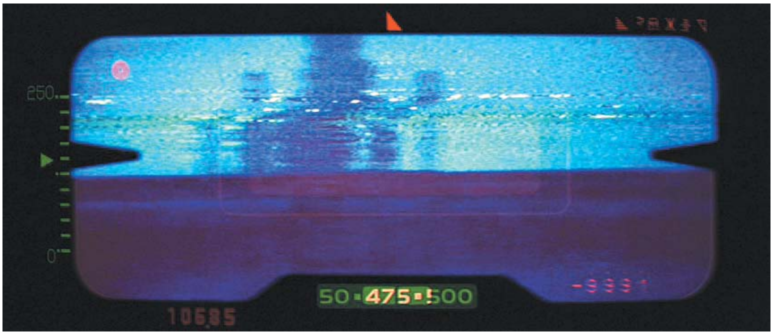



FIGURE 8.1
*Star Wars Episode IV: A New Hope* (1977).

Luke Skywalker rushes out of the farmhouse to the top of a ridge. Looking through a pair of binoculars, he scans the horizon for his new droid, R2-D2. "That R2 unit has always been a problem," C-3PO complains. "These astro droids are getting quite out of hand. Even I can't understand their logic at times." The viewfinder shows data at the edges of Luke's view, but it doesn't help (Figure 8.1). "How could I be so stupid," he whines, "He's nowhere in sight. Blast it!"

Augmented reality (AR) is technology that augments a user's perception of the real world with useful, additional information. Though any of the senses could be augmented, AR is almost always visual in nature. It appears in a number of technologies in our survey, including binoculars, weapons, communications systems, heads-up displays (HUDs) for pilots, and even inside cybernetic eyes.

## What Counts?

As its name suggests, AR is about augmenting reality, not replacing it. Representation of reality doesn't count. In *Chrysalis*, for example, Dr. Brügen cannot compare the volumetric projection of her telesurgical patient with the real thing because the patient is thousands of miles away (Figure 8.2).

This example illustrates one of the constraints of AR. Because it is tied to reality, a user cannot readily manipulate the representation for scale, position, or state. It is conceivable that a system could pass between an AR mode and a manipulable representational mode, but our survey doesn't reveal one.

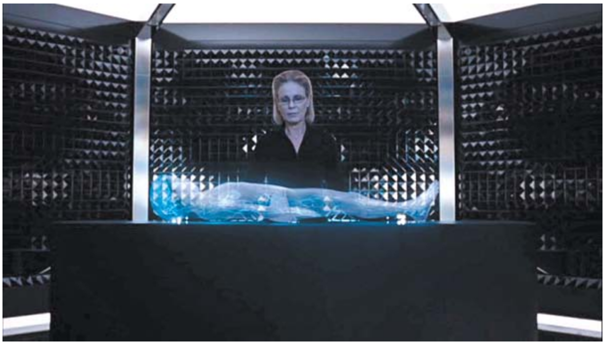


FIGURE 8.2
*Chrysalis* (2007).

Additionally, to augment reality, the information should *overlay* reality. The holoimager from *Firefly* floats its radiographic image *above* the patient (Figure 8.3a). To check it against reality, the user has to glance downward, so this speculative interface is just outside of our definition of AR. The *Lost in Space* volumetric display, in contrast, overlays Judy on the surgical table (Figure 8.3b). This allows Dr. Smith to check her for outward signs and gives him a radiographic view of her internal organs at the same time and in the same place. For this reason the *Lost in Space* example is just within our definition, even though it is quite similar to the *Firefly* example.

Virtual reality doesn't count either because, by definition, it replaces the user's perceived reality. It's conceivable that a virtual reality could be easily augmented for its users, but there isn't any such example in the survey.

These criteria define the boundaries of AR, which must refer to reality and overlay it. What we have found that meets these criteria falls into four categories of augmentation: sensor display, location awareness, context awareness, and goal awareness. But before we describe these categories, a word about the appearance of AR systems.

FIGURE 8.3a,b
*Firefly*, "Ariel" (Episode 9, 2002); *Lost in Space* (1998).

FIGURE 8.4
*Iron Man* (2008).

## Appearance

Augmenting reality without obscuring it is the primary challenge for any AR system. Nearly every example in sci-fi solves this problem with translucent overlays that allow most of the "real" view to show through. This allows cinemagenic camera shots that show the user and the interface simultaneously, which looks appropriately futuristic because such displays are not common today (Figure 8.4).

Many AR interfaces use intricacy of shape and complex motion to communicate technological sophistication to the audience. More recent examples add information that is modal, appearing automatically when needed though rarely completely disappearing. The combination of these aesthetic choices would likely be problematic in the real world because of the high degree of visual strain and distraction. Until real-world exposure informs audiences differently, however, we suspect this trend will continue because it suits storytelling needs.

## Sensor Display

The simplest examples of AR are those that display basic sensor information at the periphery of a display. Often this is "dummy data" written in obscure symbols or a fake alphabet to add credibility and the appearance of technological sophistication without needing to worry about actual meaning.


FIGURE 8.5a,b
*The Incredibles* (2004); *Transformers* (2007).

*Star Wars Episode IV: A New Hope* included simple sensor information with its binoculars (see Figure 8.1). The magnifications are enhanced with what is probably something like bearing, distance, and magnification measurements.

Though the audience can't always decipher the information, the implication is that it is useful for the user. In *The Incredibles*, the Omnidroid, a robot the villain constructs to take over the world, has an AR with lots of numbers and graphics displayed, but little sense can be made of it (Figure 8.5a). A similar AR from *Transformers* is even more inscrutable because it's based on an alien language (Figure 8.5b).

In *Iron Man*, Tony Stark's HUD shows him a great deal of sensor data, including suit performance data, flight controls, and environmental information. It's worth mentioning that the HUD is not a model for legibility—the amount of information is too great, with too much distracting motion (Figure 8.6).

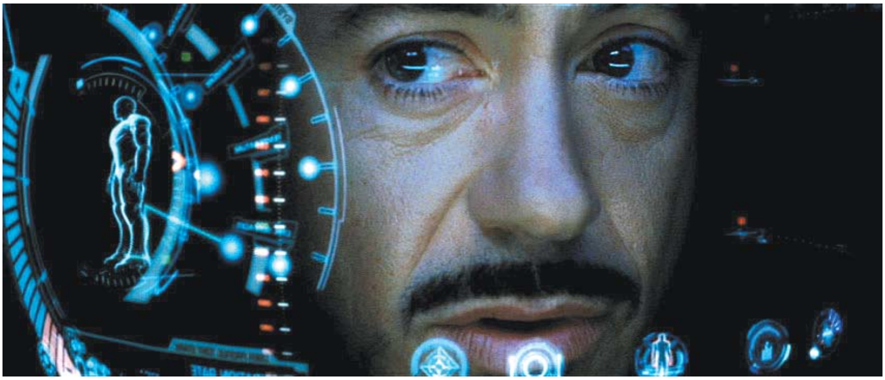


FIGURE 8.6
*Iron Man* (2008).

### LESSON AUGMENT THE PERIPHERY OF VISION

As these sensor display interfaces illustrate, AR potentially obscures too much of the user's view. To avoid getting in the user's way, designers should use visual design that maximizes transparency while maintaining readability. Objects should be placed at the edge of the user's view when they are not needed, and adjacent to the locus of attention when they are. Because human brains are hardwired to detect motion, data pushed to the periphery risks triggering false positives in the user's peripheral vision. Therefore, movement at the edges of the display should be kept to an absolute minimum.

### LESSON PLACE AUGMENTATIONS AT THE CURRENT DEPTH OF FOCUS

One of the challenges with AR and HUDs is the focal depth difference between the augmenting information and the real-world view being augmented. Users who must change focus constantly and quickly between the two—even when overlain—get eyestrain quickly. Imagine the difficultly Tony Stark might have refocusing between the glass in front of him and objects in his flight path. Ideally AR systems should have stereoscopic capabilities so the augmentations seem to be at the same distance as the thing being augmented. This way the user can access the information with a simple glance without having to fully refocus.

One of our favorite, surprising, and subtle examples of sensor display in AR appears in an apologetic for the gunner seats aboard the *Millennium Falcon* in *Star Wars*. We shared this example in Chapter 6, but in short, this interface augments the silent dogfight in space with dramatic audio to increase the gunner's field awareness (Figure 8.7). It bears another mention here because it reminds us that augmentations can happen across more than the visual channel.

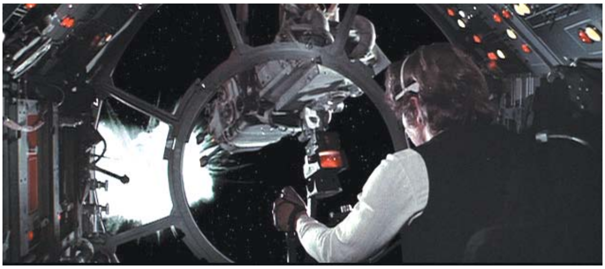


FIGURE 8.7
*Star Wars Episode IV: A New Hope* (1977).

**LESSON** **CONSIDER ALTERNATIVE CHANNELS FOR INFORMATION**

When working with one sensory channel, consider alternative channels for the augmentation. These other channels might be better suited to the information and have the additional benefit of not obscuring the primary one.

## Location Awareness

Another category of AR has the system displaying geographic information about the user's location. An early and unsophisticated example appears in *Robocop*. As Robocop searches for his past, he heads toward the location of James Murphy's old house. En route, his HUD shows the names of streets as he approaches. When he is on the right street, the interface switches to a more precise mode that displays the address for which he's looking (Figure 8.8).

A more recent and sophisticated example appears in *Minority Report*. Evanna is the field officer in charge of the search operation for the fugitive John Anderton. She remains in the pilot seat of a dropship to coordinate the operation while other officers enter a building to conduct a search. The upper right portion of her HUD shows the team's location on the city map along with several layers of additional information, such as the compass bearing of the ship. This same map appears in the lower half of the view in full perspective, adding schematics to the real view through the HUD (Figure 8.9).


FIGURE 8.8a,b
*Robocop* (1987).

FIGURE 8.9
*Minority Report* (2002).

A particularly cinemagenic type of location awareness is terrain modeling. In both *Aliens* and *Iron Man*, characters navigate difficult terrain in dim conditions. In response, their interface augments the terrain with bright cyan contour lines, helping to make the location more navigable and giving the audience a strong sensation of motion in the process (Figure 8.10).

Neither example explains how the contour lines are known to the system. It could be a real-time presentation of radar or sonar data, in which case it's a sophisticated type of sensor display. Especially in the case of the Iron Man suit, though, it seems more likely that the system accesses a topographic database correlated to the suit's current GPS and altimetry data. A third, more remote possibility is that it functions more like a human, recognizing the terrain visually and drawing on top of what it sees. This would make it a sophisticated example of context awareness, discussed next.

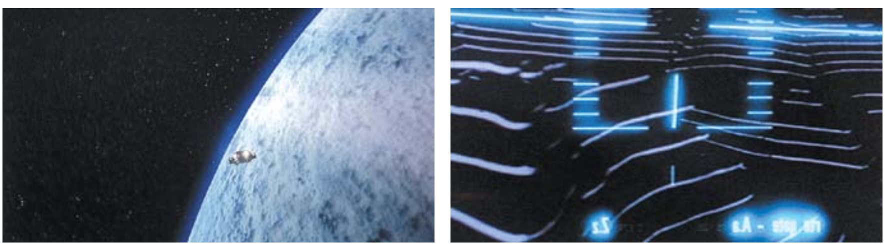


FIGURE 8.10a–c
*Aliens* (1986); *Aliens* (1986); *Iron Man* (2008).

## Context Awareness

Context awareness includes the system's awareness of objects or people in the environment.

### Object Awareness

Some AR systems display information about objects and people in view of the user. The type of information shown depends both on the system and the object or person, and sometimes its context. In the following example, Tony Stark's HUD has identified that the children he can see in magnified view are riding the Santa Monica Ferris wheel (Figure 8.11).

Recall that in this scene, Tony is in the act of flying his experimental, supersonic, and weaponized suit for the first time. Tempting him to read an encyclopedic entry about the Ferris wheel seems like an irresponsible distraction. Although his onboard artificial intelligence named JARVIS might be able to handle the piloting while Tony is engrossed in the minutiae of the 1893 World's Columbian Exposition in Chicago, a better solution, given JARVIS's presence, would be to provide just the name and schematic, and let Tony ask for more information. JARVIS could tell him what he wanted to know while letting Tony look around and monitor the flight visually.

**LESSON** **INFORMATION IS EMPOWERING, BUT DON'T DISTRACT THE USER**

It's possible to augment reality with all sorts of rich, layered information, but the user only has one locus of attention, and their focus is on the task at hand. To avoid distracting them, limit content to what is either vital or explicitly asked for, relegating cues about access to further information to a distant second level of attention.


FIGURE 8.11
*Iron Man* (2008).

FIGURE 8.12
*Firefly*, "Serenity" (Episode 1, 2002).

In the pilot episode of *Firefly*, an Alliance cruiser spots the eponymous spaceship while on patrol and suspects it of illegal salvage. While the Alliance commanding officer discusses what to do with the hapless heroes, the bridge viewport in the background encircles the view of the ship with additional information (Figure 8.12).

The tricky bit about this scene is the augmentation graphics. They are properly aligned for the camera and officers. But what do the soldiers on the left side of the bridge see? The parallax would be wrong for them, putting the augmentation far to the right of the ship. In fact, all overlays must take into account the viewer's perspective. Shared HUDs like this one can't do what it appears to do. Apologizing for episode writer and director Joss Whedon, perhaps this cruiser has a super-advanced display technology that beams separate overlays to each viewer's eyes and then crops the overlay to the boundaries of the viewport to reinforce that the object being augmented is outside the ship. But that's pure apologetics (see p. 268 for a similar parallax issue with medical volumetric projections).

**LESSON** **AUGMENTED REALITY IS PERSONAL**

It's possible that augmentations can be coordinated between AR displays such that each viewer sees the same thing as if it were "in reality," but this should be kept to high-level or public information, such as street signs or general warnings. Doing so leaves room for the personally relevant sort of information that is the promise of AR systems, like directions to a place others might not be headed to. In the case of the Alliance bridge, for example, this would mean that different officers would see different augmentations. The communications officer might be able to see graphics describing whether the communications channels are jammed. The weapons officer could see whether the ship's shields were up. The science officer might get a readout of any radiation or chemical emissions from the ship.

## Awareness of People

People are social creatures, so AR sometimes augments social interaction. In the time-traveling adventure *Back to the Future Part II*, future Marty is speaking with his boss, Douglas Needles, over a large videophone in his living room. During the course of the conversation, the system shows some peripheral information about Needles, including his age and occupation (Figure 8.13).

In *Iron Man*, Tony has access to similar biographical information on his HUD about his friend Rhodey while on a telephone call with him (Figure 8.14). In neither scene do characters make use of this information, so it is difficult to assess if it was the right stuff to display. It could be based on the users' preferences. We suspect that future systems could use the conversation itself as a source for determining what information is relevant.


**FIGURE 8.13a,b**
*Back to the Future Part II* (1989).

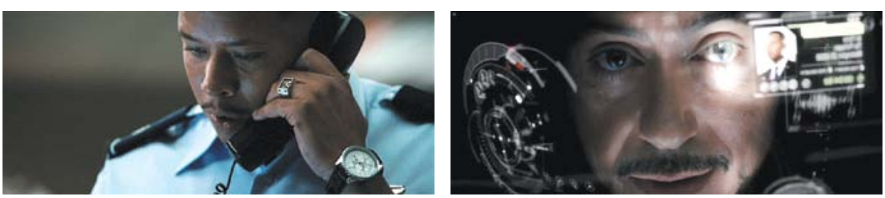


**FIGURE 8.14a,b**
*Iron Man* (2008).


FIGURE 8.15
*Terminator 2: Judgment Day* (1991).

A useful bit of augmentation in combat is to know who in view is friend or foe. In *Terminator 2: Judgment Day*, the T2 cyborg has AR built into his vision. When assessing the threat from soldiers in the Cyberdyne lobby, the overlay tells him to "select all targets," which we know he has done after he incapacitates them all in a matter of seconds (Figure 8.15).

**LESSON** **IN AUGMENTED REALITY, EVERYTHING IS SPECIAL**

We do not see a circumstance in this film where there is a mix of friend and foe in one view, so we don't know how the T2 AR would display it. We know the system has the capability of highlighting individual objects, so it could visually distinguish the dangerous ones. This view, then, must be a special mode for dealing with cases in which *everyone* is a threat. Rather than presenting a lot of overlays and requiring the T2 to specifically interpret the noisy signal, checking to see if any one of them needs to be singled out for protection or incapacitation, the special mode lets him know at a glance that he can be indiscriminate in his action. Designers should similarly help their users quickly recognize cases in which either everything or nothing is to be considered.


FIGURE 8.16a–c
*Iron Man* (2008).

Even with fast threat assessment, the T2 still has to manually incapacitate the targets. Other, more recent friend-or-foe systems perform the identification, targeting, and trigger pulling. The Iron Man HUD shows its work in progress as it assesses who in view is a hostage and who is an enemy (Figure 8.16). Though the suit fires multiple mini rockets automatically after the assessment, it overlays reticles above each target, coloring the foes red before it fires its missiles and kills them.

The suit can probably do this friend-or-foe assessment much, much faster than its display shows. Why this artificial slowness?

**LESSON** **PROVIDE OPPORTUNITIES FOR THE USER TO INTERVENE**

The results of computer processes have consequences. The direr those consequences, the more human oversight is needed to safeguard against false negatives and false positives. Provide a first checkpoint by slowing processes down to the speed at which a human can decide whether intervention and correction are necessary.

FIGURE 8.17
*District 9* (2009).

In *District 9*, the semi-autonomous alien exosuit HUD displays blue corner reticles when identifying individuals, and then color codes entities' silhouettes based on a DNA match (Figure 8.17). Human foes are automatically attacked. Though this scene occurs while the suit is in automatic mode, we can presume that when the main character Wikus is occupying it, he sees the same display and can act accordingly.

**LESSON** **SIMPLE AUGMENTATION IS FAST; FAST AUGMENTATION IS SIMPLE**

Humans see faster than they read, and when time is critical, design cues must be seen and understood quickly. Iron Man's reticles well communicate what's about to happen, but they are more visually complex than the overlays of color in *District 9*. Iron Man's reticle aids targeting, but if the computer system is doing the targeting, a simpler mechanism, such as the one in *District 9,* is called for.

**OPPORTUNITY** **SHOW THE GRAY AREA**

The friend-or-foe examples have the luxury of augmenting people in a constructed world where those in sight are either one or the other. But the real world is likely to be more complicated. Certainly, there are clear threats, such as a man aiming a loaded rifle at your head, and clear nonthreats, such as a sleeping infant in his mother's arms. But what about the loaded weapon not aimed at you? How does the system handle these in-between states in a way that both alerts the user to the nuances but is quickly understood for immediate action?


FIGURE 8.18
*Robocop* (1987).

## Goal Awareness

The most advanced AR systems combine some type of identification (sensor, location, object) within the context of the user's goals. Knowing these goals helps systems prioritize what is to be shown, and when and how it is to be displayed. These goals can be very broad, such as Robocop's prime directives (Figure 8.18).

Alternatively goals can be more concrete, such as flying or targeting.

### Goal: Flying Well

A common goal-aware AR involves flying. These systems take important elements from the instrument panel and display them on a HUD for the pilot. Most of these, such as altimeter and airspeed indicators, might be described as sensor displays, but the false horizon is one that is optimized for the goal of keeping the craft level. Each of the examples below have targeting AR as well (Figure 8.19). (For more on targeting, see the next section.)

In *Iron Man,* we get to see the HUD of a US Air Force pilot and compare it with one in the Iron Man suit. The Iron Man HUD presents more data with more intricate graphics, and has object recognition and a full-screen display. This interface is remarkable for its modality as well, bringing information to the screen intelligently as it is needed (Figure 8.20).

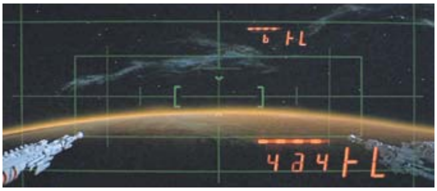


FIGURE 8.19a–c
*Aliens* (1986); *Independence Day* (1996); *X-Men* (2000).


FIGURE 8.20
*Iron Man* (2008).

## Goal: Precise Targeting

The most common AR interface found in the survey is used for targeting. In these examples, animated reticles in a targeting viewfinder help guide the shooter's eye, magnify the view to allow for more precision, or change state to let the shooter know when a hit is more likely (Figure 8.21).

*Reticle* is the formal name of the set of crosshairs and lines that help a shooter aim precisely at a target. The design of reticles varies greatly in sci-fi properties. Aside from focusing the user's attention on a point in the middle, they vary in color, shape, intricacy, and motion. (And brand! If you look closely, you'll see that Mal's AR from *Firefly* bears the Weyland-Yutani logo from the *Alien* franchise. There's some interface evidence that *Alien* is in the same diegesis as *Blade Runner*, too, implying a terrifying universe of xenomorphs, Replicants, and Reavers.)

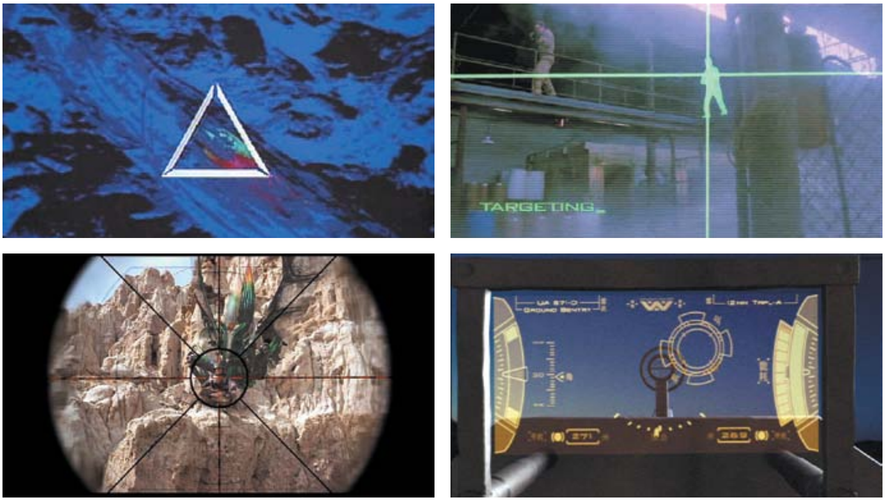



FIGURE 8.21a–d
*Predator* (1987); *Robocop* (1987); *Starship Troopers* (1997); *Firefly*, “Serenity” (Episode 1, 2002).

The assassin Zam Wesell’s weapon interface in *Star Wars Episode II: Attack of the Clones* combines fixed and dynamic reticles nicely, with the brackets from the fixed reticle repeated in fading layers as the target moves. This creates an arrow-like tunnel that points in the direction that the weapon must be aligned, and provides a logarithmic emphasis to the moment when the weapon should be fired (Figure 8.22). The augmentation doesn’t just alert her to information; it helps her achieve her goals.

FIGURE 8.22
*Star Wars Episode II: Attack of the Clones* (2002).

**OPPORTUNITY** **LET THE RETICLE FIRE**

Only the Iron Man targeting system is smart enough to place the reticle, distinguish friend from foe, and pull the trigger. Computer systems are surely much more efficient than humans at this task. Why don't we see it more often? We hope that this rarity is because sci-fi makers aren't comfortable putting an algorithm in charge of life-or-death decisions. Still, it would be useful for users in an unambiguous situation to pass control to the software and then take back control when more difficult decisions must be made.

**OPPORTUNITY** **WHEN A HUMAN MUST FIRE, LET THE EYE TARGET**

Much of the time and effort of firing a weapon comes from manually aiming the weapon at something the eye is already targeting precisely. If the AR system could monitor the shooter's gaze—something already possible with today's eye-tracking systems—then the weapon could be aimed automatically and the system would be much more efficient. This would free the hands to do other work, such as confirming the target is an enemy.

An impressive example of goal awareness appears in *Terminator 2: Judgment Day*. After time traveling to the present day, the T2 gets its bearings and walks toward a pool hall. Along the way, the AR shows simple compass information and notes in passing that the nearby vehicles are relevant to its goal of finding transportation (Figure 8.23a, b). This confirms that the AR system is tied to the T2's goals in a seamless way.

Later in the movie, young John Connor insists that the T2 not kill people. The T2 agrees as long as this limitation doesn't interfere with its goals, and the AR displays feedback about adherence to this requirement (Figure 8.23c).

Human goals are often like this, remaining strategically the same while tactics are adjusted to suit the situation, new information, and constraints. A useful goal-aware AR should accommodate this.

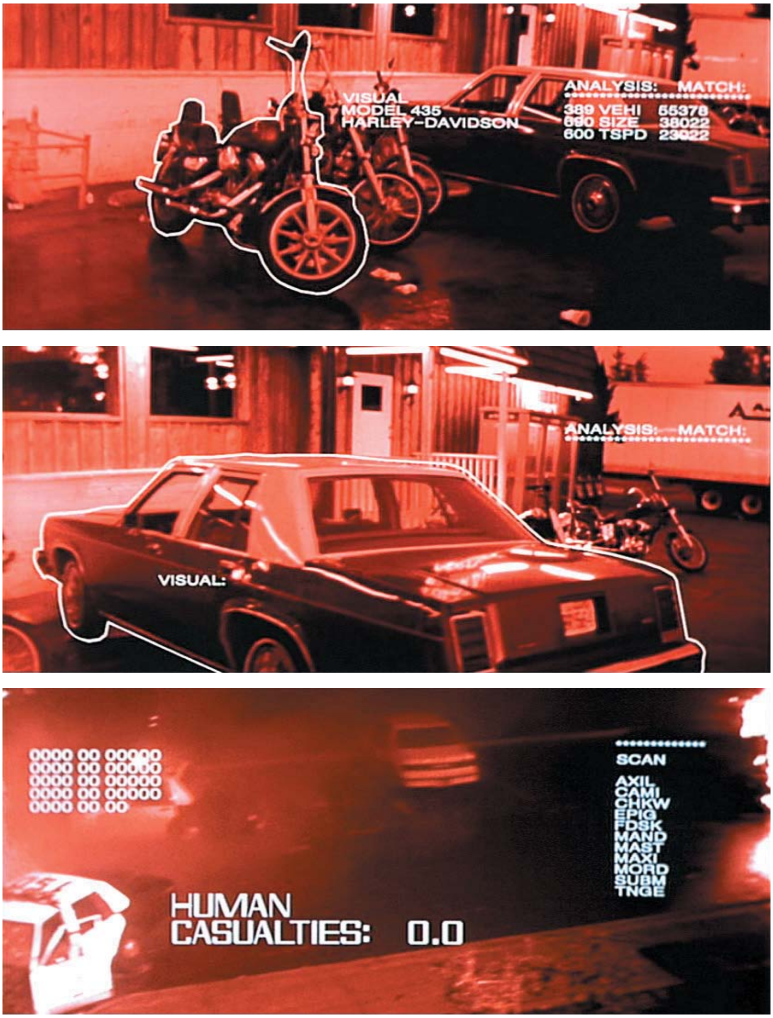



FIGURE 8.23a–c
*Terminator 2: Judgment Day* (1991).

## What's Missing?

Despite all of the examples in this chapter, our survey doesn't provide an instance of one particular aspect of AR: interaction with the AR systems. Tony Stark interacts with JARVIS vocally, but in so doing bypasses most of the input challenges by relying on the even more advanced technology of artificial intelligence. Other ARs are sophisticated enough that they show relevant information at just the right moment. We never see an example of a user needing to change the augmentation to something more useful when the system gets it wrong, or dismissing an augmentation that is in the way. The challenges of interacting with an AR to change the display can be significant if the user is occupied in some engrossing task.

## Augmented Reality Will Make Us Laser-Focused, Walking Encyclopedias

AR is a relative latecomer to the sci-fi canon of technologies, and because it is not commonly available commercially, still feels futuristic. These displays are cinemagenic and exciting, and sci-fi makers keep adapting available technology into them—HUDs, GPS, encyclopedic online data, and real-time image processing—giving rise to much of what the examples show. As sci-fi struggles with the more difficult and forward-looking features of goal awareness and interactivity, we can anticipate it setting the bar for real-world AR when it becomes widely available.

CHAPTER 9

# Anthropomorphism

Sam Bell is the solitary human worker overseeing a mining base on the moon. His only companion, GERTY, is an oversized robotic arm attached to the ceiling of the living quarters. When he talks to GERTY, it answers him in both spoken and iconographic forms.

Recently, Sam has begun to suspect there's something strange going on. "Hey, GERTY, since I've been up here, I've sent Tess over a hundred video messages. Where did those messages go? Did they ever reach her?"

GERTY answers, "Sam, I can only account for what occurs on the base." Though its calm male voice doesn't convey any emotion, its emoticon display switches between uncertainty and unease (Figure 9.1).

Sam asks, "What about the messages she sent to me?"

GERTY repeats, "Sam, I can only account for what occurs on the base," but its emoticon now changes into a smiley face (Figure 9.2a).

When Sam finally decides his fears must be true, he asks, "GERTY, am I really a clone?" The emoticon display switches to a blank (neutral) face (Figure 9.2b). The answer is likely to prove unpleasant to Sam, and the system is calculating how best to respond. When GERTY finally decides to tell Sam the truth, it displays a sad face, as if empathizing with Sam and his newfound discovery (Figure 9.3a).

When GERTY tells Sam that he's a clone and explains why he has false memories, Sam silently turns away. GERTY responds by crying (Figure 9.3b).


**FIGURE 9.1a,b**
*Moon* (2009).

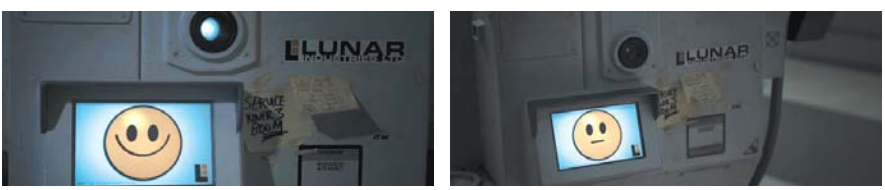



**FIGURE 9.2a,b**
*Moon* (2009).

FIGURE 9.3a,b
*Moon* (2009).

GERTY isn't human and doesn't possess any human attributes other than a synthesized voice. It doesn't look human and the emotions it expresses are little more than flashcards. Yet, GERTY does seem to sympathize, understand Sam's experience, and respond much like a human companion would. GERTY is a machine, but also a sympathetic character. Why?

## Humanness Is Transferable to Nonhuman Systems

This is a common phenomenon in both sci-fi and interface design. Most sci-fi films and TV shows in the survey include examples of anthropomorphized technology.

In the example above, Sam knows GERTY isn't human. So do we, the audience. Yet Sam treats GERTY as a companion, not merely a set of subroutines. Likewise, R2-D2 is one of the most beloved characters in the *Star Wars* films, yet this little droid neither looks nor sounds human. In the real world, we speak to our cars as if to coax them into making it to the gas station before they run out of gas, and we curse our computers when they behave unexpectedly or when their programming doesn't make sense to us. Like Sam, we know these systems aren't alive and don't understand us. Yet we treat them as if they were a living being.

The first thing to understand about anthropomorphism is that people *can* and do anthropomorphize almost everything—from hurricanes, teddy bears, and pets, to furniture, tools, and machines. It seems we have evolved specific mental equipment to understand other humans that we bring to bear in our relationships with most everything around us.

Anthropomorphism is a fundamental psychological bias about which many books have been written. For our purposes, we only want to look at the ways in which this principle applies to technology. In their work at Stanford University, Clifford Nass and Byron Reeves have shown in controlled experiments that people, whether they realize it or not, tend to deeply anthropomorphize any sufficiently sophisticated technology—whether a car, a microwave oven, or even a company. Their research, supported by B. J. Fogg at Stanford, has shown that people give computer systems a full range of social considerations, ascribe to them human motivations, assign demographic attributes to them such as age and gender, and react to them in social ways, such as through persuasion and flattery, all the while being unaware that they are doing so.[1] The successful systems, these researchers explain, conform to human social norms. Designers and engineers aren't responsible for anthropomorphizing their systems—users do that themselves. Instead, they are responsible for developing the systems so that they become acceptable characters, instead of annoying ones, by having them conform to social rules. Though a full examination of those norms and related social cognitive biases are beyond the scope of this book, it follows that designers who want to exploit this effect in the interfaces they design should look into them.[2]

Some technologies are designed specifically to trigger this anthropomorphic sense. The ASIMO robot, for example, is designed to appear and move quite like a human (Figure 9.4a). For less humanoid systems, people respond idiosyncratically. For example, some people name their Roomba vacuums and speak of them almost like a pet but others do not (Figure 9.4b).


FIGURE 9.4a,b
Honda's ASIMO robot (c. 2000); iRobot's Roomba vacuum robot (c. 2002).

1 Reeves, B., & Nass, C. (1996). *The media equation: How people treat computers, television, and new media like real people and places.* New York: Cambridge University Press.

2 As a plus, you'll be able to charm cocktail acquaintances with terms such as "outgroup homogeneity bias" and the damning "Dunning-Kruger effect." Begin your search with the phrase "social biases."

## Human Isn't the Only Possibility

Astute readers may note that in sci-fi, technology doesn't have to mimic humans. It can mimic alien species as well, and even animals and plants. These have subtly different triggers and effects worth investigating.

For example, the robotic daggits from the original *Battlestar Galactica* series (Figure 9.5a) and the Bounty Bear search program from *Until the End of the World* (Figure 9.5b) seem clunky and fake, whereas the teddy bear from *A.I.* seems wondrous, like it could become a good friend. The difference is the fidelity of the representation. In addition, the use of animals as the representation, instead of people, conveniently lowers expectations for users toward that of a pet or companion instead of an equal.


FIGURE 9.5a,b
*Battlestar Galactica* (1978); *Until the End of the World* (1991).

**LESSON** **CONSIDER ANIMAL REPRESENTATIONS FOR LOW-FUNCTIONING SYSTEMS**

Because most systems can't come close to mimicking the human behavior necessary to interact appropriately in a social context, animals, plants, and aliens can be used instead. This can create an emotional connection in users without raising expectations above the capabilities of the system. The result is often an endearing character or technology instead of an annoying one.

In the case of *Until the End of the World*'s Bounty Bear (see Figure 9.5b), only the crude animated representation and voice distinguish it from today's Google search capabilities. Yet the sum total has an endearing quality one would never claim for Google.

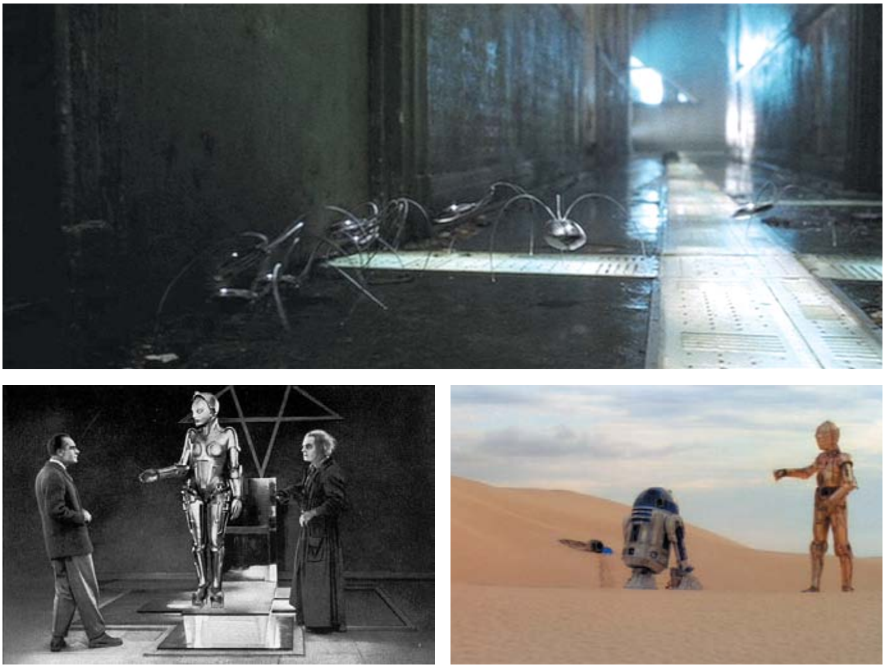


FIGURE 9.6a–c
*Minority Report* (2002); *Metropolis* (1927); *Star Wars Episode IV: A New Hope* (1977).

So what aspects of a system might provide those triggers? Humans are complex and have many qualities that a device could emulate. Our review of anthropomorphic examples in the survey tells us that they fit into the following broad categories: appearance, voice, and behavior. These categories are not mutually exclusive. Gort, the robot from *The Day the Earth Stood Still*, for instance, emulates human anatomy and behavior, but it has a silver visor where a face should be (see Figure 6.1). The *Minority Report* "spyders" display the intention of finding and "eyedentiscanning" citizens as well as problem-solving skills, but physically they don't look at all human (Figure 9.6a).

From the first robot in Fritz Lang's 1927 film *Metropolis* to the very familiar C-3PO and R2-D2 in *Star Wars*, robots are a prime example of this phenomenon (Figure 9.6b, c).

In some cases, the robot is indistinguishable from a real human, like Ash, the "artificial person" in *Alien* (Figure 9.7a). They can also be mostly humanlike but with telling differences, such as *Star Trek: The Next Generation's* Lieutenant Data (Figure 9.7b); somewhere in the middle, such as the "3 Laws Safe" robots in *I, Robot* (Figure 9.7c); or only vaguely humanoid, like Robby the Robot in *Forbidden Planet* (Figure 9.7d).

**FIGURE 9.7a–e**
*Alien* (1979); *Star Trek: Generations* (1994); *I, Robot* (2004); *Forbidden Planet* (1956); *The Terminator* (1984).

Even when the appearance is convincingly humanoid, this doesn't mean that the behavior will be. The T-800 terminator in the original *Terminator* film looked real enough but was monotone and robotic in speech and movement (Figure 9.7e). Likewise, the wax figures in Madame Tussaud's may be convincing in appearance, but they fail in every other aspect of being humanlike. Depictions that are almost but not quite perfect feel creepy to most people because we have evolved to be deeply sensitive to humans that are "off," indicating that they may be either sick or ill intentioned. Behaviors and appearances that trigger this discomfort are said to lie in the *uncanny valley*, a term coined by researcher Masahiro Mori to describe "the revulsion many people often feel for human facsimiles" (Figure 9.8).

Once a system takes human form or adopts humanlike behavior, it implies that the system has humanlike capabilities. It also triggers social conventions we normally reserve for other people. Our shorthand mechanisms for dealing with each other kick in and we start cajoling our cars, naming our computers, and treating that shopping agent as if it really knows what it's doing. These effects become more apparent when we look at the categories of things that trigger them in technology.

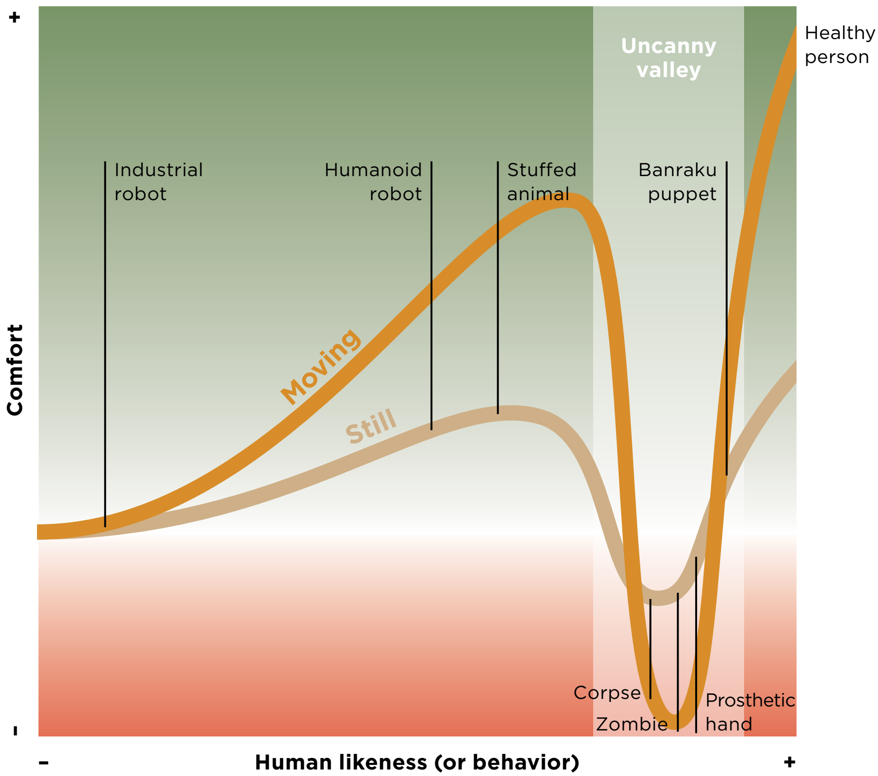



**FIGURE 9.8**
**The uncanny valley.**

### LESSON BEWARE THE UNCANNY VALLEY

People are comfortable with human facsimiles until the similarity becomes so strong that it stops registering as a thing made to look human and becomes a human that has something wrong with it. Up until the valley, we accept all sorts of representations, but only because we set our expectations accordingly. The problem comes when the representation outpaces the system's functionality as well as its ability to conform to proper behavior. This is a very real effect and it holds for all types of representation—voice, image, gesture, proportion, and so on. It's critical for designers to understand this effect as their creations approach the valley: venture too close and they become repulsive, too far and they don't register as human.

**LESSON DESIGN EITHER FOR ABSOLUTE REALISM OR STICK TO OBVIOUS REPRESENTATION**

To avoid overpromising capabilities to your user, provide clear signals of the non-humanness of your systems. For highly humanoid-appearing technologies, alter some feature that your user interacts with the most, such as the eyes. If your interface speaks to the user, have the system speak with a carefully stilted vocabulary. Finally, if your system displays anthropomorphic behavior, consider making it just stiff and robotic enough. These signs set user expectations at a lower level, avoiding the uncanny valley.

## Appearance

The first and most apparent aspect of humanness is in appearance. It can mean just the body, just the face, or just the eyes. It can vary from vaguely human to indistinguishable from human. In the *Matrix* films, programs are represented in a virtual reality as fully human characters, imparting greater impact, depth, and danger to the audience than almost any other representation could. The hunt-and-destroy program, called Agent Smith, feels more dangerous and capable than one would expect from a program (Figure 9.9a). The prediction program, called the Oracle, seems wiser and more trustworthy when represented as a cookie-baking matron than lines of code (Figure 9.9b).

Agent Smith and the Oracle are programs represented as lifelike characters who think, react, show initiative, and emote on occasion right along with the actual humans in the Matrix, triggering characters and audiences alike to ascribe human motivations, intentions, and constraints to them, to their detriment.

FIGURE 9.9a,b
*The Matrix* (1999).

## Voice

Many interfaces in sci-fi feel human because they *sound* human. This could be through the sense of "having a voice" through the use of language. It can also mean audible expressiveness without formal language.

We need to be careful not to overgeneralize though. Signs, books, and websites use language, but they aren't anthropomorphic. It is the interactive give-and-take of conversation that signals a humanlike, responsive intelligence.

This responsive use of language can be in text with no accompanying voice, like we see in the artificial intelligence called Mother in the movie *Alien* (see Figure 3.3). It answers questions and displays a crude sense of intention.

More frequently this use of language is embodied in sci-fi by an actual voice, which greatly increases the sense of humanness, beyond just the language used. In the case of the TV series *Knight Rider*, K.I.T.T. is the onboard artificial intelligence assistant in the car. Almost the entirety of its development as a character on the series is accomplished through K.I.T.T.'s voice. There is a minimal text interface, used rarely, a voice-box light that glows with his speech, a scanning red light at the front of the car, and K.I.T.T sometimes controls the car itself, but this is the extent of its behavior (Figure 9.10). The bulk of our acceptance of him as an independent character is due to his very humanlike voice, which includes intonation, sophisticated phrasing, and natural cadence, timbre, and annunciation, unlike more robotic-sounding voices.

FIGURE 9.10a,b
*Knight Rider* (1982).

**LESSON** **CONVERSATION CASTS THE SYSTEM IN THE ROLE OF A CHARACTER**

Because the effects of anthropomorphism aren't consistent for all users, some may interpret the use of language as a part of the system while others may interpret it as the system itself. For example, one driver of a car with a voice recording might associate the voice with a part of the car (perhaps the safety system), while another might associate the voice with the whole car (as with K.I.T.T.). Still another might think that the voice is an actual person speaking through a telephone-like connection. Each of these agents would have different capabilities, and mistaking the wrong set of capabilities could be frustrating. Make it clear to users what the voice represents.

In *2001: A Space Odyssey*, the HAL-9000 computer has a human-sounding voice, including intonation, though the timbre and cadence is much smoother and less expressive—even soothingly so. It's part of the reason why HAL's willingness to sacrifice the crew late in the film seems so sinister. The voice implies personality and humanness where they don't exist, so what seems like a calm, logical manner when everything is fine turns menacing and psychopathic once HAL considers the crew a threat to the mission. In both cases, HAL is still the same set of emotionless instructions.

A missile launched from a ship—even a self-guided one—may be "smart" but it isn't considered sentient and certainly isn't a character. But if it reveals a voice, it suddenly seems to have a mind of its own—and quickly becomes a character. In the cult film *Dark Star*, a member of the crew tries to convince a warhead equipped with an artificial intelligence that its countdown was triggered erroneously. The conversation ends on an existential note—right before the bomb explodes (Figure 9.11). Similarly, in the "Dreadnought" episode of *Star Trek: Voyager*, B'elanna Torres tries to convince a missile she reprogrammed to abort its mission with a similarly deep, existential argument. To her credit she succeeds where the crew of *Dark Star* failed. In both cases the bombs' voices and use of language trigger anthropomorphic senses.

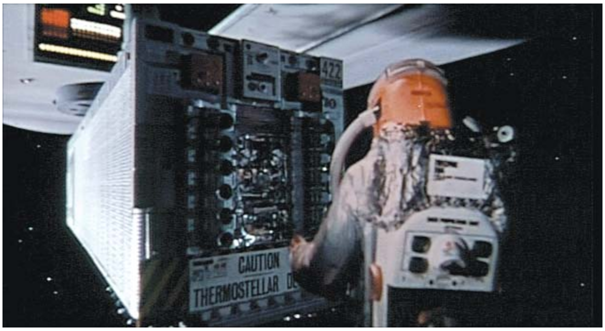



**FIGURE 9.11**
***Dark Star*** **(1974).**

If a computerized voice sounds more mechanical than human, it will be understood to be an artificial system; however, when a machine system has a natural human vocal representation, it can cause unexpected confusion. For example, when the Atlanta airport train (now called the Plane Train) opened in 1980, the cars had no human operators on board, but were equipped with a prerecorded human voice to give instructions and announce stops. What the designers didn't foresee is that some riders presumed the voice was coming from a human conductor able to make judgment calls when managing the trains. Riders would take more chances, such as rushing doors as they were closing, because they expected the conductor to see them and wait. The realistic voice created unrealistic expectations of how the system would behave. To solve the problem, computerized voice recordings (sounding just like the Cylons in the original *Battlestar Galactica* TV show) were substituted. These were not as "natural" or "comfortable" for riders, but they set the proper expectations. (This topic has been a hot one for more than 20 years. One of the authors was at a contentious panel discussion about this very subject at a conference way back in 1992!)

## Audible Expressiveness

All of the above examples involve language, but emotive sound can also express an anthropomorphic sentience, too. In the *Star Wars* films, R2-D2, one of the most endearing characters in the franchise, does not speak a human language, and he certainly doesn't look at all human, either. Still, his beeps, chirps, and whirrs are emotive enough for audiences to understand when it's feeling fear, excitement, and disappointment. These emotions are part of what tell us it's a sentient, anthropomorphic character.

**LESSON USE PARALINGUISTIC SOUNDS EXPRESSIVELY TO TRIGGER ANTHROPOMORPHISM**

The sound effects you choose to communicate with users have the potential to create a character of the system. To be effective, these sounds must have an evocative character in how they respond to system events. For example, a sad sound accompanying an "Error 404—Page Not Found" might express sympathy for the user's frustration. This can make a system more endearing but, like other uses of anthropomorphism, can raise expectations among users that extend past the system's actual capabilities.

## Behavior

At its heart, anthropomorphism is behavior centric. People see faces in most everything, so appearance is an easy win, but humanlike behavior increases the sense of anthropomorphism greatly. With humanlike behavior, even the most mechanical things seem to gain personhood. One well-known example is from Pixar's short film *Luxo Jr.*, in which two lamps, through movement alone, tell an endearing story of the exuberance of childhood. There's nothing humanoid about these objects, but their movements suggest a head, face, and hips, and their relationship to each other convince us that this pair is deeply human (Figure 9.12).

Another example from sci-fi is in *Iron Man*, as Tony Stark's robotic helper—affectionately called Dummy—becomes a believable and endearing character simply through lifelike movements while responding to Stark's conversation, despite its utilitarian, industrial robot appearance and lack of sound or voice (Figure 9.13).

FIGURE 9.12
*Luxo Jr.* (1986).

FIGURE 9.13
*Iron Man* (2008).

### LESSON ACHIEVE ANTHROPOMORPHISM THROUGH BEHAVIOR

If the technology for which you are designing an interface has the capability to move, consider consciously designing that motion to make users more comfortable and communicate capabilities or system status. Though it would require particular responsiveness, users have a built-in capability to understand and empathize with things that do so.

Anthropomorphism can even occur with behaviors limited to text responses and button clicks. For example, back in 1966, a computer program named Eliza created a stir (and controversy) by imitating a Rogerian psychologist who simply asked questions based on previous answers. It had a very simple algorithm and a pool of starter questions to ask but exhibited remarkable flexibility in "conversing" with people. In fact, some users were completely deceived into believing they were dealing with a highly sophisticated psychoanalysis program, and, even more remarkably, others reported personal insights despite knowing that the program was just a few lines of trick code. Even when we know the system is a simulation, it is still possible to build a successfully anthropomorphized experience—if the purpose and constraints of the system are appropriately focused.

## Degrees of Agency: Autonomy and Assistance

Another behavioral trigger for anthropomorphism in sci-fi is agency and autonomy. *Agency* in this context refers to a system's ability to carry out known actions per predefined parameters. *Autonomy* refers to a system's ability to decide to initiate *new* actions to help achieve a goal.

Many examples of both exist throughout sci-fi. Most robots, like R2-D2 and C-3PO, have both agency and autonomy, as do systems like K.I.T.T. from *Knight Rider*. Characters in *Star Trek's* holodeck have agency and a limited autonomy, but when they gain full awareness and autonomy it usually spells big problems for the crew. This example illustrates why it's important to distinguish these because autonomy is both more powerful and riskier to associate with anthropomorphism.

Consider Ebay's auction systems or stock-trading services that can keep placing trades up to a set amount, and even complete a purchase without needing our intervention. That's agency. It's a system we trust enough to spend money on our behalf, given its restrictions. Ebay's system isn't anthropomorphized, but if it were, it might have an impact on how people use it, and how often.

Now consider if the system had autonomy. In this case, it wouldn't just act for us, it would decide for us: that we liked but lost a bid on that previous bookcase, and this other one is similar, so it will go ahead and place a bid on it for us. It might find, buy, or even sell items without our intervention. A stock management system might do the same, choosing to buy or sell stocks we haven't even considered, not merely the ones we already own. At the heart of any of these systems would be the necessity of trust. Which system is more trustworthy—the one that acts or looks anthropomorphic or the one that doesn't? The answer partly depends on the style and degree of verisimilitude, of course, but all things being equal, the research tends to support the idea that most people trust systems that exhibit human characteristics more than those that don't.[3, 4]

*Assistance* is the least degree of agency for anthropomorphic systems. An agent designed for the purpose of assisting a user with answering questions or completing a task is called a *guide*. A guide might help you find something, but not find it on its own. It might make suggestions on how to write a letter, but it wouldn't write it for you.

There are few examples of guides in sci-fi. One is Vox, the library interface in *The Time Machine* (2002). Vox is a virtual reference librarian projected into an upright pane of glass that helps time traveler Alexander Hartdegen use the 2030 New York Public Library. Stepping into a futuristic library, Hartdegen sees a row of vertically mounted glass panes bisecting the length of the hall (Figure 9.14a). As he approaches a bookshelf contained within a glass case, a translucent figure appears as if on one side of the glass behind him and introduces itself: "Welcome to VOX system. How may I help you?" After Dr. Hartdegen muses, "Oh, a stereopticon of some sort," the machine replies, "Oh, no sir. I am a third-generation fusion-powered *photonic* with verbal and visual capabilities connected to every database on the planet. A compendium of all human knowledge. Area of inquiry?" The visual display of the photonic can watch a user and even meet his or her gaze (Figure 9.14b).

Enthralled, Dr. Hartdegen asks, "Do you know anything about physics?" The photonic replies, "Ah . . . accessing physics . . ." and raises its hand to the surface of the glass where a rectangular information browser labeled "Physics" appears and cycles through various diagrams. As Dr. Hartdegen asks for "mechanical engineering," "dimensional optics," "chronography," "temporal causality," and "temporal paradox," he is amazed to see the device instantly summon additional browsers for each of these topics. At first the photonic seems quite excited by his genuine scientific interest, but as Hartdegen continues requesting topics, Vox's expression turns perturbed and dismisses the browsers to clarify, "Time travel?! . . . accessing science fiction" (Figure 9.14c).

3 Lee, J. L., Nass, C., & Brave, S. (2000). *CHI '00: Extended abstracts on human factors in computing systems*. New York: ACM.

4 King, W. J., & Ohya, J. (n.d.). The representation of agents: Anthropomorphism, agency, and intelligence. Retrieved from www.sigchi.org/chi96/proceedings/shortpap/King/kw_txt.htm


FIGURE 9.14a–c
*The Time Machine* (2002).

**LESSON** **USE AN AGENT'S SOCIAL PRESSURE FOR A SOCIAL AGENDA**

Why would a learning interface convey attitudes—positive or negative—about requested topics? Such a negative attitude about a particular topic could serve the cultural purpose of encouraging certain types of learning, such as practical science, and discouraging others, such as creative expression, while not outright prohibiting them. That this pressure is due to the fact that the interface looks human probably adds to its effect, but designers need to be careful about when, how, and if social cues should cast opinion on learning.

The real world doesn't have enough artificial intelligence to create truly autonomous agents yet. They're strictly products of sci-fi at the moment. And there are only a few examples of good agents. We see plenty of examples of guides outside sci-fi, however, in real or prototyped products, including Apple's *Knowledge Navigator* and the *Guides 3.0* prototypes, Microsoft Bob, Microsoft Office's Clippy, and myriad "wizard" interfaces. It's a step outside of sci-fi, but to get interactive anthropomorphism right, we need to head there for a bit.

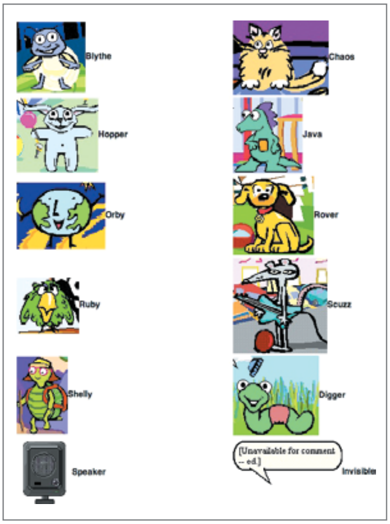




FIGURE 9.15a–c
Microsoft Bob's characters and home screen (c. 1995); Microsoft Office's Clippy (c. 1997).

Two famous examples from Microsoft were unsuccessful guides, underscoring how difficult it can be to do these well. Despite the fact that much of the research behind the personalities of Microsoft Bob, a personal information manager, and Clippy, an assistant inside Microsoft Office, was based on the work of Nass and Reeves (see page 179), the behaviors exhibited by these products were deemed nearly universally annoying by users (Figure 9.15). A clear mismatch existed between expectations and actions in terms of behavior. In particular, Clippy was often interruptive and presumptuous about its help, overpromising and underdelivering. It was difficult to turn off permanently. Software often transgresses social norms, but Clippy felt worse because it seemed like a social being that should have known better. It had two eyes, it used conversational language in response to your behavior. It behaved like a real person—a really annoying person.

**LESSON** **ANTHROPOMORPHIZED INTERFACES ARE DIFFICULT TO CREATE SUCCESSFULLY**

This is particularly true in terms of agency, autonomy, authority, and cooperation. Because of this, all system behavior should conform to social rules appropriate to users' cultures in order to be fluid, helpful, and appropriate, regardless of any outward appearance or representation of humanness. This isn't easy and isn't easily generalizable. Designers must have firsthand knowledge of what is appropriate and what isn't.

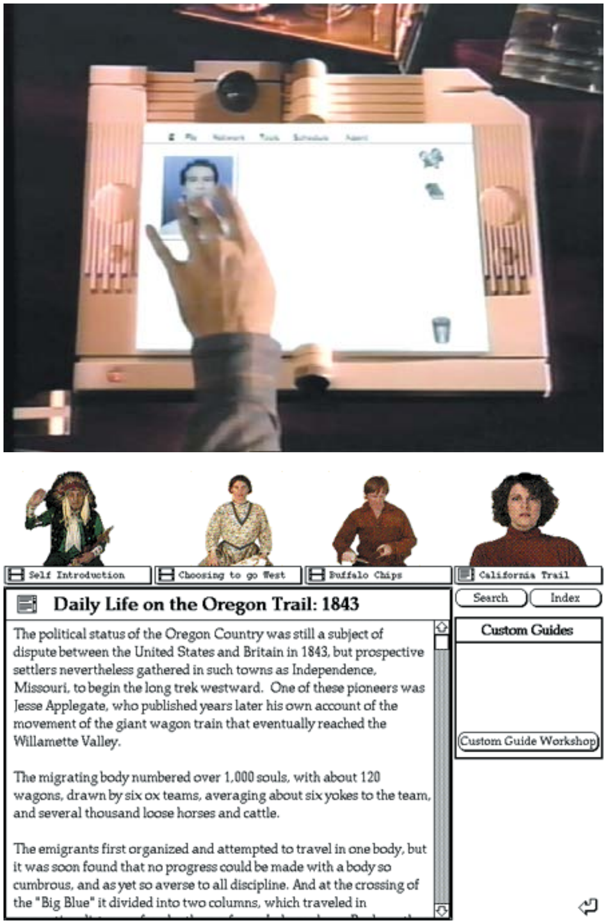



FIGURE 9.16a,b
Apple's *Knowledge Navigator* (1987); Apple's *Guides 3.0* (1990).

It is possible to get guides and agents right, though. One real-world example comes from Apple. In *Knowledge Navigator*, an industrial film created in 1987 to show possible future technologies in action, Phil, a partly realistic animated agent, assists a college professor in a variety of tasks before his upcoming lecture (Figure 9.16a). Phil works because he is easily interruptible, doesn't presume too much knowledge, and isn't represented with too much realism. This helps signal that although he's advanced, he's not as capable as a human assistant would be. He conforms to social conventions appropriate to his capabilities.

The other example was a working, experimental system of guides for learning. It was created in Apple's Advanced Technology Group to demonstrate new database technologies, though it never made it to market. *Guides 3.0* had four guides, all with algorithms controlling their behavior, and all characterized as people—three as content guides in period costume, and one as a system guide named Brenda (Figure 9.16b). The content guides offered perspective and further material on entries in a historical database of the United States. They were specifically chosen to represent different—and differing—points of view on the content in the database, and their behavior was designed to reflect how much they had to add, or not, to any particular entry. The purpose was to make clear that history is open to interpretation and to offer just a few perspectives. In this way, teaching history was also teaching students to form, accept, and acknowledge their own point of view. It was as if Hartdegen from *The Time Machine* had three other guides available to him in addition to Vox that could help him interpret information from different perspectives and not just find it.

**OPPORTUNITY** **OFFER SEVERAL PERSPECTIVES ON INTERPRETABLE INFORMATION**

People have different learning strengths and multiple ways of understanding. Offering users a single point of reference may give them confidence, but at the cost of omitting other useful points of view. Offering users multiple perspectives, either from the system or other users, can help people understand the complexity of the material or situation in a way that suits them best.

This probably wouldn't be a good strategy for instructions in an emergency or information that isn't open to interpretation. When the information isn't definitive or can't be clearly applied, however, differing points of view offer users a mechanism for considering advice from experienced others without the implication that there is one right way to proceed.

## Anthropomorphism: A Powerful Effect That Should Be Invoked Carefully

People are used to interacting with other people, so this plays into our experiences of technology in both sci-fi and the real world. In sci-fi we see software, robots, cars, and search engines take on aspects of humanity to make it easier for the characters and easier for the audience to relate to and understand. Studying these examples shows that humanlike appearance makes people more comfortable and helps interfaces communicate more expressively. Humanlike behavior can make systems more instantly relatable and be well suited to assisting users with accomplishing tasks and achieving their goals.

Designers wanting to incorporate anthropomorphism should take great care to get it right, however. Anthropomorphism can mislead users and create unattainable expectations. Elements of anthropomorphism aren't necessarily more efficient or necessarily easier to use. Social behavior may suit the way we think and feel, but such interfaces require more cognitive, social, and emotional overhead of their users. They're much, much harder to build, as well. Finally, designers are social creatures themselves and must take care to avoid introducing their own cultural bias into their creations. These warnings lead us to the main lesson of this chapter.

**LESSON THE MORE HUMAN THE REPRESENTATION, THE HIGHER THE EXPECTATIONS OF HUMAN BEHAVIOR**

When we design technologies to be anthropomorphic, it raises user expectations about the extent of their capabilities for intelligence, language, judgment, autonomy, and social norms. If your technology cannot fulfill these expectations reliably, you risk frustrating your users. Design signals into the appearance, language, and behavior that communicate clearly that the system is not human, so that expectations and reality are well matched.

One way to hedge bets with the phenomenon of anthropomorphism is to ease into it with the half-step of zoomorphism. Because people have lower expectations of animals yet still find themselves building social and emotional connections with them—particularly their pets—representing a system as an animal rather than as a human can often score the positive attributes without risking a slip into the uncanny valley. This may be the more effective strategy while we continue to learn more about developing systems whose behaviors can truly stand up to social conventions and possess what users might consider intelligent behavior.

CHAPTER 10

# Communication

FIGURE 10.1a–c
*Metropolis* (1927).

Joh Frederson walks to a large wall-mounted device. While checking his messages on ticker tape (Figure 10.1a), he sees that Grot in the Lower City needs his attention. Reaching up to the dial on his right, he turns its hand counterclockwise from 10 to 6. Then he turns the left-hand dial to 4, and the screen comes to life. It displays "HM 2" overlaying a shifting blend of different camera images. Joh fiddles with a few controls to clear the signal (Figure 10.1b).

Once he has Grot in view, Joh picks up a telephone handset from the device and reaches across to flip a button on and off to signal Grot. In response, the lightbulbs on Grot's videophone begin to flicker and make a sound. Grot rushes to his device, looks into the screen, and lifts his handset. His screen comes to life with Joh's image, and the two have a conversation (Figure 10.1c).

Communication technology makes up the largest proportion of any type of technology in the *Make It So* survey. This is no surprise because communications technologies—including cinema itself—are among the most radical changes to our sense of space and time and to ourselves both as individuals and as cultures. There are so many examples of communication tech that there is no way to survey them all, much less reference them in this chapter, but even the ones in the survey provide clear enough patterns to structure the chapter.

## Asynchronous versus Synchronous Communication

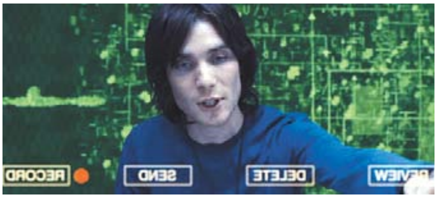
Communications technology can be distinguished in several ways. One helpful distinction is whether the communication is synchronous or asynchronous. Synchronous technologies have the communicators interacting in real time, both attending the communication simultaneously, as on a telephone call. Most of the communications examples in the survey are synchronous. Asynchronous communications involve a sender encoding his or her communication in some medium, such as a letter, video, or audio recording, and then sending it to the receiver. The terms *asynchronous* and *synchronous* are an eyeful, so we'll talk about the more friendly words *message* and *call*, respectively. These two types overlap quite a bit, but where they don't is largely a function of composing, editing, and sending messages.

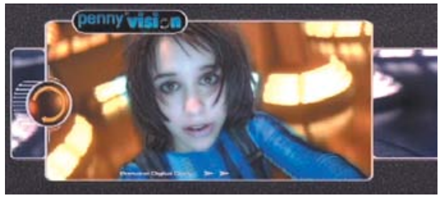
### Composing

Composing a message requires that you record the message in advance. It also gives you time to reflect on what you've recorded and change it if you like. Recording a text message would require handwriting tools, a keyboard, or some transcription tools, but we don't see as many of these in action as we do the time-based media of audio and video messages. Some alien controls for composing messages are impossible to interpret, as when Klaatu prepares an audio report using gestural controls in *The Day the Earth Stood Still* (see Figure 5.1).

Of the rest, audio messages are seen much less frequently than video messages. The controls for these interfaces are the basic ones that would appear on a digital video camera. A standard example appears in the movie *Sunshine*, as Robert Capa prepares a final video message for his family. On the screen we can see that he has controls to review, delete, send, and record his message (Figure 10.2a). The film doesn't show the corresponding physical controls.

Other examples of such tools include Penny's video log from *Lost in Space* and Jake Sully's video log from *Avatar* (Figure 10.2b, c). It's worth noticing that neither interface provides on-screen recording controls. It's as if the filmmakers believed that recording devices were already so familiar to audiences that controls needn't be shown. What is shown in the *Avatar* example are four simple buttons with a somewhat confusing information hierarchy: main cam, past entries, submit, and task.





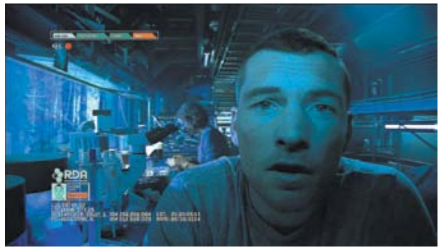



FIGURE 10.2a–c
*Sunshine* (2007); *Lost in Space* (1998); *Avatar* (2009).

These interfaces share one important feature. They all have a prominent signal to indicate that the system is currently recording. *Sunshine* and *Avatar* show the familiar red dot indicator that flashes. Of all the possible cues in a recording device, this is the one they almost universally have in common.

**LESSON** **SIGNAL WHILE RECORDING**

If the design of a recording interface is too busy, it can distract and annoy both the audience and the sender, who needs to focus on his or her message. Reducing the interface to only the minimum needed while recording helps the sender focus on the message, but there should still be some signal that the system is in fact recording. This signal doesn't just help the recorder but in sci-fi it also helps the audience understand what a character is doing. The most common visual icon for this signal is a blinking red dot. This signal is so common that using another visual cue might confuse users and audiences alike.

No other midrecording information is displayed in the interfaces seen in the survey, such as duration of recording, time remaining, or a sense of how much has been recorded so far. Similarly, no editing interfaces are seen with which a character could review and edit the message.

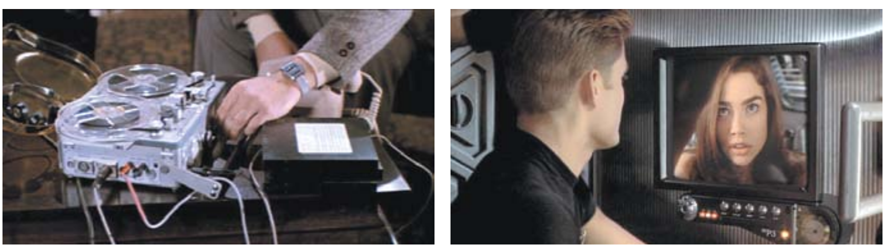
## Playback

A recipient needs a way to play recorded messages. In addition, sensitive messages may require the recipient to be identified, as seen in *Star Wars* and *The Incredibles* (Figure 10.3). In the former, R2-D2's artificial intelligence does the identification. In the latter, the message plays automatically upon identification of Mr. Incredible. In each case, the recipient doesn't have to initiate playback manually.

More often, recipients have control of the playback. Commonly, only Play and Stop controls are seen. These controls follow the predominant technology paradigms of the time: toggle switches, buttons, or touch-screen controls. Little if any screen time is given to these controls, and usually only the Power and Play functions are used (Figure 10.4).

FIGURE 10.3a,b
*Star Wars Episode IV: A New Hope* (1977); *The Incredibles* (2004).

FIGURE 10.4a–c
*2001: A Space Odyssey* (1968); *Brainstorm* (1983); *Starship Troopers* (1997).



## Activating the System

Communications technologies need to be able to be turned off for privacy, quietude, and power conservation. The separate On and Off functions are often combined into a single control and are almost always physical toggle switches, such as the flip-open cover of a *Star Trek* communicator (Figure 10.5a). Some are innovative alternatives, such as the touch-activated combadges first seen in *Star Trek: The Next Generation* (Figure 10.5b).

**LESSON** **BALANCE EASE AND CONTROL IN ACTIVATION**

Users appreciate easy controls. The *Star Trek* communicators use large, easy motions to activate and deactivate. The combadges are positioned so that tapping them is easy. You can imagine that these systems could be activated in even easier ways, such as by simply touching the communicator. But when activation becomes too easy, it can become error prone. Designers must ensure that the controls are easy to use but protect against accidental activation.

**LESSON** **SIGNALING CHANGE OF STATE ISN'T ENOUGH**

One advantage that the handheld communicator has over the combadge is that anyone can tell at a glance whether the communication channel is open or closed. Though audible signals indicate when the combadge is connecting or disconnecting, when someone walks into a room wearing one, its status is unclear. It would be easy to use one to covertly record a conversation. A better system would clearly indicate its current status as well as when that status changes. This is true for almost all systems, not just communications.

FIGURE 10.5a,b
*Star Trek: The Original Series* (c. 1968); *Star Trek: The Next Generation* (c. 1987).

## Specifying a Recipient

Whether for a message or a call, the sender needs to specify a recipient. This task can be accomplished in a variety of ways: automatically through a fixed connection, with the help of a system operator, by specifying a unique identifier such as the recipient's phone number, or by a stored attribute such as the recipient's name.

### Fixed Connection

Some communications devices are tied to companion devices and are unable to communicate with any others. Some of these broadcast continually while activated, such as the headsets seen in *Aliens*, and the only interface needed is a switch to turn them on.

If the technology is designed to broadcast to many people, the sender only needs to activate a switch to indicate that he or she is speaking. This can be a momentary switch on a microphone, or a hook on which the microphone rests, as seen in the ship address system used by Commander Adams in *Forbidden Planet* (Figure 10.6).

FIGURE 10.6a,b
*Forbidden Planet* (1956).

FIGURE 10.7a,b
*Aliens* (1986); *Chrysalis* (2007).

Semipublic interfaces such as intercoms are fixed to a recipient, but the interface needs a way to request the receiver's attention (see "Notification," page 208). In *Aliens*, when corporate stooge Burke visits Ripley at her apartment, he presses a button on the intercom to get her attention (Figure 10.7a). Thereafter, the receiver can flip a switch to open continuous communications, or engage in push-to-talk exchanges as with walkie-talkies (see "Audio," page 214). These communications can smoothly flow into action, as happens in the film *Chrysalis*, as Hoffman lets Clara into his home. She rings, he glances at the video, and after making up his mind, he presses a lock icon on the intercom touch screen to let her in (Figure 10.7b).

**LESSON** **MINIMIZE THE NUMBER OF CONTROLS**

The trade-off between control and clarity is longstanding in interaction design. Giving an interface more controls means there is more to learn and distinguish, and too many controls can crowd the interface with unnecessary visual noise. Typically, control works better for experts, and clarity works best for novices. As a rule of thumb, however, closely related functions, such as activation and connection, can be combined into a single, easy-to-use control.

## Operator

When a device can connect to any other on a network, callers need a way to connect to the right one. One solution is to have an operator—whether a human, alien, or artificial intelligence—make the connection. What is important is that the operator can understand the caller's request and communicate back when there is a need for clarification or to convey a problem with the system. Most often in sci-fi these requests are spoken, but there's no reason why these requests couldn't be some other input, such as written or gestural.

**LESSON** **THE HUMAN IS SOMETIMES THE IDEAL INTERFACE**

New technologies can be complex or unfamiliar enough to require user training, but this may be impractical or scale poorly. An alternative is to train certain people to act as operators on behalf of users. This strategy offers many benefits that an automated system might have difficulty with. Aside from language barriers, people need no training to communicate with operators. The operator can interpret the user's intentions and emotions, and respond accordingly. Operators can also handle problems that arise with the system—especially those that are unexpected by the system designers. The history of job specialization can be considered an interface to the complexities of technology (operators), biology (doctors), law, politics, and even religion (clergy). Until we have perfected both android appearance and artificial intelligence, well-trained humans, despite their flaws, may remain the most usable interface.

## A Unique Identifier

Despite their benefits, operators don't scale well to handle massive numbers of users. Letting communicators find one another across a system alleviates this burden, but requires that the system work for both the callers and the network. To solve this problem, many networks use a unique identifier (UID). This is the strategy of modern telephone systems that use telephone numbers as UIDs. The telephone system is the predominant first-person communication technology, and it is also the predominant paradigm in sci-fi. These interfaces almost always use a numeric keypad, whether analog or screen-based (Figure 10.8a, b). Activating the keypad buttons in sci-fi follows conventions of the time and includes push buttons, touch screen, and in *Johnny Mnemonic*, a remote control with a laser pointer to indicate a number and a button to select it (Figure 10.8c). Most of these systems are

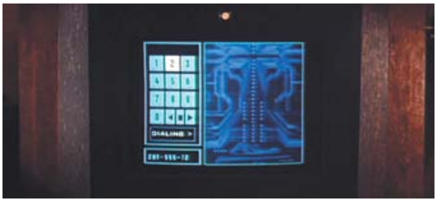



FIGURE 10.8a–c
*Blade Runner* (1982); *2001: A Space Odyssey* (1968); *Johnny Mnemonic* (1995).

direct entry, but these familiar systems pose an interface problem, in that they increase the chance for user error.

**LESSON COMPOSE, THEN SEND**

Telephone number entry systems like the TouchTone system seen in *2001: A Space Odyssey* are direct entry, meaning each number is registered by the system as a button is pressed or a number dialed (see Figure 10.8b). The challenge of this interface is that mistakes can't be undone and must be retyped from the beginning. This effect gets worse with longer numbers.

A better solution for this problem is seen in modern mobile phones and in the example from *Johnny Mnemonic* (see Figure 10.8c). In these systems, a user enters the number to the system explicity and then submits an Enter or a Call command once the entire number has been composed. This gives the caller the opportunity to review and correct errors before committing to the call. To avoid errors when asking users to supply a set of inputs, let them compose first, then review and correct before committing.

## Stored Contacts

One problem with the unique identifier (UID) strategy is that it requires people to remember lots of long number strings, and people aren't generally good at that. Characters in sci-fi almost never have difficulty remembering these numbers, but this is a major concern for users of real-world communications technologies. As a result, storage systems such as speed dial, voice dial, and contact lists reduce the burden on users' memories, letting them remember a single digit or name for frequently called numbers. The owner of a device often has the burden of inputting and managing these shortcuts, but an interesting counterexample appears in *Aliens*.

When Burke meets with Ripley, he leaves a calling card with her. When she finally decides to contact him, rather than remembering his number or even his name, she simply slips the transparent card into a videophone, and the system automatically connects to him. Note that it's his Weyland-Yutani business card, but the system finds him on a videophone at home that is presumably as immobile as the one Ripley is using (Figure 10.9). This interaction speaks to a great deal of sophistication.

FIGURE 10.9a–c
*Aliens* (1986).

**LESSON** **THE GOAL IS TO CONTACT A PERSON, NOT USE AN INTERFACE**

As technology becomes increasingly networked and ubiquitous, a person's whereabouts can be more and more confidently assessed. Presuming that privacy and disambiguation issues can be managed, this provides an excellent opportunity to save a caller from having to manage UIDs to contact particular devices. Instead, the caller should be able to merely identify the recipient and let the system worry about where she is and what devices she has with her. Could it be in the future that whenever a phone near you rings, you should answer it, because it will be for you?

**OPPORTUNITY** **FIND PEOPLE BY ATTRIBUTES**

What if instead of UIDs, the system could find who we want with more ambiguous data? It's not too far-fetched. Virtual assistant software, such as Apple's Siri, is already doing something similar with available locational information. Siri interprets what you ask for and checks against available location-relevant information automatically in the hope that it relates to what you want. In the future, a user might ask her phone, "Contact Joe, or maybe it was Joseph, in the Chicago area with whom I met at that conference in 2005?" or "Who was that guy I met at Jennie's party who said he was a financial consultant?" Eventually, will a person just think of a recipient and the computer takes it from there?

## Receiving a Call

Communication is more than sending a message or placing a call. It needs to be received. This section looks at things from the recipient's perspective.

### Notification

Once a caller or a message finds its way through the network it needs to get the recipient's attention. When we look at these examples, a note of caution is called for. If a sci-fi story bothers to include a message in the plot, it is important. This gives these signals a weight that isn't applicable to all types of messages or calls in the real world.

While Logan watches the Carousel ceremony in *Logan's Run*, he receives a text message from central control letting him know that they have been assigned to handle a runner who is nearby. Carousel is quite loud, but the audio is conveniently loud enough to get his attention (Figure 10.10).

**LESSON USE SOUND FOR URGENT ATTENTION**

Users want to attend to urgent calls and messages. To gain a user's attention, an interface should immediately send a signal to a sense that does not depend on a visual cue, because the user's eyes may have a limited range of perception at that moment. Hearing is one sense optimized to provide full-field awareness, making audible signals a good candidate. Ideally, audio alerts should be context-sensitive in order to set a volume for the sound above the ambient noise and select a type of sound that contrasts with the ambient noise so it is more likely to be heard. Touch signals such as vibration require physical contact with the device, making it less likely to be detected. Sci-fi technologies may have access to other full-field senses such as orientation, pressure, temperature, and smell, but they cannot carry as nuanced and discernable a meaning as sound, and real-world designers rarely have access to actuators that affect these.

FIGURE 10.10
*Logan's Run* (1976).

## LESSON INCLUDE A SIGNAL IN A SECOND CHANNEL FOR URGENT ATTENTION

Of course, not everyone can hear, and there are times when even those who can may be in an environment that prevents them from hearing an alert. Sound coupled with a vibration, a visual alert, or something that stimulates other senses is a good idea if the alert is truly important.

In the time-travel comedy *Back to the Future Part II*, the family is at the dinner table when Marlene receives a call by putting on a pair of goggles. Red LEDs flash the word PHONE on the outside of the goggles as they ring (Figure 10.11). Marty Junior's goggles are already on, and he announces to Marty Senior that the phone is for him and that it's his supervisor Needles, implying a caller ID system, which had only just been released commercially in the United States the year before the film was released.

Marty Senior takes the call in the den on the large video screen there. As he approaches the screen, it displays a portion of the Renoir painting *La Moulin de la Galette,* and has the blinking legend INCOMING CALL along the bottom (Figure 10.12a). When he answers it, the Renoir shrinks to a corner of the screen, revealing the live videophone signal (Figure 10.12b). During the conversation, the Renoir disappears, and text appears near the bottom of the screen to provide information about the speaker. This text appears automatically, with no prompting from Marty Senior (Figure 10.12c).

In *Iron Man*, Tony is in his workshop on the lower level of his sprawling home when he sends a voice message to his assistant, Pepper Potts. The system finds Pepper in the living room and plays the message as the ring tone to get her attention. Simultaneously a display near her shows Tony's portrait and an alert reading INCOMING LINK. This audio draws her attention from the *Mad Money* TV program playing on the main screen (Figure 10.13). There are several notable things about this interface, and we will return to it below.


**FIGURE 10.11**
*Back to the Future Part II* (1989).


FIGURE 10.12a–c
*Back to the Future Part II* (1989).



FIGURE 10.13
*Iron Man* (2008).

**LESSON PLACE A VISUAL SIGNAL IN THE USER'S PATH**

Many visual signals can be missed if placed too far from the user's locus of attention. To ensure that signals are received, it is best for designers to place them where the user cannot help but find them. If the system has eye-tracking controls, the place they are looking can be known exactly. Alternatively, if an input device such as a mouse has been used recently, it or its on-screen manifestation (such as the cursor) is an excellent proxy. Otherwise, place signals along the critical waypoints of the interface where the user's attention is most likely to fall.

## What We Don't See

The survey hasn't revealed a recipient declining or rerouting a call through a visual interface, though both are options for such systems in the real world. We see examples of people doing this with human operators, as when Picard responds to a verbal message about an incoming communication with "I'll take it in my ready room," but we don't see examples of these functions outside of a conversational interface.

## Accepting

Once a recipient has been notified of a call or message, he or she needs to connect to the call or open the message to review it. If the technology is commonplace in the real world, sci-fi adheres to the paradigm: for example, nearly all telephone calls are received by picking up a receiver, and nearly all text messages to mobile devices are received by pressing a button on the device. If the communications technology is not common, the show must develop some new way to accept the message. A few of these examples follow.

As we've seen, characters in *Star Trek: The Next Generation* touch their combadge to accept an incoming call, routed through the ship's computer.

That the combadge doesn't show recording status is discussed above, but the action for accepting the call is simple and accessible. Combadges are worn on the left breast, and after being notified audibly, the recipient only needs to tap it once to accept. The gesture is simple to execute and not likely to be done accidentally. We don't see a circumstance in which a crew member has his or her hands full but needs to take a call, but given their universal translation capabilities, it's likely that a voice command to accept would be understood.

To receive Tony's call in *Iron Man*, Pepper reaches out and taps the notification message on the tablet screen. This opens an audio link between them, presents a stored photograph of Tony, and adjusts the layout so that the *Mad Money* video feed she was watching takes up less of the screen (Figure 10.14).


FIGURE 10.14
*Iron Man* (2008).

**LESSON** **TAP TO RECEIVE A CALL**

Social pressures require that accepting a call be quick, and a desire to control one's own privacy requires that it be discrete and unmistakable. Until gestural controls become more ubiquitous (and corresponding communications technology more fully embedded in environments), tapping satisfies the user's need for speed and deliberateness.

## Monitoring the Connection

As with recording, callers need to know when they are connected. This can be a signal that indicates when the link is disconnected, or it can be an indicator that persists while the connection is active.

In blended-media telephony systems, both strategies can be used. *Iron Man* shows an example of this, as Pepper can see on her JARVIS screen a label confirming the active audio connection to Tony (Figure 10.15). It additionally provides a visual confirmation of the disconnection as the call panel on the display disappears when the call is over, adjusting the display so that the *Mad Money* video fills the screen again.

**LESSON** **SIGNAL CONNECTIONS VISUALLY AND DISCONNECTIONS AUDIBLY**

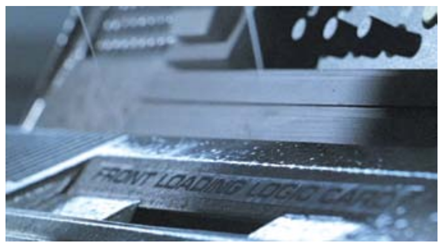
Video calls provide continual feedback, so disconnection is usually apparent: the caller disappears or the image freezes. Audio calls are another matter because people take turns when speaking, and silence on the other end could mean either listening or disconnection. Any audio signal that served to confirm the connection would necessarily add noise to the call, and so such systems provide an audio signal only when the caller becomes disconnected.


**FIGURE 10.15**
*Iron Man* (2008).

## Ending a Call

Typically, both parties to a call can end it when they want. There are a number of ways this is seen in sci-fi. Of course, we see examples that mimic real-world systems, such as returning a handset to its cradle, as an older telephone paradigm would imply. In systems that use tokens to represent recipients or initiate calls, removing the token ends it. In *Aliens,* for example, Ripley yanks Burke's business card out of the videophone to quickly terminate her uncomfortable call with him (Figure 10.16). There are also a few radio paradigms in which the caller turns a stop-dial or flips a toggle to sever the connection. More recently, computer and television metaphors are becoming more apparent, with a user pressing or tapping a button to end the call.

The survey doesn't reveal any voice commands for ending a call, either to an operator or a voice control system, but given that Tony's hands are fully occupied while flying the Iron Man suit (and he does not appear to have ocular controls), his call with Brody must have been ended this way (Figure 10.17).



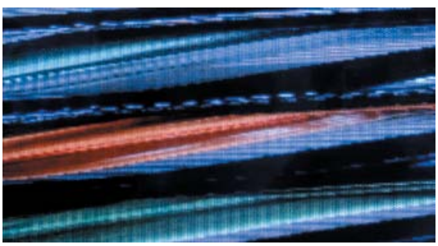



FIGURE 10.16a–c
*Aliens* (1986).

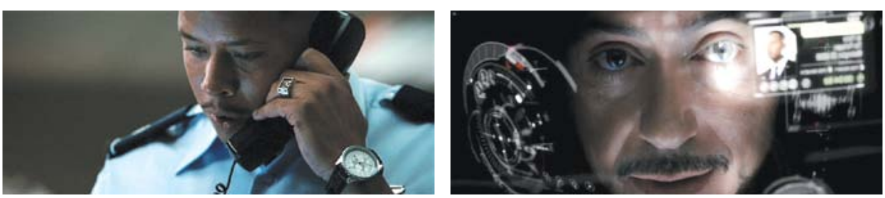


FIGURE 10.17a,b
*Iron Man* (2008).

FIGURE 10.18a–c
*Johnny Mnemonic* (1995).

A very unusual means of ending a call is seen in *Johnny Mnemonic*, as Takahashi ends a frustrating video call by swiping his hand horizontally through the air, like a backhanded slap. In response not only does his call end, but the display retracts into the surface of his desk (Figure 10.18).

**LESSON** **HANDLE EMOTIONAL INPUTS**

We have to presume that the system does not require a massive, arm-swinging swipe to end each of Takahashi's calls. The system can handle both the perfunctory wave that ends an earnings announcement as well as the angry slap that silences the rebuking caller. When technology allows for a range of inputs, users can channel emotion into them, making the input more than a control but also a medium of expression. If the degree of emotion affects the degree of system response, all the better. This means that the technology fits the way we communicate as people much more readily than the precision that best fits computers.

## Audio

Another way of looking at communications technologies is through the controls particular to their medium or channel. For example, during a call, how does a speaker control when they want audio privacy and when they want to be heard?

Some sci-fi interfaces don't have such controls and are continuously sending signals. The only way to mute them is to cover the microphone or turn off the system. These are most often military or aerospace applications.

More commonly, audio interfaces adopt a push-to-talk paradigm like a two-way radio or pager. In these interfaces, only when the speaker holds down a momentary switch is their voice sent. These buttons often appear at the bottom of the interface, within easy reach and controllable without obscuring other parts (Figure 10.19).

FIGURE 10.19a–d
*Buck Rogers* (1939); *Space: 1999* (1975); *Star Wars Episode IV: A New Hope* (1977); *Firefly*, "Safe" (Episode 5, 2002).

The reverse is a mute function.

A few microphones operate by proximity. One comes from the campy Sean Connery film *Zardoz*. The Eternals communicate with a central artificial intelligence called the Tabernacle through clear rings worn on the left hand (Figure 10.20a). The ring senses when it is near the mouth, and only then sends the wearer's voice. The sleeve microphone in *Minority Report* operates the same way (Figure 10.20b).

Though we imagine that callers using videophones might have a similar need for a mute button, the survey didn't reveal an instance of such controls.

FIGURE 10.20a,b
*Zardoz* (1974); *Minority Report* (2002).

## Audiovisualization

Sci-fi often adds a visual layer to audio-only calls, especially if the camera lingers on the communications technology for a length of time without showing the recipient's face.

**LESSON** **IN AUDIO-ONLY CALLS, SHOW SOUND LEVEL VISUALLY**

When a communications technology doesn't have a visual for the person on the other end of the line, sci-fi supplies one so audiences aren't staring at a still image while the audio plays. Some are basic like the level meter seen on Pepper's call with Tony (Figure 10.21a). Sometimes it can be artistic and quirky, like the wall of tiny shutters from Barbarella's shipboard computer Alphie (Figure 10.21b). But one thing remains consistent: when levels are louder, the system displays more light. Though the inverse relationship is possible, as is the connection of any of the other measureable qualities of sound and light, the sci-fi default is that more sound equals more light.

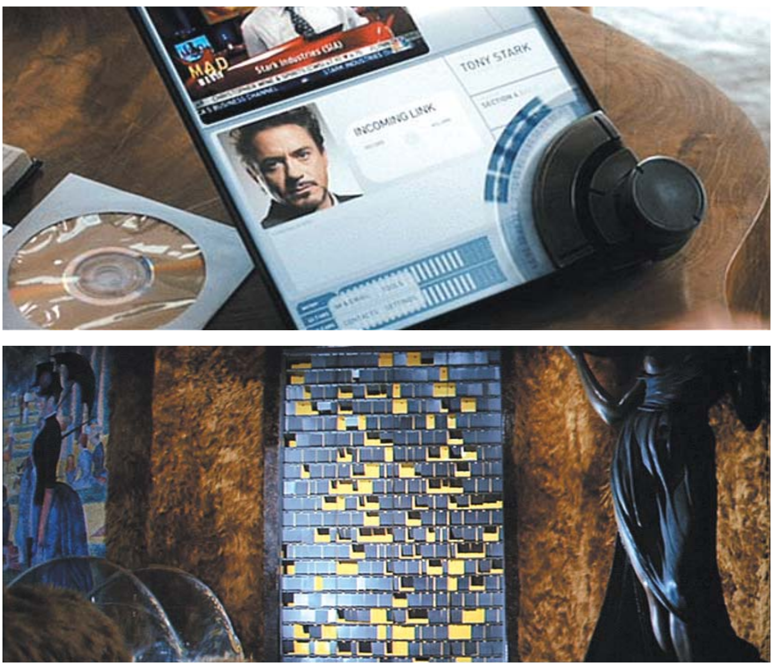



FIGURE 10.21a,b
*Iron Man*, detail (2008); *Barbarella* (1968).

### What We Don't See

In addition to lacking physical mute controls (mentioned above), we don't see volume controls for interfaces in sci-fi. The sound level is always perfect for the situation: loud enough to be heard over any other sounds yet quiet enough to be comfortable. This is a necessity in storytelling, and audio engineers carefully balance many channels of audio to get the mix just right, but from the perspective of the characters, their communications systems are able to expertly do the same thing.

## Video

There are some interface issues particular to video as well. One that appeared early is that of the invisible camera. Videophones need cameras to capture the image of the speaker, but they're almost always missing from views. This holds true for large, flat video screens, like we see on the bridges of *Star Trek* spaceships, as well as volumetric projections. For sure, we see cameras in sci-fi—mostly for surveillance—but we don't see them for communications systems like videophones. One possibility is that the camera is "hidden" inside the screen, focusing through or between the image. Another possibility is that the display is capable of seeing as well as recording, making the entire screen a recording device.

The one exception to the rule is *2001: A Space Odyssey*, where the lens is apparent not only in incidental technologies, but it is also central to the imagery of the film, as the terrifying, ubiquitous, unblinking interface to the inhuman HAL artificial intelligence (Figure 10.22).

While the invisible camera seen elsewhere deftly avoids the gaze-matching problem (discussed in Chapter 4), it raises important questions about privacy: How do you know when you're being recorded if there isn't even a camera lens?


FIGURE 10.22a,b
*2001: A Space Odyssey* (1968).

**LESSON** **FOCUS ON THE PERSON, NOT THE MEDIUM**

> The cameras in sci-fi interfaces are missing because neither the makers nor the audience want to think about the interface. They're focused on the meanings implied in the conversation, and the emotions on the speakers' faces. In other words, they are notably not thinking about the location of the camera. When the interface recedes, people can focus on what they care about—the social interaction.

### What We Don't See

In addition to the absent volume controls discussed above, we don't see any privacy controls other than those that terminate the communication.

## Two More Functions

Besides the fundamental communications issues listed above, there are two functions in sci-fi communications technology that bear mentioning: language translation and disguise.

### Language Translation

Given the multicultural (and multispecies) universes in sci-fi, some sci-fi makers have given a nod to addressing how it is that all of the characters are speaking the one language that the audience happens to understand. Natural language processing of a single language is one of the toughest problems in modern computation, much less translating across different languages that evolved for different species' speech organs, brains, and cultures, and at vastly different points in their cultural evolution. Credit goes to those TV shows and movies that give the issue at least a nod: the translation chip from *The Last Starfighter*, the universal translators of the *Star Trek* franchise, and the Babel fish from *The Hitchhiker's Guide to the Galaxy* (Figure 10.23). Sadly, these are often throwaway technologies that do little to illustrate the complexities of their use, other than to reinforce the lesson above ("Focus on the Person, Not the Medium"). When and if the real world finally tackles these problems, these sci-fi interfaces will seem as quaint as Joh's wall phone in *Metropolis*.

One of the oddities we see in *Star Trek* is with the universal translation built into the computer's communications. The system offers seamless, instantaneous translation between any known languages by any number of speakers, facilitating effortless communications. It is sophisticated enough to quickly parse and decode new languages quickly. It works for ship-to-ship communications and is built into the small communicators worn on uniforms in the *Star Trek: The Next Generation* series and later.

FIGURE 10.23a–c
*The Last Starfighter* (1984); *Star Trek IV: The Voyage Home* (1986); *The Hitchhiker's Guide to the Galaxy* (2005).

The oddity in the technology is that we also *see* each speaker speaking our language in their voice rather than in their own language with a dubbed translation or subtitling. It's likely, of course, that this is just a convenience for the television makers, but it offers an opportunity through apologetics. What if this was actually a feature of the ship-to-ship communication system? What if at the same time it's processing language, it processes the speech organs of a speaker and overlays subtle changes so that the mouth makes movements consistent with the translation? This couldn't work for the in-person universal translators without some seriously sneaky augmented reality technology (for which there is no evidence in the series), but for ship-to-ship translations, it offers a useful lesson.

**LESSON** **TRANSLATE BOTH THE VOCAL AND ANATOMICAL ACT OF SPEAKING**

Where possible, a translation system that matches a text translation with a similar translation of the sonic and physical parts of speaking will reduce cognitive friction on the part of the listener. Attentive readers may notice that this is similar to the gaze-matching lesson on page 84. In the case of speech, though, much more than head and eye position would need to be altered.

For voices, this includes timing, diction, intonation, accent, and of course, the content of what was being said. This is complicated by the grammar and word differences that can take more or less time to say in a different language. A synchronizing system might need to increase or decrease speed significantly to fit speech and meaning into the same amount of time, and with the same emphasis, as the original speaker. It would also include all of the sonic qualities of the speaker's voice, such as pitch, breathiness, and timbre. Then once you add anatomy it includes altering the mouth, eyes, and facial expression of the speaker, all blended together to make them seem like they are fluently speaking another language.

As an ambassador might tell you, the act of learning another language favorably connotes an interest in the people who speak it. Those who have taken the time to do so will want that fact recognized. Additionally, unless the translation software is absolutely perfect, listeners will need to know when the fault of an off-seeming remark might lie with the system. For these reasons, systems doing such translations should provide an unobtrusive signal to distinguish when someone is being translated and when they aren't.

## Disguise

Given that communications technologies are, by definition, mediated, there is an opportunity for disguise that is only rarely seen in the survey. Here we turn again to Takahashi's deceptive calling system in *Johnny Mnemonic*, in which the wicked businessman Takahashi uses a gestural interface to control the video avatar of a trusted friend of Johnny's. On his end of a call, Takahashi moves his hand like a puppet over a scanner, and the system uses the input to make the avatar speak its parts of a predefined script (Figure 10.24a). From Johnny's end, he sees the avatar's head move and speak on a video monitor (Figure 10.24b). As a gestural interface, we first introduced this example in Chapter 5, and it is noted above in this chapter for the emotional way in which the call is ended. Here we note it for its ability to grant its user a near-perfect disguise as a part of the communication.

It is only near-perfect because the avatar speaks in a stiff and stilted manner, which raises some questions about the input method. If the computer needs a physical guide to move the avatar, wouldn't Takahashi's own face be a much more easy-to-manipulate and true-to-form input than his hand? This cinematic trick certainly helps the audience understand what's going on, but as an interface it only serves us by illustrating an opportunity.

FIGURE 10.24a,b
*Johnny Mnemonic* (1995).

**OPPORTUNITY** **LET USERS ALTER THEIR APPEARANCE, SUBTLY**

One challenge for videophone adoption is that people often don't feel they're in a socially presentable state—especially at home. As technology advances enough to create real-time renderings of people well out of the uncanny valley (see Chapter 9 for more of this anthropomorphic principle), why not help out with a little real-time cosmetic alteration? Digitally fix that cowlick, render a clean and pressed shirt over that stained one, improve your muscle tone, or maybe smooth a few wrinkles. It's easy to see where vanity might quickly get the better of us with flawless avatars that drift too far from the real thing. But many sci-fi authors have suggested that this is the natural evolution of mediated identity, and it is a primary opportunity for us to experience our posthuman selves. Maybe verisimilitude isn't the right goal at all.

Of course disguise can always be used, as this example illustrates, for unscrupulous reasons—especially by identity thieves. This raises a corresponding opportunity for a counterpart sci-fi technology that verifies the identity of the caller.

## Communication: How We'll Be Talking Next

Every major advance in communication technology has expanded the horizon of what we could experience across time and space: mark making, writing, the printing press, photography, radio, television, and the Internet. Today the capabilities are so vast and so commonplace it is difficult to appreciate. We can watch in real time as the sun rises in different parts of the world. We can hear the voices of the long dead, the alien moans of whales singing to each other in the depths, and the mysterious static of deep space. We can send and receive messages from people thousands of miles across the globe in a matter of seconds. We can become enraptured in the fantastically realized lives of people inhabiting worlds that only exist on screens. These advances in communication are happening faster and faster and don't look to stop anytime soon. Sci-fi will help us make sense of our vastly expanded senses by using these same technologies to envision possible futures, of whom we may be speaking to, and how we may be speaking to them, next.

CHAPTER 11

# Learning

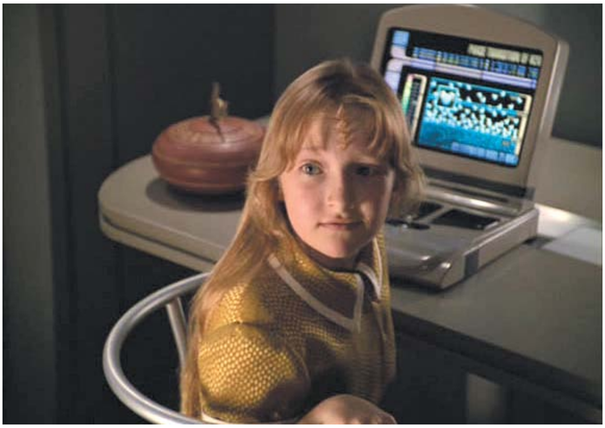


FIGURE 11.1
*Star Trek: Voyager*, "Once Upon a Time" (Season 5, Episode 5, 1999).

Ship's cook Neelix enters the room where his young friend Naomi sits at a computer, diligently studying. She has been sad since her holodeck storybook friend Flotter, who is made of water, was "killed" by the Ogre of Fire in a holodeck simulation called "The Forest of Forever." He asks, "What are you working on?"

She turns around to explain, "I'm researching the evaporation of water."

"Why?"

"Well, I've been thinking. Water doesn't just disappear when it's heated. It turns into invisible gas. So, if we could get the forest to cool down enough, Flotter might reliquefy."

Neelix pauses a moment before commenting, "Clever." He knows that Naomi has just learned the science that will save her friend (Figure 11.1).

Learning is important in sci-fi narratives, just as it is in life. It contributes to what writers call the *character arc*, or the way a character changes over the course of the story. And when characters learn about interfaces or technology that is new to them, the audience learns about them, too, without additional exposition. Because of this, it's no surprise that we find learning interfaces in the survey. They can be divided into six categories:

1. **Direct download** of knowledge into the brain
2. **Psychomotor practice** interfaces that facilitate practice of a physical skill
3. **Presentation tools** used by teachers during lectures
4. **Reference tools** for simple information queries
5. **Machines to think with,** which assist learners in processing their thoughts and developing cognitive skills
6. **Testing interfaces** that measure knowledge and intelligence

## Direct Download

This first category is often used as a "cheat" to save time by showing characters learning something important to their development or to advance the story quickly. Outside of sci-fi, filmmakers often use a montage to show a lengthy learning process in a short time. In sci-fi, however, it's possible to simply invent a technology that makes this knowledge transfer happen in a matter of seconds. Sometimes an author wants a character to just *know* something that wasn't known before, in order to get to the crowd-pleasing action. The interfaces for this type of direct-to-brain knowledge transfer vary widely, as no real-world analogue exists. Seldom is the technology for such learning explained.

The first direct download interface in the survey appears in *Star Trek: The Original Series*. In the episode "Spock's Brain," an alien race sneaks on board the *Enterprise* and surgically removes Spock's brain from his skull. On a distant planet, a search party finds the brain installed in a computer controlling the civilization's infrastructure. The citizens there are far too unsophisticated to perform such advanced surgery, which is even beyond that of the *Enterprise*'s Dr. McCoy.

They find a learning device called The Teacher that transfers sophisticated, ancient knowledge quickly, but the process is painful and the knowledge is only retained for a few hours. McCoy uses the device to learn how to replace Spock's brain. To absorb the information, he stands within a transparent dome with rods radiating outward from it (Figure 11.2a). There is no indication how McCoy selects the lesson he wants to learn, but perhaps he simply thinks it. After some fun sound effects and suffering what appears to be a splitting headache, a wild-eyed McCoy understands what he needs to do and sets to work on the intricate brain surgery (Figure 11.2b). Even though the knowledge lasts only for a short time, this is long enough to allow him to surgically reinsert Spock's brain and reconnect all of the nerves (Figure 11.2c).

FIGURE 11.2a–c
*Star Trek: The Original Series*, "Spock's Brain" (Season 3, Episode 1, 1968).

We have deliberately eschewed hand-drawn animation in the survey, but in the animated feature *Fantastic Planet*, a major component of the film's plot is an interesting device that transmits narrated video clips directly to the brain of the wearer. These "lessons" are, in the words of the narrator, "engraved on their memories forever." Though the content resembles reference material (see "Reference Tools," page 236), the technology is a direct-download device because it imprints the information in the brain passively and permanently, albeit at the inconveniently poky pace of language.

To use the device, an adolescent of the giant alien Traag race named Tivva places the thing, which is shaped like a thin horseshoe with small spheres along its length, over her head like a hairband. The device blinks and bleeps a number of times, and the "infos" appear in her mind's eye. To show the *audience* what is being learned, the wearer's forehead is overlaid with narrated videos of the lesson. There is no indication that she requests any of the topics, so it is likely that it is a long, sequentially structured series of lessons (Figure 11.3).

The device is also used by the smaller, human Oms, who are able to gather together in a group within the band and "watch" the infos simultaneously. The band works through a wireless or empathic technology that requires it to be close to the learner's brain.

The primitive Oms use their newfound information to vastly improve their culture and advance their technology, to the extent that they are eventually able to create rockets to escape from the planet and the oppression of the Traag (Figure 11.4).

FIGURE 11.3a–c
*Fantastic Planet* (1973).

FIGURE 11.4a,b
*Fantastic Planet* (1973).

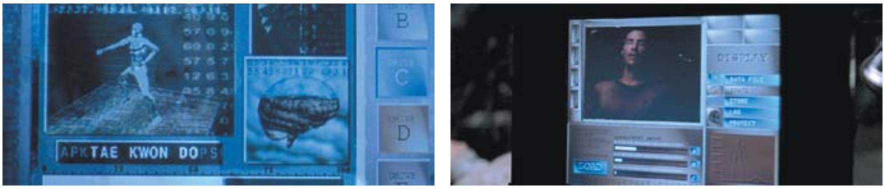



FIGURE 11.5a,b
*The Matrix* (1999).

Perhaps the most well-known knowledge-download interface appears in the film *The Matrix*. After Neo is liberated from the Matrix, he undergoes training in a small and self-contained virtual reality called the Construct. Knowledge of every martial art known is uploaded directly to his brain by a jack in the back of his head. The pilot named Tank begins the upload by means of specialized software, operated by a touch-screen interface and keyboard. As the upload progresses, a portion of Tank's screen shows illustrative figures labeled with the martial arts knowledge currently being uploaded, a wide progress bar along the bottom, and a spinning 3D brain that "fills up" with an opaque solid (Figure 11.5).

After the upload, inside the Construct, Neo looks up at Morpheus and says with amazement, "I know kung fu." Morpheus replies, "Show me." They fight. (See more direct-download interfaces and the erroneous myths they expose about brain interfaces in Chapter 7.)

## Psychomotor Practice

Some systems provide an interface for practicing a physical skill. Called *psychomotor learning* in learning theory, it involves coordination between the brain and body.

An example occurs in *Dune*, when the young prince, Paul Atreides, undergoes combat training with a "fighter," and practices his ability to control the strange weapon known as a "weirding module." (Learn more about the sonic interface of this unusual weapon in Chapter 6.) The fighter is a mechanical device that descends from a hole in the ceiling above a practice space. The fighter has several rings stacked along its height, each of which has a weapon of some sort, such as blades, holes that shoot metal darts, scissor-like bayonets, and extending spears with razor sharp points. The fighter can spin each weapon ring independently to create an intimidating, whirling machine of death (Figure 11.6).

Paul's valet, Thufir Hawat, summons the fighter with a spoken command, and just before the fighting begins, gives it a verbal command, "Make the range two meters." Thereafter, the fighter obeys some internal program to conduct combat. Paul is an expert with the weirding module, defeating the fighter's weapons one by one.

FIGURE 11.6a–c
*Dune* (1984).

In *Star Wars Episode IV: A New Hope*, Luke Skywalker spends some of the travel time between Tatooine and Alderaan practicing his lightsaber skills under the watchful eye of Obi-Wan Kenobi. He stands facing a baseball-size sphere that floats at head height. The sphere has half a dozen small circles on its surface that can deliver a harmless but painful laser blast at Luke. The sphere hovers in the air, spinning, bobbing, and weaving, and shoots intermittently. Luke tries to intercept each blast with his lightsaber, and mostly succeeds (Figure 11.7).

When Ben swoons at the moment the destruction of Alderaan causes a large disturbance in the Force, Luke disengages his saber. Apparently context aware, the sphere stops moving about and firing. It is only when Obi-Wan gathers his wits about him and moves Luke to his next lesson—defending himself without being able to see—does the sphere take up its sparring duties again. No other explicit interaction occurs to signal the device to pause or resume its firing.

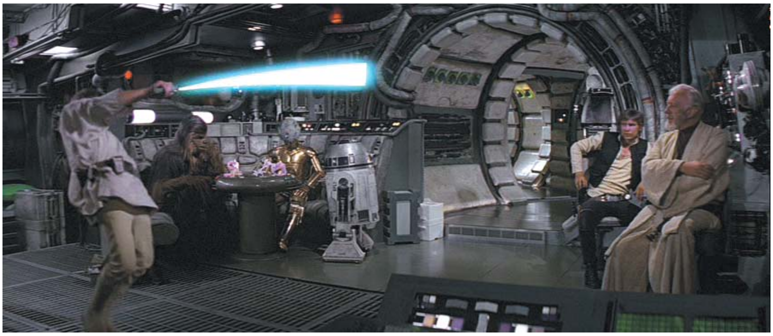


FIGURE 11.7
*Star Wars Episode IV: A New Hope* (1977).

## LESSON FACILITATE A TEACHER'S INPUT

People enjoy working with good teachers—particularly in social contexts. When designing learning interfaces, even for technologies largely expected to be used by one learner at a time, let the system accommodate the participation of a teacher to observe, model, comment, and challenge the learner as he or she progresses.

In the film *The Last Starfighter*, the protagonist, Alex, spends many of his summer hours playing the video game *Starfighter* (Figure 11.8a–c). He plays it because he enjoys it, but after beating the final level, he learns that it is actually a secret training and testing device that has been deployed throughout the universe to find the best candidates for recruitment into the Rylan Star League. His skills in playing the game are directly applicable to becoming an ace gunner in the spaceship *Gunstar*, defending the forces of good against the onslaught of the evil Kodan Armada. The controls and heads-up display of the *Starfighter* game are, of course, very similar to those of the *Gunstar* (Figure 11.8d–f). In this case, the interface is the bridge between the safe challenge of learning in the game and the deadly serious situation in real life.

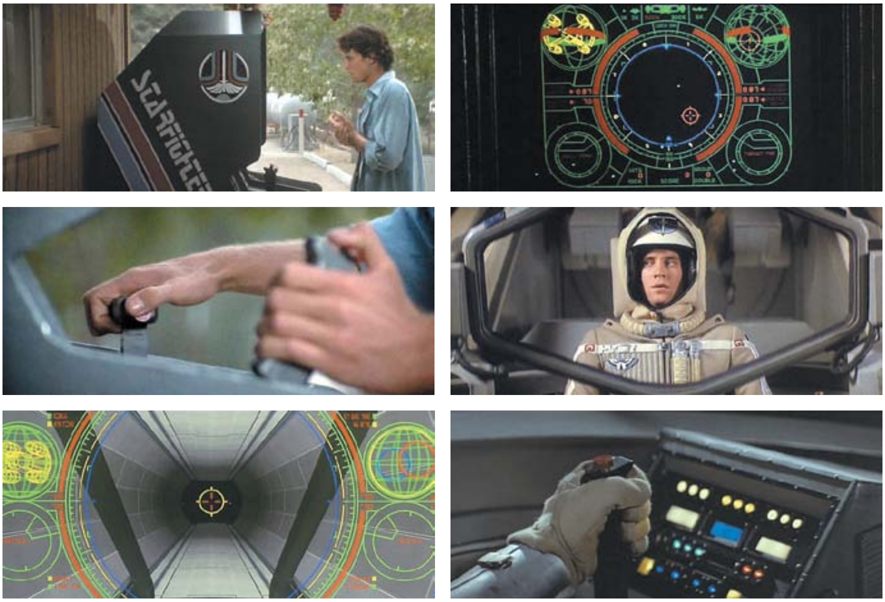


FIGURE 11.8a–f
*The Last Starfighter* (1984).

**LESSON** **ALIGN LEARNING EXPERIENCES WITH REAL ONES CLOSELY**

If the learning interface is meant to develop real-world skills, the closer it matches the real thing, the easier learners will find the transition. Though by definition the learning interface isn't the real thing, it can help build skills that are directly applicable.

**LESSON** **MAKE LEARNING A GAME**

Though a game model doesn't work for every type of learning, many of the tenets of good game design can turn learning from a tedious task into something fun and deeply engaging: with progressive challenges, integrative skill building, role playing, and so on. (If you want to read more on this topic, try Chapter 12 of John Ferrara's *Playful Design,* which focuses specifically on games for learning.)[1]

The military cadets in *Starship Troopers* break into teams to fight in mock combat similar to the real-world game laser tag. The weapons they use in this scenario fire lasers that are harmless in and of themselves, but when they strike sensors on a harness worn by an "enemy," the harness delivers a nasty shock to the wearer, disabling him or her for the remainder of the exercise (Figure 11.9).

FIGURE 11.9a,b
*Starship Troopers* (1997).

1 Ferrara, J. (2012). *Playful design: Creating game experiences in everyday interfaces.* Brooklyn, NY: Rosenfeld Media.

**LESSON** **RAISE THE STAKES PROGRESSIVELY AS SKILLS BUILD**

As the troopers in *Starship Troopers* are mastering basic skills, such as how to operate their weapon, distracting them with worry about being horribly shocked would be counterproductive. Only after they master these component skills do the shocks need to be added. By letting the stakes gradually increase along with the level of mastery, systems keep learners in the engaging balanced state between boredom and being overwhelmed.

The one noncombat psychomotor interface found in the survey is the tennis trainer seen in *Total Recall*. At home, Lori turns on a device with a click, and a life-size, volumetric tennis coach appears in her living room. It repeats the same serve over and over (Figure 11.10a).

As the display continues, a disembodied female voice repeats, ". . . and pivot . . . and serve . . . and shift . . . and stroke . . ." Lori stands behind the coach, watching it and mimicking its motion (Figure 11.10b). After a handful of these repetitions, the virtual coach blinks red twice as a tone sounds (Figure 11.10c). Then the voice congratulates Lori: "Very good. Perfect form!" The system is not only projecting the coach but scanning Lori's movements and comparing them to an ideal.

These psychomotor practice interfaces teach through experience, replicating some aspect of using the skill in the real world, whether by a virtual model of ideal form, a safe space to fight in, or a stand-in for a real opponent.

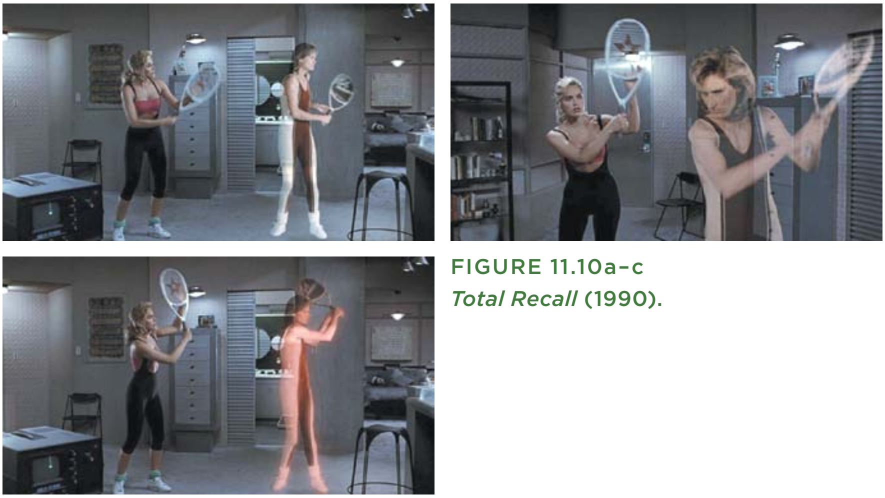


FIGURE 11.10a–c
*Total Recall* (1990).

## Presentation Tools

When it is not practical to bring an object to learners or the learners to an object to be studied, teachers can use technology to model it in a presentation instead. Most scenes of this type of learning in early sci-fi show individuals standing at lecterns and speaking to their audience, with no accompanying display of any kind. Even the prescient film *2001: A Space Odyssey* (1968) did not augment its presentations visually.

One exception appears in the original *Star Trek* TV series, when Spock briefs Captain Kirk about their new mission, using images on a monitor mounted near the ceiling (Figure 11.11).

As this capability was becoming possible in the real world in the mid- to late 1970s, presentations in sci-fi began to use accompanying motion graphics. This helped visually tell the story, as well as telegraph the importance and logic of an upcoming action sequence. The survey's first example of this narrative strategy is in *Star Wars Episode IV: A New Hope*, when General Dodonna presents the attack plan on the Death Star (Figure 11.12). Over the next decade, these presentations become more elaborate and three-dimensional (Figure 11.13).

**LESSON** **MODEL TASKS OVER TIME**

When a task is being presented, learners benefit from seeing it modeled visually over time. This helps them quickly understand how it should progress, what they must do, and how the system responds. In interaction, this can mean temporarily taking control of the interface and showing users what they should select or how they should gesture before they are asked to do it.


FIGURE 11.11
*Star Trek: The Original Series*, "What Are Little Girls Made Of?" (Season 1, Episode 7, 1966).

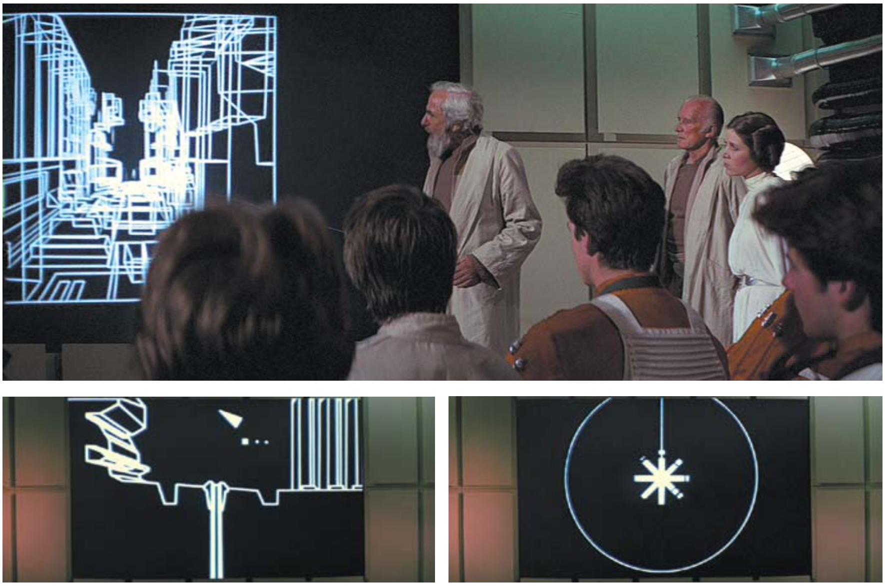


FIGURE 11.12a–c
*Star Wars Episode IV: A New Hope* (1977).

FIGURE 11.13a–c
*Star Wars VI: Return of the Jedi* (1983).

By the late 1990s, filmmakers could afford to show 3D presentations in more mundane educational settings, such as the biology lecture in *Starship Troopers*, which features a rotating volumetric display of a "bug" (Figure 11.14).

In *Star Wars Episode II: Attack of the Clones*, Obi-Wan seeks help from Yoda to find the location of a planet missing from the Jedi archives. Yoda is in the Jedi training school, leading a class of young children in lightsaber practice. To illustrate his problem, Obi-Wan places a small sphere onto the tip of a thin, upright rod (Figure 11.15a). It immediately begins to glow, and a slowly moving volumetric display of many star systems appears (Figure 11.15b). Obi-Wan is able to point to the place where the planet should be (Figure 11.15c). After one of the young students solves the mystery, Obi-Wan ends the display by telekinetically summoning the sphere back to his hand. Though this is not exactly a lesson, the technology's presence in the classroom indicates that it is ordinarily used for teaching purposes, with different spheres containing different materials to display.

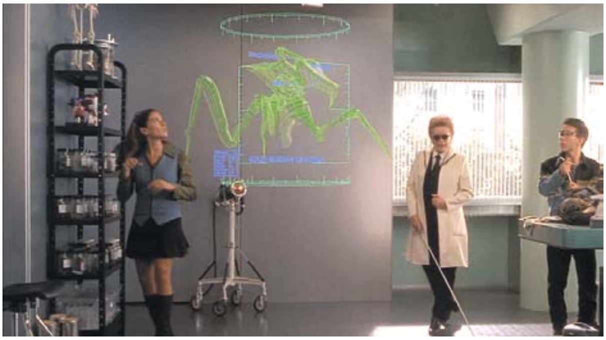


FIGURE 11.14
*Starship Troopers* (1997).

FIGURE 11.15a–c
*Star Wars Episode II: Attack of the Clones* (2002).

FIGURE 11.16a–c
*Serenity* (2005).

Part of the beautiful introduction to the movie *Serenity* is a school scene from River's childhood. (Though how much of it is constructed or hallucinatory is ambiguous.) The lesson is about the evacuation of "old Earth" and is illustrated by an animation of those events, which the instructor is narrating (Figure 11.16). The animation occurs on a wall-size video display encircling the classroom. After the presentation is complete and the instructor wishes to talk with the students, the display fades from view, exposing greenery beyond. There does not appear to be any interface or controls by which the instructor is changing the display. It may be that she is narrating a large, silent video that is programmed to fade from view at its close.

**LESSON** **ENGAGE LEARNERS IN MULTIPLE MEDIUMS ACROSS MULTIPLE SENSES**

The use of voice, video, animation, text, and other media in a blended, seamless whole helps keep the learner's attention. It also affords the content designers the opportunity to put content in the medium that fits it best. If the interface helps a teacher to plan and give the presentation, this assists both the teacher and the learner.

In a classroom environment, an engaging presentation is often the first step in getting students interested in a problem or new material. Highly cinematic displays of large and detailed motion graphics serve several purposes. These satisfy the need of the learners to learn the material, the need of the author to explain the material to the audience, and how the learner encounters it. In addition, these presentations are often visually and auditorily stimulating for both audience and learner, and a chance to showcase new or speculative technologies.

## Reference Tools

The reference materials seen in sci-fi are also predictably cinemagenic. When a character needs to look up a fact or ask a question, the answer is often animated and/or narrated.

The first reference interface in the survey appears in the movie *Things to Come*. As John Cabell, a leader of a technocratic city of engineers, shares with his granddaughter some history of their great civilization, he shows her clips of silent video that help illustrate his stories. The only controls for this device are a pair of dials to the left of the screen (Figure 11.17). How this simple dial provides access to the potential library of video is unclear.

Another notable reference appears in *Dune*. Paul Atreides uses a handheld tablet device as part of his studies. The device rests on a display stand while on a desk, but can also work comfortably on his lap (Figure 11.18). The content of a small oval screen at the top is controlled by four large push buttons below. Paul presses buttons to summon narrated videos of requested topics. The encyclopedic content includes star maps, surveys of indigenous plants, information about social castes, the behavior of the giant worms on the Spice planet Arrakis, and the industrial processes of Spice mining.

FIGURE 11.17
*Things to Come* (1936, colorized version).

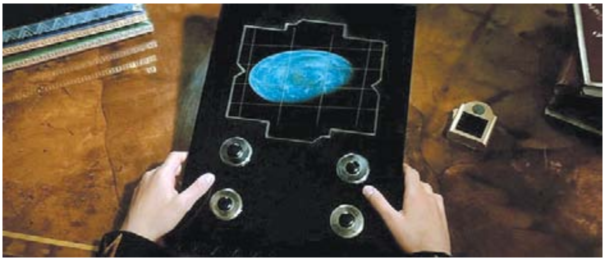


FIGURE 11.18
*Dune* (1984).

One bit of historical interest from this scene is the information architecture of the device, which is needlessly tied to the space efficiency needs of a printed book. That is, when Paul requests the topic "Weather," he is shown a screen with white text reading WEATHER [SEE STORMS]. Paul navigates to the cross-referenced topic "Storms" and begins to watch. Modern audiences familiar with Wikipedia recognize that there is no reason why a digital medium can't just automatically reroute from the requested keyword to the actual content, with a bit of text to reinforce the correct keyword.

**LESSON** **DESIGN FOR THE CAPABILITIES OF THE NEW MEDIUM**

When working in a new medium, try to avoid merely replicating the interface from an old medium. Specifically when moving something from print to interactive media, try to remove the unnecessary work required of a passive medium like paper that can be done on the reader's behalf.

*Superman* and *Superman Returns* adhere to the reference technology from the *Superman* comic books: Superman has, in his crystalline Fortress of Solitude, a platform bearing a bank of crystals (Figure 11.19a). Inserting a crystal into a slot activates a database of Kryptonian knowledge (Figure 11.19b). A recorded image of his father, Kal-El, introduces the database by telling him, "Embedded in the crystals before you is the total accumulation of all literature and scientific fact from dozens of other worlds spanning the twenty-eight known galaxies" (Figure 11.19c).

To request a topic, Superman speaks a command or question to the crystalline walls, and Kal-El appears and narrates a volumetric projection display (Figure 11.19d). The interface appears to be a fully functioning artificial intelligence, but the dialogue later reveals it is just a Kryptonian automated voice response system built on top of a vast database that anticipates thousands or perhaps millions of queries and responses. (Readers may enjoy comparing this to the reference technology from *The Time Machine*, already discussed in Chapter 9 for its anthropomorphic qualities.)

FIGURE 11.19a–d
*Superman* (1978).

A screen-based version of a similar interface appears in the film *The Fifth Element*. The character Leeloo, who has been resurrected from a bit of alien DNA, must learn all she can about the human race she is meant to save. Her tool to do this is a screen-based reference that goes unnamed in the film. This tool is available in many places: in Cornelius's home, on the Flogiston Paradise transport, and aboard Zorg's spaceship (Figure 11.20).

To use it, Leeloo either selects from an on-screen menu of alphabetized topics or calls up a topic directly by typing it on a keyboard. Within each topic, she is shown pictures and video. For the topic of war, she is shown a series of rapid-fire images that illustrate the concept. This sequence might be a film editor's exaggeration of Leeloo's rapid learning, but the audience is given no evidence that this is the case.

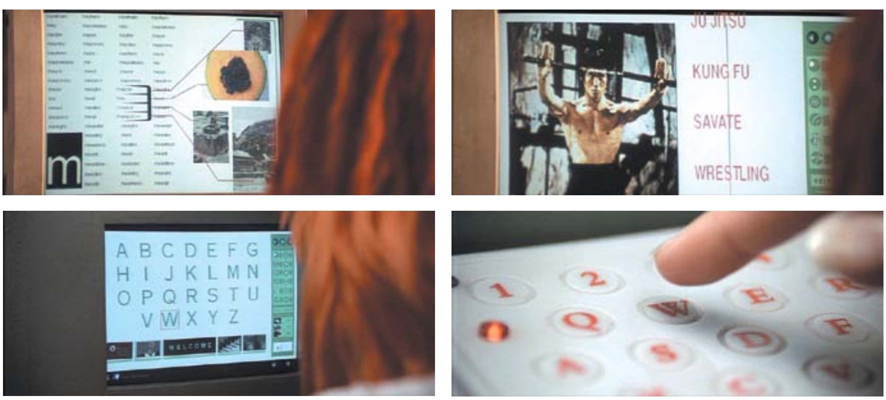



FIGURE 11.20a–d
*The Fifth Element* (1997).

These two interfaces illustrate one trade-off between command-line and WIMP interfaces (each described for their graphic qualities in Chapter 3). The Krypton database is very easy to use: Superman just asks his question aloud. Some of his questions aren't in the system, though, and it's a process of trial and error to learn what those missing questions are. He could waste a lot of time trying to figure out a way to re-ask questions only to ascertain that it's not how he's asking the question, but that the answer just isn't there. In contrast, Leeloo's interface looks less easy to use. She has to read the long menu of options, understand them, and make a selection. Presuming she's a competent typist, the costs she bears in parsing the interface pay off in helping prevent her from wasting time requesting an entry that isn't there. Each of these interfaces illustrates one side of a balancing act: Superman's shows ease of use; Leeloo's shows error prevention.

### LESSON BALANCE EASE OF USE WITH ERROR PREVENTION

Requiring users to select from a list of options avoids input errors and sets their expectations of what is available, but for vast amounts of content, it can be cumbersome. Giving users free-form inputs may be easier for them to express themselves, but it introduces problems of resolving unexpected input, disambiguating search terms, and hit-or-miss strategies of guessing what's available. When dealing with large amounts of content or options, designers should strike a balance in their search and navigation, setting expectations of what's generally available, providing free-form input, suggesting most-likely content from context, helping them understand when they're about to request something that isn't available, and pointing them to alternate content or destinations when they request missing content anyway.

Another note of caution about Leeloo's interface: the topics aren't clustered by meaning or by their connection to one another, but alphabetically, which is a common but meaningless organizing principle. Admittedly, Leeloo is using reference software built for a purpose other than learning about the human race in one fell swoop, but for it to be useful as a reference, multiple ways of getting at the information—including some sense of information hierarchy—would be appropriate.

### LESSON ADD MEANING TO INFORMATION THROUGH ORGANIZATION

Information designer Richard Saul Wurman identified five primary ways to organize any set of information: by category, time, location, continuum (along a variable), and alphabet.

The first four of these add a level of meaning that helps a learner compare and make sense of the information, while the last is arbitrary. Alphabetic organization was popularized because most English speakers have the order memorized, but modern search capabilities obviate such manual search methods. So, while it's best to give learners ways to reorganize as part of making sense of the information, the smart default is most often anything but alphabetical organization.

Another (and much beloved) example is *The Hitchhiker's Guide to the Galaxy*, a small device with a horizontal screen and a metal frame that folds in half like a book. To use it, the reader opens it and speaks a word or phrase. In response, an animated and narrated clip describing the topic plays on the screen. The characters use the *Guide* to look up a variety of things during the course of the film, including information on the Vogon alien race, the language-translating Babel fish, and even practical matters such as how to fill out the notoriously bureaucratic Vogon forms (Figure 11.21).

A device seen in Apple's industry video, *Project 2000,* gives us some insight into how speculative interfaces can act as a real-time reference. In one vignette, a man is learning to read with a device. It listens to his words, highlights the words as he's speaking them, and even calls up the proper pronunciation when he's unable to read the word correctly (Figure 11.22).

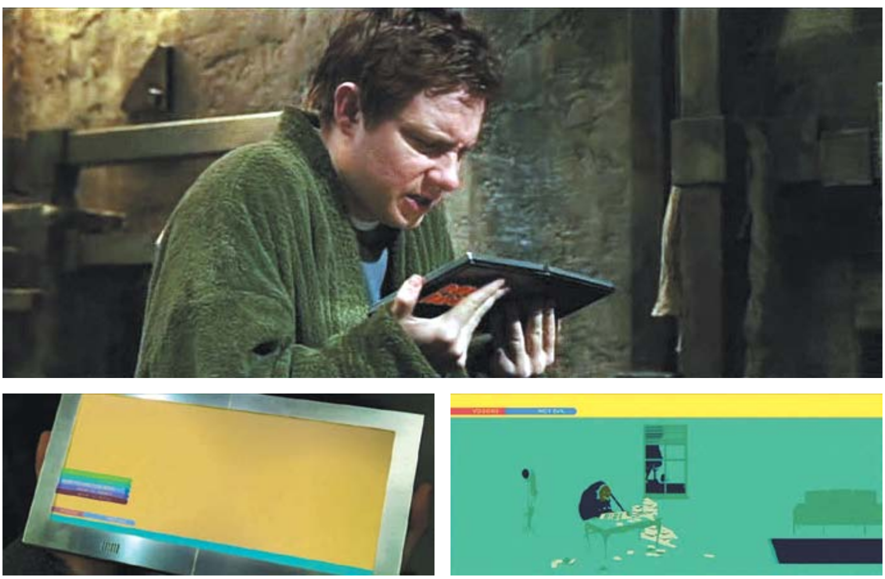


**FIGURE 11.21a–c**
***The Hitchhiker's Guide to the Galaxy*** **(2005).**

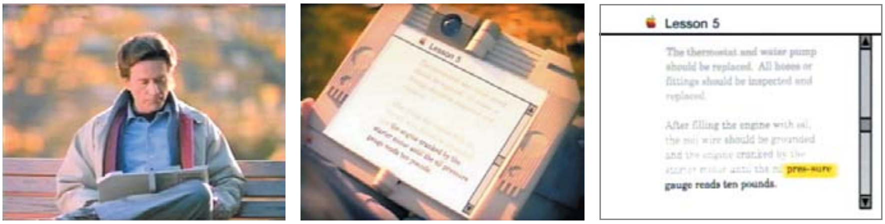



FIGURE 11.22a–c
Apple's *Project 2000* (1988).

There is one other aspect of this inspired prototype that bears mentioning. During the course of the lesson, the man tires of the instructional book he's assigned. Instead, he circles an article in the newspaper's sports section, tells the device that he wants to read "this," and places it face down on the screen. The device scans the article and automatically converts it to text, allowing him to read in the same way as before, but with his own material.

**LESSON** **MAKE THE CONTENT RELEVANT TO THE LEARNER**

When a learner is focused on acquiring a skill, he or she will be simultaneously engaged in the content of the task. For example, learning to sing is partly motivated by a love of the song being sung, not just getting arbitrary notes correct. Give learners options of many types, or if feasible, the ability to supply their own content to help keep them interested and engaged (see Figure 11.22).

## Machines to Think With[2]

Information must be internalized in the mind of the learner before it can become knowledge. Internalization isn't a simple process. Learners need tools to consider new information in different ways, compare it to what they already know, build new representations, and consider new hypotheses. For skills learning, the practice interfaces seen above are sufficient to this task, but for more abstract and symbolic information, learners need a place to ruminate on symbols and concepts, as well as systems to make sense of what they study.

The tools and processes for abstract learning must be, necessarily, open-ended, and adaptable. Pencil and paper, clay, drawing boards, and Legos are all good examples. In the survey we see such tools being underused, adapted for unintended purposes, or in use only in the background.

2 The title of this section is taken from a chapter in Howard Rheingold's *Tools for Thought*, 2000 (Cambridge, MA: MIT Press).

In the “Mirror, Mirror” episode of the original *Star Trek* TV series, Captain Kirk consults the computer to learn whether a poorly understood accident could have been produced deliberately (Figure 11.23):

KIRK: Computer.

COMPUTER: Ready.

KIRK: This is the Captain. Record: Security research, classified under my voiceprint or Mr. Scott’s.

COMPUTER: Recording.

KIRK: Produce all data relevant to the recent ion storm, correlate following hypothesis. Could a storm of such magnitude cause a power surge in the transporter circuits, creating a momentary inter-dimensional contact to a parallel universe?

COMPUTER: Affirmative.

KIRK: At such a moment, could persons in each universe in the act of beaming transpose with their counterparts in the other universe?

COMPUTER: Affirmative.

KIRK: Could conditions necessary to such an event be created artificially, using the ship’s power?

COMPUTER: Affirmative.

FIGURE 11.23
*Star Trek: The Original Series*, “Mirror, Mirror” (Season 2, Episode 9, 1967).

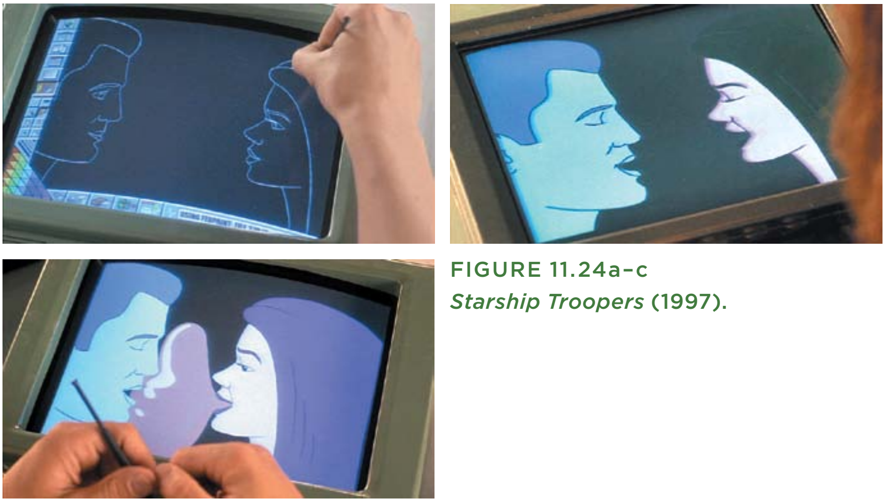


FIGURE 11.24a–c
*Starship Troopers* (1997).

What's notable is that during the interchange, Kirk isn't playing with ideas, he's just asking yes or no questions. Even though he's asking about something fairly mind-blowing (which could have changed the nature of the *Star Trek* franchise into something much more like *Quantum Leap*), he is essentially using the device as a reference. Still, the scene gives the sense that this is something that has never been done before, with the computer instantly modeling options and testing variables to produce its answers. This makes it a good tool for thinking.

In one of the schoolroom scenes from the film *Starship Troopers*, Rico makes an animated drawing of him and Carmen about to kiss, using his pen and tablet. He starts by drawing their profiles in white lines. He then adds some flat color and animates them such that the faces get closer, their eyes close, and their mouths open in readiness of a kiss. He then sends it to her through an in-class message system. She sends it back after adding a funny bubble gum bubble that ruins the anticipated kiss (Figure 11.24).

Though this is used in a social way, the tool, called FedPaint, is provided by the school and seems to be designed for use in class to draw and model events across time rather than flirting.

Why do we see so little of these most important tools? Most likely, the needs of the story outweigh any need to generate novel ideas. Because of the time constraints in cinema and television, writers prefer to show the sudden insight and eureka moment to the slow and sometimes disorderly process of real learning. Additionally, dialogue is a natural relationship between a teacher and a student, creating a learning-moment bias toward characters interacting with each other through technology.


FIGURE 11.25a–c
*Star Trek IV: The Voyage Home* (1986).

## Testing Interfaces

Testing is seen in the survey a few times, all within the *Star Trek* films. In *Star Trek IV: The Voyage Home*, we see such a system when the recently reanimated Spock is rebuilding his sense of self and knowledge of the world.

In the testing cell, he approaches a bank of three transparent screens. When he says, “Computer, resume testing,” a metallic voice begins to ask him questions on a wide variety of esoteric topics, such as, “Who said ‘Logic is the cement of our civilization with which we descend from chaos using reason as our guide?’”[3] and issuing challenges such as “Adjust the sine wave of this magnetic envelope so that anti-neutrons can pass through it but anti-gravitons cannot.” When Spock correctly answers a question, the computer responds with “Correct!” and moves on (Figure 11.25).

For each question, either the text or an illustration of the posed problem is presented on the screen and remains there until Spock answers it. He answers some of the questions vocally. For others, he places his hands on a set of touch pads. Only his gaze identifies which of the three simultaneous questions he is answering. He answers with increasing rapidity until he comes to a particularly difficult question he does not understand (Figure 11.26).

3 T’Plana Hath, matron of Vulcan philosophy, in case you were wondering.

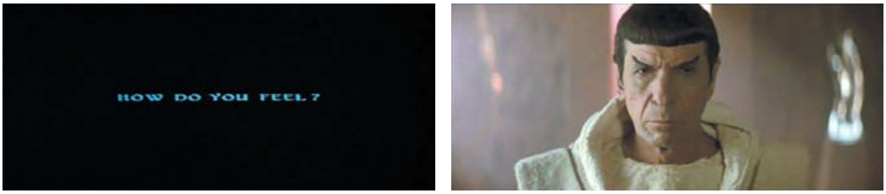



FIGURE 11.26a,b
*Star Trek IV: The Voyage Home* (1986).

Seriously, he's stumped.

One of the most memorable examples of testing interfaces is in the *Star Trek* reboot film when a young Spock is attending school on Vulcan. He is standing at the base of a concave hemisphere that surrounds him with a projected expanse of overlapping and moving images, formulae, and illustrations (Figure 11.27). He responds to a voice asking him factual questions, such as "What is the formula for the volume of a sphere?" As he answers questions correctly, the related figure fades from view and another is asked. We do not see Spock make an error, so we don't know what would happen in that case.

When the camera pulls back to reveal many similar learning pods with one student at the center of each, we understand that testing on Vulcan is done alone, and we assume that each student progresses through this gauntlet at his or her own pace.

In both cases, the interface fires a barrage of questions at the student, testing recall of facts in rapid succession.

FIGURE 11.27a–c
*Star Trek* (2009).

Both of these systems equate intelligence with the simple recall of facts. Memorization is a core skill, but data in the age of the Internet is cheap. Just as or more useful is the ability to *apply* that knowledge—to take a complicated problem in the real world, identify what information is and isn't pertinent, and form and execute a plan for solving it. Granting the benefit of the doubt, perhaps these testing interfaces we see are just one part of Spock's education and there are other systems for learning other skills. It makes sense that a filmmaker would want to pick the most cinemagenic of possible learning components. This testing pod qualifies for its pace, exciting visuals, and an emotional callback to what it felt like for the audience to take difficult tests in their youth.

Another testing interface seen in the *Star Trek* franchise is the Kobayashi-Maru test. To participate, a group of Starfleet cadets gather on a simulated starship bridge in assigned roles. The test taker plays the role of captain. Through video screens and information interfaces, the crew encounters a situation in which they must face hostile and overpowering enemies while trying to rescue the crew of a stranded vessel. Though the cadets try to solve the problem, it is designed to be unbeatable, and is rather a test of character, creativity, and the ability to handle stress.

We first see the test in *Star Trek II: The Wrath of Khan*, with Cadet Saavik in the role of captain (Figure 11.28). It next appears in the 2009 *Star Trek* reboot film, in which James T. Kirk reprograms the simulation so that he can easily defeat it—an event referred to in *Star Trek* several times but never before shown (Figure 11.29).

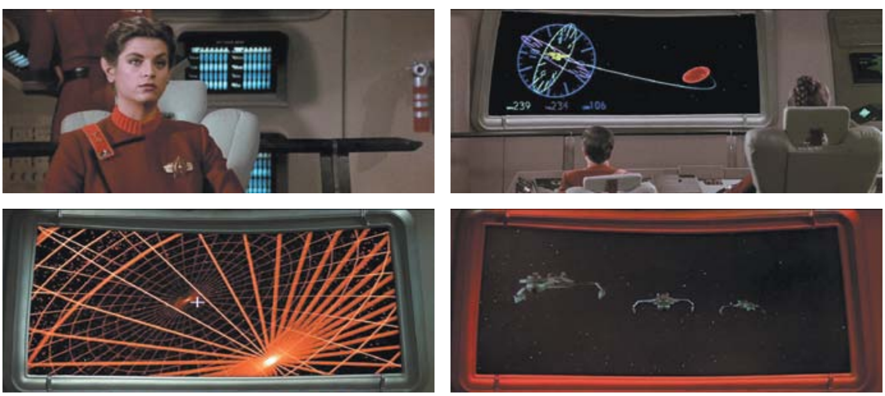


FIGURE 11.28a–d
*Star Trek II: The Wrath of Khan* (1982).

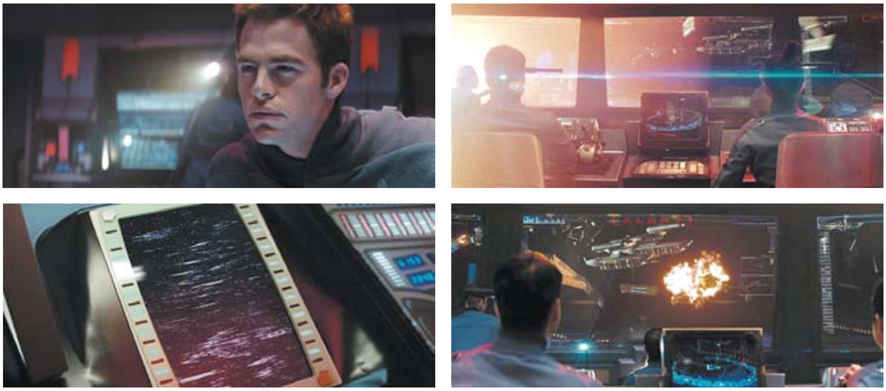


FIGURE 11.29a–d
*Star Trek* (2009).

Both versions of this test illustrate an interface that simulates a complex problem in a very realistic way, requiring the cadet to analyze the situation, form a plan of action, and execute it to see the results. The only thing to break the highly realistic illusion of the simulation is the observation gallery out of view of the cadet in the captain's chair. We know from dialogue in the films that, though it's rare, cadets may take the test multiple times, enabling them to learn from the experience, in order to reflect on their actions or reconsider how to handle the situation, particularly their emotions.

**LESSON** **PROVIDE A SAFE SPACE TO LEARN**

The fear of failure and the consequences of failure can paralyze a learner. Grant them the confidence to try new skills and new approaches by providing a safe space to learn, where the consequences aren't permanent, there is an opportunity to reflect on performance, and it is easy to return to face the challenges again and improve.

## Case Study: The Holodeck

With the exception of direct brain downloads, every type of learning interface in sci-fi is found in the holodeck from the *Star Trek* franchise. Though references cite its original appearance as "the rec room" in *Star Trek: The Animated Series,* the much more popular *Star Trek: The Next Generation* brought it to a wide audience.

The holodeck is an amazingly ambitious piece of speculative technology. It is a chamber that can project perfect volumetric projections of any conceivable scenario, including the environment, objects, and lifelike characters within it. The environments and objects are perfectly visually detailed. The characters within it behave with full agency and even occasionally display a disturbing degree of self-awareness. It also creates finely controlled force fields to provide users with real-life tactile feedback and various degrees of real-world physics.

Outside the chamber is a wall-mounted touch interface that lets users see if the holodeck is occupied, schedule their own session, and select a holodeck program. While in the room itself, the holodeck is controlled primarily by voice. Users speak aloud, addressing the computer with such commands as "Computer, halt program" or "Computer, freeze." The simple voice control means the barrier to participation is minimal. Users can also summon command panels in the doorframe for additional control and instruction.

In the holodeck, users can interact with notable fictional or historical figures and places, play virtual sports, and ride virtual horses across limitless landscapes. The user's appearance can be altered, though only in subtle ways, such as color saturation or simple changes in clothing. The crew can reserve the room and use it for a huge array of purposes: entertainment, games, training, problem solving, exercise, sex, and even authoring holodeck novels.

For learning, in particular, the holodeck is used in a number of ways.

## Psychomotor Training

One of the first examples of the holodeck being used for psychomotor training is when Lieutenant Yar demonstrates an Aikido program for visiting dignitaries (Figure 11.30). She summons the Aikido master and performs a few moves, explaining that the master evaluates your progress and adjusts accordingly, challenging the user to improve. When the demonstration is over, she dismisses it with a verbal command.

FIGURE 11.30
*Star Trek: The Next Generation*, "Code of Honor" (Season 1, Episode 4, 1987).

**LESSON** **PROVIDE EXPERT GUIDANCE AND SUGGESTIONS**

Learners can only get so far studying on their own, and they won't add significantly to a culture's body of knowledge if they are rediscovering lessons that are already well documented. To help learners move to the forefront of knowledge, systems should be able to provide some expert guidance when asked (see the section on "Degrees of Agency: Autonomy and Assistance," page 190, in Chapter 9). This can be as simple as reasonable goal formation. For example, if a student tells the computer "I want to be the best pilot in the Alpha quadrant," then the computer should be able to suggest a course of study and practice to achieve that goal.

System guidance and assistance can also challenge assumptions. If in the "Once Upon a Time" episode that opened the chapter, Naomi had shouted, "Oh no! Flotter's been killed!" a guide could have asked, "Are you sure? Let's watch it again. What do you *see*?" and by pointing out the evaporation, set her down the right path. (Read more about this particular example below.) Often, this type of guide should be outside of the main narrative to be able to discuss things dispassionately and without confusing the learner.

Other skill training includes very specific field rehearsals. In the episode "Chain of Command (Part 1)", an away team rehearses their mission in a perfect replica of Kardassian tunnels for a difficult covert operation (Figure 11.31). By rehearsing inside a replica, they can commit the geography and tactics to memory, pause and repeat the more difficult parts, and get their timing down to the second.

FIGURE 11.31
*Star Trek: The Next Generation*, "Chain of Command (Part 1)" (Season 6, Episode 10, 1992).

FIGURE 11.32a–c
*Star Trek: Voyager*, "Once Upon a Time" (Season 5, Episode 5, 1999).

## Presentation

The infinite display capability of the holodeck means that the presentation of material can be tailored to the learner—in whatever genre or presentation medium suits the scenario best—aural, visual, or tactile.

The *Star Trek: Voyager* episode mentioned at the beginning of this chapter ("Once Upon a Time") involves a young girl's use of a holodeck novel that feels much more like a storybook for learning. Naomi enters a colorful world where charming characters embody materials from nature: Flotter represents water, and Trevis represents trees. Solving problems for these characters teaches her about their properties, and she is deeply engaged through the narrative presentation.

A major problem occurs when she and her friends, Flotter and Trevis, encounter the Ogre of Fire, who in his fiery rage evaporates Flotter (Figure 11.32). The narrative creates a problem that Naomi wants very much to solve—how to get Flotter back. To do so, she has to learn how a liquid turned into a gas through evaporation can be condensed back into water again.

## Reference

There is no reason why the holodeck could not be used to present reference material in a highly engaging way, but this is not seen. Occasionally, characters may ask the computer factual questions, but there is no *Hitchhiker's Guide to the Galaxy*–type holodeck programs that appear so the learner can conduct some research while the main holodeck program is on hold. Instead, the holodeck facilitates simulation and learning experientially.

Still, Naomi has access to reference materials through a computer terminal in her cabin, which she uses to solve the problem of her evaporated friend Flotter.

Though the details of this reference interface are not shown, it is vital that she have access to the materials so that, in solving the problem, she can learn.

## Machines to Think With

The storybook presentation of "Once Upon a Time" is itself a way of thinking. Characters present problems, such as "Where do you think the fire came from?" and Naomi offers hypotheses after thinking about it for a bit.

There are other ways to use the holodeck to represent current thinking and evaluate it, of course. In the *Star Trek: The Next Generation* episode "Nth Degree," Lieutenant Barclay has his brainpower greatly amplified by an unknown force. Unable to sleep, he spends the night in the holodeck, discussing ideas with a holodeck display of Einstein. They write equations on a chalkboard, then discuss and revise them (Figure 11.33).

Evaluating hypotheses means considering multiple options. In the *Star Trek: The Next Generation* episode "Booby Trap," Geordi La Forge uses the holodeck for just this purpose. Faced with a life-threatening problem, he calls up a virtual recreation of the original designer of the *Enterprise*'s engines to work through the possibilities. Together, they create simulations to vet their ideas and find the best solution (Figure 11.34).

FIGURE 11.33a,b
*Star Trek: The Next Generation*, "Nth Degree" (Season 4, Episode 19, 1990).

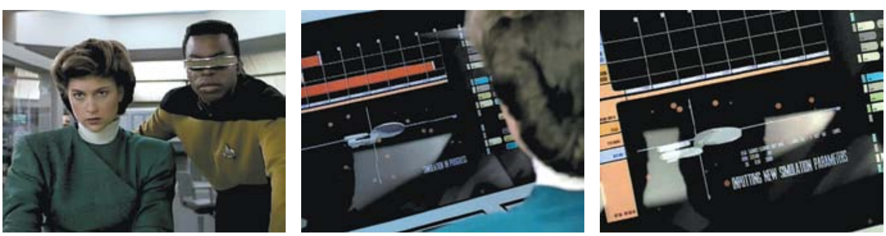



FIGURE 11.34a–c
*Star Trek: The Next Generation*, "Booby Trap" (Season 3, Episode 6, 1989).

La Forge employs an educated hit-or-miss method with the simulation. For example, he asks, “What is the effect of reducing thrust levels another four percent and adjusting trajectory to compensate when in an energy-draining environment?” Though this just may be his personal style of exploration, the interaction would be more efficient if it simply tested a range of options and shared those that best fit his criteria.

**LESSON** **SUGGEST THE BEST OPTION WITHOUT BEING ASKED**

Hit-or-miss methods of testing hypotheses are a waste of a user's time. When computing power is abundant, let the computer do as much look-ahead computation as it can, present the results, and guide users proactively toward the best options.

This example illustrates another lesson: recognition is easier than recall. La Forge is having to watch variables, represented as horizontal bars, change over the course of the simulation. But when is the variable at its highest? When is it at its lowest? The display forces him to remember. Had it presented a line chart of the variable over time with a highlight showing the current state of the variable, he would not have to recall how it has changed and additionally understand it in context.

A second way this principle could have improved this interface is to help La Forge compare one model against another visually. What was this same variable doing in the other simulation at this point? Was it better or worse? What about the end results of the multiple simulations? How did this simulation compare against the one four variations back? Presenting real-time comparisons between simulations and keeping results persistently visible would help lighten his memory load and help him recognize the best solution when he came across it.

Though the holodeck could conceivably handle much more complicated ways of representing an abstract hypothesis, such as multidimensional graphs of equations, nothing like this is shown in the holodeck.

**LESSON** **RELY ON A USER'S RECOGNITION RATHER THAN RECALL**

Recall places a burden on a user's short-term memory, which is more fallible than the ability to select from a set of visible options. Whenever possible, display options or data across space to let users review, feel confident that they have identified the salient option, and act on it.

## Lessons Unique to the Holodeck

The holodeck's unique capabilities provide some lessons for learning systems not found elsewhere in the survey.

At the end of "Once Upon a Time," Flotter even expresses admiration over the way that Samantha, Naomi's mother, has grown since he saw her last. This social interaction indicates that the holodeck characters remember individual learners and can respond to how they change over time.

**LESSON** **PROVIDE A SENSE OF PROGRESS**

> Learning is not simply a matter of stringing together a series of small lessons. At times, it is helpful to step back, create context, and put the pieces together to understand something of the whole. Additionally, recognizing the progress that they have made gives learners a sense of accomplishment. For this to happen, the system needs to remember and recognize an individual learner. Though it is handled conversationally, it is clear that individual programs recall individual users and can return them to the point where they last left off.

In the "Author, Author" episode of *Star Trek: Voyager*, crew members use the holodeck to read the Doctor's holographically recorded novel, in which the reader acts as the lead character in a number of scenarios. Each scenario is meant to elicit empathy for that character's oppressive circumstances. Because the lead character is based on the Doctor's own experiences, the stories become an interface to understand his perspective.

**LESSON** **HELP LEARNERS UNDERSTAND DIFFERENT PERSPECTIVES**

> If the system recognizes individual users, then they should be able to learn from each other's experiences, either in aggregate (e.g., "Most of your friends took the left path, Naomi. What do you think?"), or from direct observation of familiar situations from others' viewpoints.

Another application of the holodeck is as therapy and social practice, creating a "trial version" of the real world. In the *The Next Generation* episode "Hollow Pursuits," Lieutenant Barclay uses the holodeck to work through a number of personal issues, modeling exaggerated versions of crewmembers with which to enact fantasies of romance or even domination. When the crew discovers these simulations, they become upset. Counselor Troi defends the program against deletion and encourages Barclay to use it as part of an ultimately successful therapy.

**LESSON** **SUPPORT EMOTIONAL LEARNING**

People are emotional creatures, and many of our lifelong lessons are about understanding and dealing with our emotions. While many skills and knowledge are impersonal and "extrospective," future learning technologies must account for these more introspective and interpersonal topics as well, through instruction, role-playing, and the ability to retry situations that don't play out as well as expected.

## What We Don't See

Even with the holodeck representing the best of the learning interfaces, some tools and features we don't see in it would help a learner even more.

**OPPORTUNITY** **PROVIDE INTRICATE PHYSICAL SCAFFOLDING**

When users practice difficult physical skills, the holodeck could provide gentle force field nudges to act as a scaffold. Although it could do this with character embodiments, such as a trainer to help with acrobatic maneuvers, it does not need to be constrained to the physical limitations of a humanoid to provide this service. A diver rehearsing a back one-and-a-half somersault with four-and-a-half twists could never expect a real trainer to help position her correctly throughout the dive, but the holodeck could, while providing feedback on the tactics and principles behind the assistance. It could even simulate the slowing of time to allow the diver to concentrate on form.

**OPPORTUNITY** **FACILITATE SENSITIZATION**

Instructors in the real world often point out details of a thing while reviewing it. The holodeck could easily do this by augmenting its real-world presentation with a 3D augmented reality overlay of relevant metrics and useful information similar to a heads-up display. For example, while Naomi is reviewing the Flotter incident (see Figure 11.1), she might want to reference a diagram of the water cycle, with its components labeled in the scene, such as "heat source," "water," and "water vapor." (See Chapter 8 for more on augmented reality.)

**OPPORTUNITY** **ENABLE LEARNING IN GROUPS**

Though the holodeck does have a memory of its past users, where are the tools to encourage social learning? We don't see collaboration by multiple users in separate holodecks or on different ships, which would allow students to study together and help each other. We don't see friendly competition among users of popular programs, such as a leaderboard for completing a mountain climb within time and adhering to safety protocols. And learners are surrounded by other individuals—such as family, friends, teachers, and counselors—who are not directly involved with the learning, but would like to know how things are progressing. Where does Samantha go to see Naomi's accomplishments and challenges?

## Learning: Aiming for the Holodeck

People in the real world are constantly learning, and technology has advanced how interfaces can help learners see, understand, model, and test their new skills, both physical and mental.

But learning technology seems to be a mismatch for screen-based sci-fi. Certainly characters learn, but they do it either through events in the story or through student–teacher relationships. Using purely technological tools isn't as cinemagenic to watch.

As a result, learning interfaces in sci-fi generally come up a bit short. They neglect cognitive modeling and testing (machines to think with), offer a narrative shortcut to the messy process of actual learning (direct downloads), showcase tools for developing physical skills (psychomotor practice), or play a strong role as a narrative tool even if their use in real-world learning would be small or dubious (testing and presentation and reference tools). Perhaps when learning interfaces in the real world become more cinemagenic, they'll make their way into sci-fi, and we can learn more from them.

CHAPTER 12

# Medicine

FIGURE 12.1
*Star Trek: The Original Series*, "The Naked Time" (Season 1, Episode 4, 1966).

In sickbay, Dr. McCoy gestures with an open palm, inviting Mr. Spock to rest against the nearly vertical biobed. Nurse Chapel presses down on the head of the bed, swiveling it horizontally. At once a panel above the bed illuminates, showing how the patient's vitals are doing against normal parameters (Figure 12.1). McCoy glances at the panel and shakes his head, saying to Spock, "Your pulse is two hundred and forty two, your blood pressure is practically nonexistent . . . assuming you call that green stuff in your veins blood."

Unperturbed, Spock sits up and replies, "The readings are perfectly normal for me, Doctor, thank you. And as for my anatomy being different from yours, I am delighted." Having completed the examination, the nurse swivels the biobed back to its near-vertical position, allowing Spock to easily step off.

Medicine is a complex domain that deals with complicated, connected, and overlapping biological systems: skeletal, digestive, muscular, lymphatic, endocrine, nervous, cardiovascular, reproductive, urinary, and psychological. The number of things that can go wrong with any of these is huge. Medical practitioners must attend medical school for years to fully grasp the knowledge needed to master their chosen specialty. Neither Hollywood nor audiences have that kind of time, which puts a major constraint on medical interfaces in sci-fi.

What kind of time is available to tell satisfying stories involving medicine in sci-fi? It depends on the medical literacy of the audience. The goal is to strike the right narrative balance between boredom and unintelligibility. At the most remedial level, according to Harvard psychologist Steven Pinker, all people have a basic biological understanding of life: "All living things possess an invisible essence that gives them their power, drives their growth, and is inherited by their progeny. A dead thing no longer possesses this invisible essence."[1] Modern sci-fi audiences probably come to the cinema or turn on the television with a little more medical expertise than this, but in general, Hollywood tends to err on the side of caution and present medical problems simply—that is, as "dire situations," with any interfaces in the scene helping to build the tension and explicate final outcomes.

This chapter is primarily organized around the two types of medical interfaces: those that help people perform medicine, and systems that perform medicine autonomously. These sections are followed by a discussion about technology assisting birth and signaling death.

## Assistive Medical Interfaces

Most of the medical technologies we see in the survey help a human perform, or as in the next section avoid, medicine.

### An Ounce of Prevention

Western medicine focuses much more on treatment than prevention, but prevention helps people avoid the pain and stress of problems in the first place. One such example appears in the *Battlestar Galactica* TV series reboot. In season 3, pilots must steer their ships through areas with high levels of radiation while searching for food supplies. To help them gauge the amount of exposure they've received, they wear a badge on their wrists that slowly turns black as it is exposed (Figure 12.2). When the badge is completely black, the pilot is at the maximum safe radiation dosage.

There are few examples of preventative interfaces in the survey. There are some plots involving vaccines and antidotes, but they are usually given as a treatment rather than as prevention (see the section on injections, below).

FIGURE 12.2a,b
*Battlestar Galactica*, "The Passage" (Season 3, Episode 10, 2007).

1 Pinker, S. (2002). *The blank slate: The modern denial of human nature* (pp. 220–21). New York: Viking.

**OPPORTUNITY** **DESIGN PREVENTATIVE INTERFACES**

Preventative interfaces could help warn users away from behavior or circumstances that would result in medical problems, allowing for just-in-time notifications and an easy-to-judge comparison of outcomes. There are many nascent technology projects like this happening in the world of health care now, but sci-fi seems disinterested in them.

## Evaluation

The first task for medical professionals is to understand the problem that they're up against. Interfaces for evaluating patients break down into technology for monitoring, scanning, and testing. What distinguishes each? For the purposes of this chapter, *monitoring* is the measurement and display of real-time, specific physiological data, such as heart rate. *Scans* are the visualization of large areas of general physiological data, such as an MRI (magnetic resonance image) or X-ray. *Tests* are the measurement of specific, discrete physiological data, such as checking for the presence of a certain antibody. These tasks may be done repeatedly throughout a patient's diagnosis and treatment.

### *Monitoring*

Most medical interfaces seen in the survey belong to the first category: monitoring the health of a patient. These interfaces help visualize the story of a character's internal health status—which is especially useful when the producer doesn't want to bloody or disfigure a protagonist to show that there's a problem.

What gets monitored? In modern medicine, there are seven biometric indicators commonly used to monitor patients. These are heart rate, arterial blood pressure, central venous pressure, pulmonary artery pressure, respiratory rate, and less commonly, blood oxygen and body temperature. These seven indicators tell physicians and nurses a lot about a patient's current health status within the context of their illness.

In the survey, monitoring interfaces almost always include some variant of these basic vital signs shown as waveforms scrolling from right to left. Two aspects of monitoring interfaces are nearly universal: First, when only a single waveform is shown, it is almost always heart rate. Second, when things become dire, elements of the interface turn red and alarms sound to draw the physician's (and the audience's) attention to the problem. Beyond these two similarities, interfaces vary a good deal.

In *Star Trek: The Original Series*, patients' vital signs are monitored on a screen built into the wall above each biobed in sickbay. This screen features an array of six graduated registers with white triangles indicating whether a reading

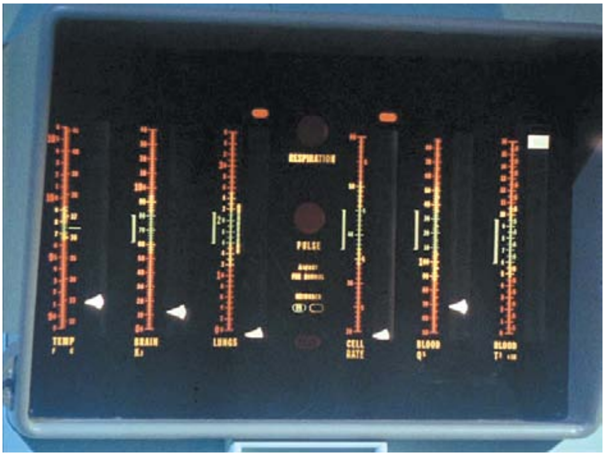



FIGURE 12.3
*Star Trek: The Original Series*, "Space Seed" (Season 1, Episode 22, 1967).

is in a stable, concerning, or dangerous range. Readings are labeled with things like temperature, blood Q3 levels, and "cell rate" (whatever that means). "Normal" health is indicated in green in the small range around the midpoint, transitioning above and below to yellow and then red (Figure 12.3).

This monitor is useful for showing the current state of the patient, but it doesn't indicate trends. Its design poses a number of other challenges as well: the label species and the data field humanoid look too similar, pulse and respiration are shown without metrics at all, and numbers are too small to be read at a distance, to name just a few.

One of the best features of the interface is that when there is only one patient on a biobed in sickbay, his or her heart rate is represented as audio as well. This benefits the audience, of course, but is also helpful ambient information for doctors and nurses, especially in critical situations like surgery. Having an auditory indicator allows them to focus their eyes and hands on other tasks while being aware of the status of this fundamental sign. This auditory signal disappears when there is more than one patient in sickbay, providing an excellent lesson in system design.

**LESSON ONE IS SPECIAL**

Many systems are built to handle any number of items simultaneously: zero, one, or more than one. When the system has zero items, its interface can shift to tools that allow for monitoring or selection. When the system has multiple items, its interface must allow the user to indicate which of the items is currently selected and should be acted on. Ambient signals, such as background color and audio, would be difficult to associate with one of the particular items.

When there is only one item, however, the system should adjust accordingly. No one should have to select when there's only one option. Even a simple shift of language to *confirm* the selection accomplishes this. Additionally, selection tools for the primary object are no longer necessary, and ambient signals can be used since their connection will not be ambiguous. Designers should adjust the designs of systems to accommodate the special case of having only one item.

Having noted how the audible heartbeat assists the doctors and nurses, we should also note that there is no indication about how this same signal affects patients in the sickbay. Does it cause them stress, or fill them with a morbid self-awareness? Unless the ambient signal was delivered only to the medical professional by augmented reality systems, care would need to be taken to consider all stakeholders of a design.

### *Shifting to Waveforms: Data over Time*

The now-familiar waveforms of the electrocardiograph, or EKG, have been known to medicine since Willem Einthoven invented the device around 1903. But it was not until 1932 and the development of direct pen on paper—rather than photographic—instruments that the technologies began to be used widely. Starting in the 1940s, people would have been exposed to these displays, but they aren't depicted in sci-fi until 1968, in *2001: A Space Odyssey*. This film showed vital signs on computer screens as the HAL-9000 computer monitored the hibernating crew members (Figure 12.4). Waveforms were commonplace in the world at the time, but the fact that they were on a computer screen with dynamic displays and smart alerts brought the notion of computerized patient monitoring into the future.

*2001* and most of the sci-fi that came after it augmented the display of vital signs with big labels to tell the audience in words what might be missed from the graphics, and what a doctor who is knowledgeable about the data might interpret from a glance at the same interface.

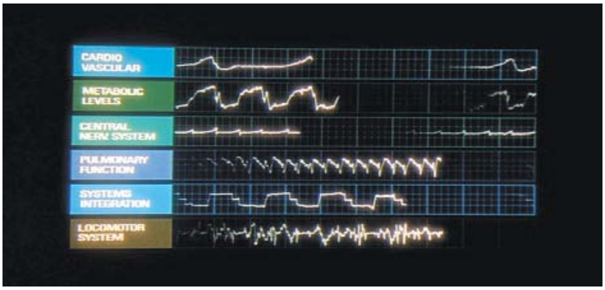



FIGURE 12.4
*2001: A Space Odyssey* (1968).

## LESSON USE THE WAVEFORM TO INDICATE VITAL SIGNS OVER TIME

People instantly identify waveforms as vital signs. In addition to their instant recognition, waveforms are well suited to the task of reading a simple variable over time within a range of values, allowing physicians to quickly understand trends and identify problems. For these two reasons, designers should stick with displaying vital signs as waveforms unless there is a very good reason to depart from this standard.

After *2001*, we see many similar medical monitors in sci-fi that differ mostly in their visual style (Figure 12.5).

Some sci-fi medical monitoring interfaces are very complex. As an audience, we may be impressed with a character's mastery of such complexity, but it's likely that these systems wouldn't be useful in the real world. The multiple, overlapping layers seen in *Star Trek* seem to obscure important data more than highlight it (Figure 12.6). In these cases, films must show bright overlays or use character dialogue to compete with the background noise of their own designs and let audiences know what's going on.


FIGURE 12.5a–d

*The Island* (2005); *Aliens* (1986); *Space: 1999* (1975); *Defying Gravity* (2009).

FIGURE 12.6
*Star Trek* (2009).

**LESSON** **BEING USEFUL IS MORE IMPORTANT THAN LOOKING IMPRESSIVE**

Many of the medical monitoring interfaces that we see in sci-fi are meant to impress us quickly with motion and complexity, but they defy usability and readability principles of clarity. For such systems in the real world, this kind of showiness would become noise, diluting the user's attention. Designers should show just enough information to provide the context, and should control the visual design so that directing the physician's attention to problems is easy.

The TV series *Space: 1999* introduced medical monitoring concepts that were novel for its time. Each resident in the space station was continuously monitored by an "X5 computer unit." When some medical alert occurred, the system would automatically contact Dr. Russell and her medical staff in the sickbay with both on-screen text and an audible alert. The system had voice recognition input and provided text output that it would simultaneously speak, two concepts that were very new at the time.

In the episode that shows this ubiquitous monitoring and alert system, technician Dominix's death was nearly instantaneous, so the X5 didn't have time to issue any critical warnings to summon an emergency response team, but it seems safe to imagine that such a system would be capable of this.

Additionally, the X5 could make medical "conclusions" based on data it had, though this fell short of actual diagnosis. In the pilot episode, Dr. Russell consults the X5 by voice about a particular patient she has been monitoring. She points her comlock (a portable communications device) at it, presses a button, and says, "Computer, please verify that last report." The X5 replies, "Stage 5 mutation complete. All brain activity stopped. Cell life sustained by artificial life support systems only. Conclusion: Astronaut Eric Sparkman deceased" (Figure 12.7).


FIGURE 12.7a,b
*Space: 1999*, "Breakaway" (pilot episode, 1975).

### *Suspended Animation*

Suspended animation is quite common in sci-fi, and often includes a special interface for onlookers to monitor the health of the suspended. In *Star Wars Episode V: The Empire Strikes Back*, Han Solo is encased in "carbonite" for transport by the bounty hunter Boba Fett. For the procedure, Han is lowered into a chamber and the process encases him in a slab of solid material that includes a small control panel on the side to monitor his health and, in the next film, revive him with the press of a few buttons (Figure 12.8).

More recent suspended-animation monitoring interfaces adopt more modern styles, such as the real-time 3D organ rendering of *Minority Report* and the cool monochrome of *Pandorum* (Figure 12.9).

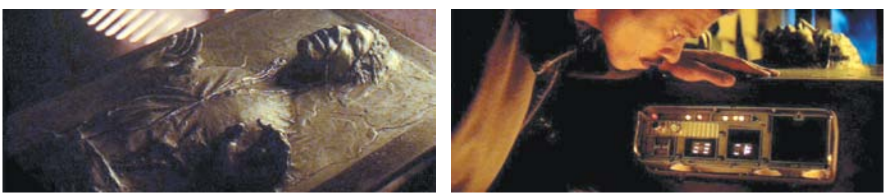


FIGURE 12.8a,b
*Star Wars Episode V: The Empire Strikes Back* (1980).


FIGURE 12.9a,b
*Minority Report* (2002); *Pandorum* (2009).

### *Scanning*

Sometimes a physician needs to scan a patient to create a picture of the patient's insides. Many of these scans are visually similar to an X-ray. Most of these are static, fixed pictures, but some show "live" data changing in real time. In almost all cases, patients are lying down and covered by the reading technology (Figure 12.10).

The scanning interface from *Dune* is notable because it displays a life-size image in real time, but the screen is significantly smaller than the patient's body. To examine different parts of the body, the doctor slides the screen left and right, and the screen adjusts to show the part of the body beneath it (Figure 12.11).

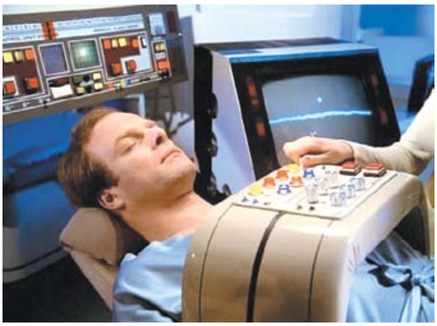


FIGURE 12.10a–c
*Space: 1999* (1975); *Star Trek: Voyager* (1995); *Alien* (1979).

FIGURE 12.11
*Dune* (1984).

**LESSON** **MAKE MANIPULATIONS PHYSICAL**

Users have years of direct experience with manipulating objects in the physical world. Designing physical controls for manipulating systems reduces the amount of training needed and the amount of cognitive weight during use, where the physical movement is natural to the intended result. This lets the user focus attention on the more difficult problems at hand. This effect is increased when there is a direct mapping of the controls—for example, moving the display screen left and right to move the X-ray camera similarly. (See Chapter 2 for more on physical controls.)

### *3D Visualizations*

The biggest leaps forward in the types of visualizations for monitoring coincided with advances in computer-generated graphics in the 1990s, which enabled the display and animation of such internal systems as bones, nerves, and organs. These visualizations help show physical, immediately apparent problems such as fractures, tumors, or internal bleeding, and so are very useful for physicians.

However, 3D visualizations still need to be augmented by 2D monitoring graphics and waveforms. This makes sense because the value of the EKG-like readouts is precisely that they show vital information invisible to the naked eye. For instance, even if you had lovely, full-color, selective X-ray vision into the human body, what organ would you look at to determine your patient's blood pressure, or how it has been trending over the last two minutes?

In addition to being useful for the physician, these "transparent human" visualizations are very cinemagenic, which is one of the reasons they have appeared with more frequency in recent years.

A good example comes from *Star Trek: The Next Generation*. In the episode "Ethics," Dr. Crusher consults with Dr. Russell about an experimental spinal surgery for Worf. They use a volumetric display of his spine to aid their discussion (Figure 12.12).

In the movie *Lost in Space,* Judy's suspended animation tube fails to revive her. She's placed on a medical bed that projects a translucent, real-time volumetric projection of her internal organs above her and that slowly lowers to overlay her body. A pink, translucent cube rotates around her heart to tell onlookers where the problem is (Figure 12.13). A separate screen displays vital signs. Using the bed's interface, Dr. Smith attempts to resuscitate her with what amounts to a sci-fi crash cart.

FIGURE 12.12
*Star Trek: The Next Generation*, “Ethics” (Season 5, Episode 16, 1992).

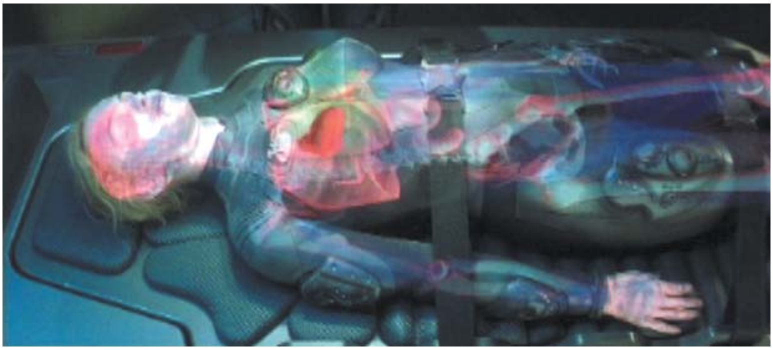


FIGURE 12.13
*Lost in Space* (1998).

As shown in the movie, Judy’s volumetric projection works beautifully to let us see through her skin to her internal systems. This is good, because it’s a noninvasive way to understand what might be wrong in a physical context. But it can’t work the way it appears at first glance. Consider this: How does the display appear for Maureen, Penny, and Dr. Smith, who are all on different sides of the bed? Remember that the projection of her heart appears to be *inside* her chest. This could work only if it were an optical illusion giving the *appearance* of depth from one particular observer’s point of view. If that person were to walk around the bed, the perspective would be all wrong, like seeing one of those sidewalk chalk illustrations from the wrong direction (Figure 12.14).

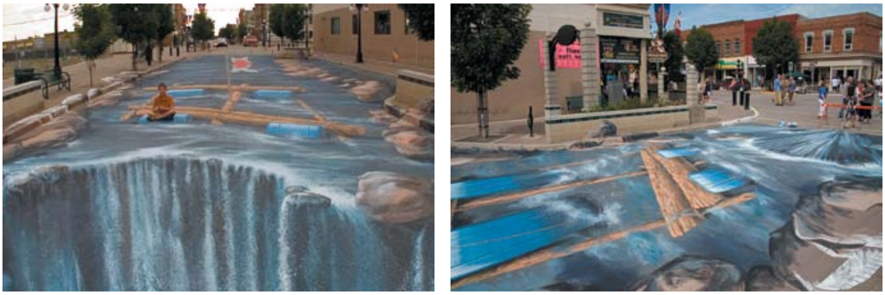


FIGURE 12.14a,b
Chalk art by Edgar Mueller.

So is this idea a nonstarter? Not entirely, if we use it as an opportunity for apologetics. It *could* work if the system provided everyone who is viewing the patient with a custom rendering. So although it looks like a volumetric projection (and every clue in the scene indicates that that's what the filmmakers meant), it can only work if it is actually *augmented reality*—views that are particular for the observer. No one is wearing special viewing lenses in the scene to provide the overlay, so perhaps the augmentation is being broadcast from projection points on the operating table directly onto their retinas (and, we must suppose, the camera). In any case, examining what at first seems broken gives us a useful insight into how it might work in the real world.

The TV series *Firefly* featured a scene with a display initially similar to the one from *Lost in Space*. In it, the ship's doctor, Simon Tam, is able to do some noninvasive investigation into his sister's brain using a holoimager at a sophisticated medical facility. Using this tool, he is able to peer into a translucent volumetric projection of a real-time scan of her brain and activate gestural controls to change the orientation of the projection to get a thorough view of things. Animated graphics of brain activity and other vital signs are provided along the side of the display for quick reference (Figure 12.15).

FIGURE 12.15a,b
*Firefly*, "Ariel" (Episode 9, 2002).

This is remarkable among the examples because, first, the physician interacts with the display to look for problems, and second, it is an interesting combination of gestural and volumetric projections. His direct gestures allow him to "grab" the image of her brain, strip away the rest of the display, and turn the projection to explore it.

Although these sci-fi 3D visualizations are cinemagenic, they lack tools vital to the actual work of conducting a scan, which is to find the problem. The *Lost in Space* interface automatically finds the problem (her motionless heart) and highlights it for Dr. Smith. That's useful when the system's confidence is high, but not for the trickier task of finding an elusive problem. *Firefly*'s interface comes closer. It allows Dr. Tam to isolate the brain from the other body parts and turn it to look for surface problems. The display could have gone further, subtly directing him to prospective problem areas, such as scar tissue. It could also have had view controls—different spectra filters for comparing magnetic resonance and radiographic views, cross-section controls to let him observe arbitrary "slices," or scale controls to let him magnify the view to look at details very closely. (See the *Chrysalis* example on page 280 for a surgical example of magnification.)

It might be worrisome if real-world designers were only referencing these sci-fi interfaces, but fortunately, they're ahead of Hollywood in this matter. For example, the Stanford Radiology 3D and Quantitative Imaging Lab at the Stanford University School of Medicine develops techniques for visualizing radiological studies as 3D-rendered images while hiding organs and tissue not related to the problem under consideration (Figure 12.16). Although they require an enormous amount of processing power, today's workstations and even laptops can generate interactive visualizations in real time, often within minutes of an exam's completion.


**FIGURE 12.16a–d** Medical imagery from the Stanford Radiology 3D and Quantitative Imaging Lab surpasses the examples we see in sci-fi.

### *Testing*

We don't see a lot of medical testing interfaces in the survey. Two examples help explain why. The first is the medical tricorder from *Star Trek*, the portable box with the wireless, all-purpose sensor that McCoy uses on away missions (discussed below). The second is the ubiquitous DNA-testing device in the movie *Gattaca*, which takes tiny samples of blood, skin, or hair and provides the identity of its "owner" (Figure 12.17).

In the real world, testing as part of medical procedures is uncertain ("Well, this could mean a polyp or it could mean gallstones"), iterative ("That test didn't reveal anything; let's try another"), and specific (measuring something with a device built for the job).

Uncertainty and iteration aren't very cinemagenic or exciting and can digress distractingly from the plot. The exception is the medical mystery format, in which this uncertainty *is* the plot. Sci-fi dabbles in this, especially in TV shows. "Bones" McCoy from *Star Trek: The Original Series,* the Doctor from *Star Trek: Voyager,* and Dr. Tam from *Firefly* all face novel challenges on their respective spaceships. Particular episodes can focus on these characters and the mysterious medical problems they face. But even these shows run into problems with *specificity.*

Specificity is challenging because tests often require specific devices with specific sensors, all of which takes time to explain narratively and represents yet another prop to build. *Star Trek* gets around this with the medical tricorder because it's an all-purpose device, but this solution doesn't help us with the reality of testing.

In addition, if the story is too specific about the thing being tested, you lose the audience, who don't have the necessary medical expertise to understand. So what's often more important to sci-fi than the test results is the diagnosis. Supporting this argument, most sci-fi medical systems that perform tests output a diagnosis rather than numerical data. When they do that, it's better to categorize them as diagnosis interfaces, as below. This is why *Gattaca*'s DNA testers are problematic: they provide unerring identities, not interpretable measurements.


FIGURE 12.17a,b
*Gattaca* (1997).

**OPPORTUNITY** **DESIGN THE FUTURE OF MEDICAL TESTING**

Until we actually have exhaustive, perfect diagnosis machines, we'll want to improve the testing interfaces that clinicians use to do their work. Because sci-fi doesn't really dive into this regularly or with rigor, this leaves a number of tasks for designers to imagine and design:

- Selecting which among the thousands of tests available are appropriate to the circumstances at hand
- Performing the test accurately
- Understanding the results
- Communicating the results to patients
- Determining next steps, whether initiating treatment or going back for the next test

## Diagnosis

Evaluation supports diagnosis—that is, using measurements and observed symptoms to form a hypothesis about a patient's problem. But diagnostic tools are problematic both in the real world and in sci-fi, which may account for the very few examples we see in the survey.

Diagnosis in the real world is difficult for a number of reasons. Knowing what signs to look for in the first place is constrained by the physician's knowledge and subject to his or her specialist biases. The set of possible problems is simply enormous. Tests to confirm a diagnosis may be inconclusive or imprecise, and even if they are noninvasive, may cause additional complications or be expensive. Finally, even given the best set of reliable data, the givens may not easily resolve into a single root problem.

Diagnostic technology proves problematic for sci-fi as well, and not just because the characters are dealing with alien species or environments. When the story is a sci-fi medical drama, the most common structure is that of a mystery puzzle to solve. The symptoms are shown in scenes that cleverly distract the audience from the true cause, which the protagonist puts together in a dramatic moment that makes the audience look back and think, "Well, of course. It was there right in front of our eyes the whole time." In these narrative structures, if the computer simply spat out the correct answer in scene 3, there would be no reason to go on. Diagnostic technologies are counter to the purpose of such stories.

If the story is not a medical drama but has need for diagnosis, it still proves problematic, because an accurate depiction of the complexities may not add to the story. Fortunately, sci-fi has all the high-tech, noninvasive sensors and computing power of its authors' imaginations. Authors can streamline a diagnosis so that the medical MacGuffin quickly and confidently keeps the plot moving.

The original *Star Trek* TV series introduced portable and fast diagnosis with its medical tricorder. The ship's doctor, Leonard "Bones" McCoy, would wave the handheld scanner over a patient and simultaneously look at the handheld screen (Figure 12.18). Though the series never showed exactly what he was looking at, after a glance at the screen he would describe exactly what was wrong with the patient, even if the problem was obscure or the patient was an alien species. Though McCoy might have been viewing a screen very similar to the sickbay monitoring screens discussed above (see Figure 12.3), it is more likely that the device was also able to suggest a diagnosis based on its readings.

Other series in the *Star Trek* franchise evolved the appearance and shrunk the size of the medical tricorder. (Figure 12.19)

FIGURE 12.18a,b
*Star Trek: The Original Series* (1966); studio prop photo.

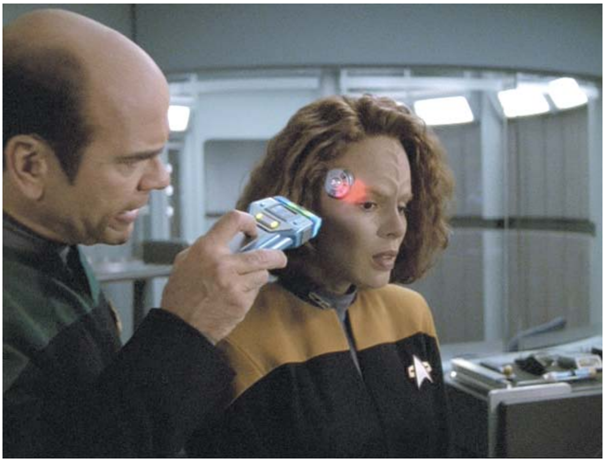


FIGURE 12.19
*Star Trek: Voyager* (1995).

Few other sci-fi properties have presumed such portability and speed of medical diagnostic tools.  Although the medical tricorder was largely a narrative tool rather than a serious speculative technology for assistive diagnosis, the notion of a portable and near-instantaneous diagnostic tool inspires medical technology inventors to this day. And that's not by accident. In one deliberate attempt to have sci-fi influence the real world, *Star Trek* creator Gene Roddenberry reportedly signed a contract with Desilu/ Paramount stipulating that anyone who can create a device that operates like a medical tricorder can use the already-popularized name for their device. In essence, he is offering nearly 50 years of in-show marketing to anyone who can live up to the vision.

**OPPORTUNITY** **DESIGN THE FUTURE OF MEDICAL DIAGNOSIS**

The survey shows a number of different hardware designs for diagnostic tools, but it is pretty much devoid of software interfaces for aiding diagnosis. There are some diagnostic tools in the real world, such as MEDgle and WebMD, that are targeted at both patients and practitioners, so it's just an instance of sci-fi not yet finding an interest in it.

One important tool used to assist diagnosis is the patient medical history, but it is rarely seen in our survey. One example appears in *Star Trek: Voyager*. In the episode "Riddles," we get a quick glance of one when the Doctor must treat the science officer, Tuvok (Figure 12.20).


FIGURE 12.20a,b
*Star Trek: Voyager*, "Riddles" (Season 6, Episode 6, 1999); *Star Trek: Voyager*, "Life Line" (Seasons 6, Episode 24, 2000).

## Treatment

After diagnosing a problem, a physician decides on a course of treatment to heal the patient or, at minimum, alleviate suffering. Treatment interfaces are the easiest to depict in sci-fi because they generally involve physical devices or clear actions. In the survey, we see three main categories of treatment: devices for injecting medicine, some imaginative surgical interfaces, and a few systems for reviving the dead.

### *Injection*

Injections—whether of a sedative, vaccine, antidote, or painkiller—are important in sci-fi because the event is significant to the characters and to advancing the story.

Perhaps the most famous injection device is *Star Trek*'s hypospray (Figure 12.21). It allows medicine to be injected directly into the body without a needle puncturing the skin. *Star Trek* didn't invent these injectors. In 1947, a similar device was mentioned in an episode of the radio play *The Shadow*. And in 1960, Aaron Ismach patented such a device and won a Gold Medal from the US government for it in 1964, two years before the original *Star Trek*'s premiere. But *Star Trek*'s version did the real world even better—it could fit into the palm of your hand, it worked through clothing, and it didn't hurt at all. In a 1969 book called *The Making of Star Trek*, Gene Roddenberry explained that the hypospray was "invented" for the show as a means of circumventing NBC's prohibition against showing syringes piercing skin. Later *Star Trek* properties advanced the idea further, allowing doctors to select the medicine and dosage on the fly.

FIGURE 12.21
*Star Trek: The Original Series*, "Where No Man Has Gone Before" (second pilot, 1966).

FIGURE 12.22a–e
*Sleeper* (1973); *Gattaca* (1997); *Men in Black 2* (2002); *Total Recall* (1990); *Firefly*, "Serenity" (Episode 1, 2002).

Despite not having invented it, *Star Trek* popularized it with generations of fans, and it has become a staple of sci-fi medicine. The term *hypospray* has even leaked into other fiction properties, getting a mention just a few years later in the 1967 TV series *Mission: Impossible*. It has also leaked into the real world and is used interchangeably with *jet injector* in scientific papers.

There are other injectors in sci-fi, but none seem to solve the problem as well. Other designs differ in three industrial design details: their component materials, how they are held, and whether the medicine inside is visible or not (Figure 12.22).

### *Surgery*

Surgical treatments are a familiar staple in many genres. The bright lights surrounding an unconscious patient, the beeping machines, surgeons in scrubs shouting "Ten ccs, stat!" with sweat beading on their foreheads, and life most certainly hanging in the balance. Sci-fi is no exception. Surgical interfaces in the survey are common and show great variety. They have evolved over time from simple modesty panels to increasingly sophisticated, robotic, gestural, remote, and even volumetric projection technologies.

In the *Star Trek: The Original Series* episode "Journey to Babel," Dr. McCoy performs a blood transfusion between Mr. Spock and his father, Sarek, while Sarek undergoes surgery. Sarek's torso is covered by a surgery canopy that gives McCoy access to Sarek but shields him from everything else—including Nurse Chapel (Figure 12.23). NBC had serious restrictions on what could be shown on prime-time broadcast television at the time, so this was likely a function of cultural modesty. But could there be a user-centered reason for this design?

Perhaps the canopy prevents infection or assists the doctor in the mechanics of the surgery. It could have robotic arms applying and removing sutures or suctioning blood. It could house cameras so that remote doctors could observe and assist. It could even be a recording device for later study and witness in malpractice cases. The scene gives no clue about any of these purposes, however. It's left to our imagination.

Another example is seen in *Logan's Run*. The scene in the New You plastic surgery boutique fits into the film's overall social criticism that technology will worsen society's self-indulgent obsession with youthful appearance. At the boutique, any customer can drop in and select new facial features with a push-button interface (Figure 12.24).

FIGURE 12.23
*Star Trek: The Original Series*, "Journey to Babel" (Season 2, Episode 15, 1967).

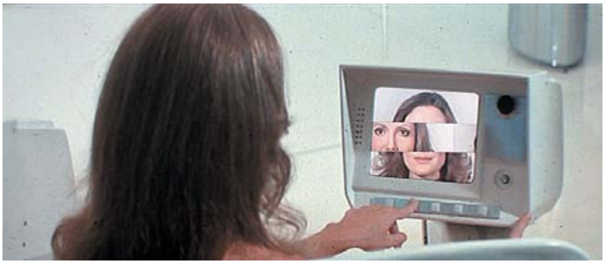


FIGURE 12.24
*Logan's Run* (1976).


FIGURE 12.25a,b
*Logan's Run* (1976).

The patient then lies down on a round, lighted table in the middle of a glass room, below what looks like a menacing, spiderlike, mechanical chandelier (Figure 12.25a). Each arm of the chandelier houses a laser and a nozzle that sprays a healing liquid. The system automatically calculates the necessary incisions and conducts them efficiently. In the scene, a physician overrides the safety protocols of the surgery machine in an attempt to kill the protagonist, Logan-5, apparently by setting it to "random" (Figure 12.25b).

The physician's control interface seems entirely inadequate for the system to be operated manually with any kind of precision. The crude buttons, levers, and displays unconvincingly describe an interface capable of any sophisticated control.

This kind of automated surgery is seen again in the movie *The Island*, in which clones are grown for organ harvesting. In one scene, a clone is placed in surgery to harvest his heart. The interface is impressively and appropriately complex. The physician uses a light pen on a radiographic view of the patient's body, alongside other controls, to specify the surgical work to be done. The surgery itself is done by robotic arms (Figure 12.26).

A similar pen interface is seen a few years earlier in *Minority Report*, when John Anderton must have his eyes replaced to evade ubiquitous retinal identification systems. At an underground clinic, Dr. Eddie uses a desktop computer with a sophisticated real-time visualization of the eyes. Dr. Eddie specifies parameters by tapping a pen on the screen and then plans the actual surgery with a gestural interface, using lighted controllers worn over his fingertips (Figure 12.27). The surgery is then conducted by a complex actuator placed over Anderton's face.

FIGURE 12.26a–c
*The Island* (2005).

In both *Star Wars Episode V: The Empire Strikes Back* and *Starship Troopers*, fallen warriors are brought back to health while suspended in vats of fluid. In the latter film, mechanical arms flutter back and forth weaving new tissue to repair Johnny Rico's leg wound. No interface to control treatment is seen in either film, though the transparent walls of the chambers are something of an interface for observation by caregivers and visits by well-wishers.

In the film *Chrysalis*, Dr. Brügen conducts surgery standing in a surgical theatre where the translucent volumetric projection of her patient appears on a table before her (Figure 12.28a). She also sees representations of the small robotic arms doing the actual remote incisions.

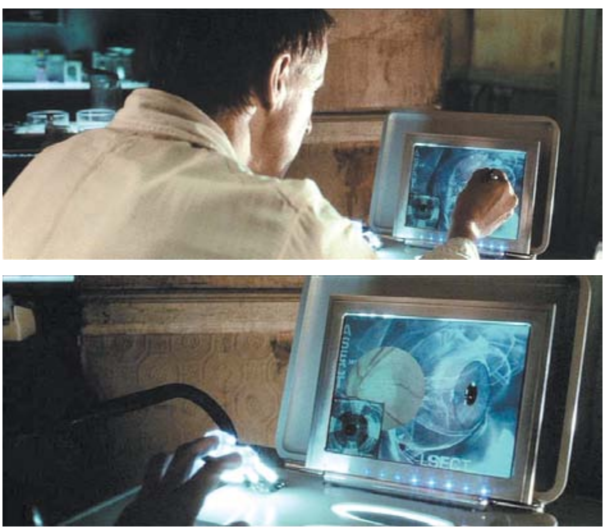
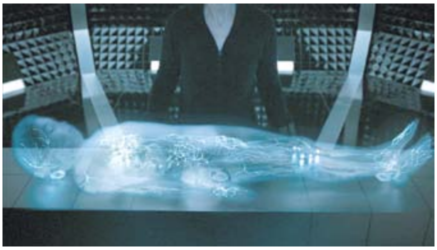


FIGURE 12.27a,b
*Minority Report* (2002).



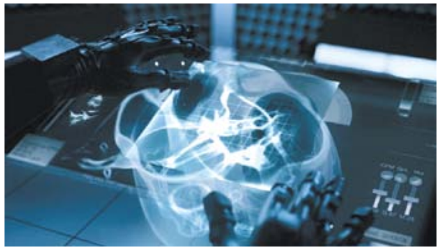


FIGURE 12.28a–c
*Chrysalis* (2007).

Using a combination of gestures and voice, she is able not only to perform the surgical procedures but also to change scale and shift the perspective of the projection to see what she needs to see at the magnification that is most useful. She is able to achieve fine control using comfortably large gestures. In addition, she changes the projection so that only the relevant cardiovascular system is visible, eliminating from the display other data and imagery (Figure 12.28b). She is able to describe arbitrary planes of cross-section (Figure 12.28c). In the authors' opinion, this sequence is one of the most sophisticated, believable, and informed in our survey. It is a convincing prototype of such a system and, at the same time, works very well in the story.

**OPPORTUNITY** **BUILD VOLUMETRIC TELESURGERY**

At the risk of fawning, the authors see this as a very well-realized prospective interface that should be seriously considered by designers working in this domain. It's easy to imagine that some technologies could get us partially there in the near term, such as 3D glasses in lieu of volumetric projection, without losing much of the brilliance of the design.

## Autonomous Medical Interfaces

More and more frequently, technology is seen handling medical duties in sci-fi, either as robots or as artificial intelligences, such as the volumetrically projected doctor in *Star Trek: Voyager*. These generally provide the same services as human doctors, though the latter boast greater precision, less emotional detachment, and ready access to more medical information.

As autonomous agents, they are designed to need little more than an interface capable of conversation and touch.

Luke's medical doctor in *Star Wars Episode V: The Empire Strikes Back* is robotic (Figure 12.29). Its appearance is more humanoid, though with a severe, militaristic look. The robot is both surgeon and caretaker, with nimble mechanical arms. It's not clear if there's anything more than a pedestal below the robot's torso, and it doesn't vocalize even though Luke speaks to it.

Contrast this robot with the one that attends Padmé in *Star Wars Episode III: Revenge of the Sith* (see "Assisting Birth," below). This midwife robot is a remarkably different kind of medical robot that is clearly designed for caring, particularly in its appearance. It has very rounded shapes and edges, with only a hint of human characteristics—head, eyes, ample breast, and rounded belly. Its soft coloring and matte textures speak of comfort and safety. The face alone balances humanlike structure with non-humanlike features. It has four jewel-tone "eyes" of unequal size, with the location of the two larger ones mimicking the human face, and the two smaller ones in an odd asymmetric grouping. Still, its design suggests a gentle softness while maintaining a professional distance.

**LESSON** **IT SHOULD *FEEL* HUMANE**

Industrial designers have known this for a while, but the robot examples from *Star Wars* remind us that the surface design of medical technology can communicate different emotions and feelings to the patient. Warm nurturing and cool functionality may each have its place, but designers should take care to consider which is most important to their users.

FIGURE 12.29
*Star Wars Episode V: The Empire Strikes Back* (1980).

## Case Study: The Doctor

The ultimate medical technology may be the volumetrically projected doctor from *Star Trek: Voyager* (Figure 12.30). When the ship's human doctor is killed in the pilot episode of the series, the ship's emergency medical program is activated. It is a volumetric projection of a human doctor that acts as a humanlike interface to the ship's medical system. Though originally designed for emergency situations only, it becomes the ship's only functioning doctor. Given its human appearance, it curiously never adopts—and the crew never bestows upon it—a name; it is referred to only by its role. The Doctor's program is made autonomous and allowed to grow and learn beyond its original programming. It has fully human speech capabilities, and because of the ship's detailed force-field holodeck technology, it has a full physical presence as well, able to touch people and lift equipment. In these senses it is very human, able to address its patients in a way that is familiar and comfortable, although its bedside manner sometimes borders on irritating.

Still, it is not human, and it has some very nonhuman abilities. Because it is connected to the ship's computer, it has an encyclopedic knowledge of medical precedent, procedures, and the medical histories of the crew. Because it can turn off the force field that is its "skin," it can become incorporeal and move through force fields that quarantine patients. Because it is a program, it can also be sent via compressed data signals to other locations across the galaxy and appear there, complete with memories and experience. If it weren't for *Voyager*'s isolation, one would expect the Doctor to become adopted as the dominant medical paradigm across the Federation in short order.

FIGURE 12.30
*Star Trek: Voyager* (1995).

**OPPORTUNITY** **LET THE DOCTOR CHANGE SHAPE TO FIT THE TASK**

Given that the *Voyager* Doctor's human shape and appearance are merely a convention adopted for patients, could it adopt other forms for different purposes? Could it become a caring midwife to assist with a birth? If it has access to a food replicator, can it become a wet nurse? Could it raise confidence by appearing as the patient's favorite doctor from back home? Or the greatest doctor ever? How about Florence Nightingale or Mother Theresa? If a real-world designer is working on a telemedical interface or an avatar, such questions become relevant.

**LESSON** **PEOPLE NEED PEOPLE**

Humans are social animals. We are hardwired to be good at dealing with other humans. The *Voyager* Doctor reminds us that even with a technology combining an infinite medical database, instant access to a patient's medical record, and an infinitely malleable appearance, there is something comforting in wrapping these inhuman capabilities in a very human wrapper.

## Life and Death

A few interfaces help with fundamental moments of medicine: assisting birth, revival, and signaling death.

### Assisting Birth

There is very little birth technology in the survey. (Indeed, there may be very little in sci-fi. An Internet Movie Database search for "birth" in the plot summaries for the genre "Sci-Fi" only lists around 50 titles, and they are mostly obscure.) Scenes of birth in sci-fi largely focus on the human drama and don't support the tale with the medical interfaces surrounding it. The only example we've seen comes from *Star Wars Episode III: Revenge of the Sith*, as Padmé gives birth to Luke and Leia (Figure 12.31).

In this scene, we see volumetric displays with monitoring information. These seem to be out of view of the mother and only contain information about Leia; monitoring of the twins is not evident. There is no other doctor in the scene, so the presence and function of these displays is hard to explain (as is the width of the "modesty skirt"). The only other technology particular to the birth is the midwife robot. (See "Autonomous Medical Interfaces" above for more on this robot.)

FIGURE 12.31
*Star Wars Episode III: Revenge of the Sith* (2005).

**OPPORTUNITY** **VISUALIZE THE CHILD FOR THE MOTHER IN REAL TIME**

Even though many mothers choose natural childbirth, they may be interested in new technologies that display the health of the newborn and some sense of progress through the ordeal. Would a real-time visualization of the child through the birth canal help keep a mother focused on the physical effort she must undertake? Would confirmations that important stages had been passed without any complications be reassuring to her? Would an audible heartbeat help the doctor keep ambient track on the newborn's stress? Could some household or taxicab technology assist a woman through a birth that happens before she can get to a medical facility?

There also seems to be an absence of prenatal technologies in sci-fi. With the glut of volumetric displays, what mother wouldn't want to see and reach out a hand to the image of the child growing inside of her?

## Revival

We see revival from death or the brink of death fairly often in sci-fi, partly due to the fact that it's easy and dramatic, and partly because it seems impressive, as this isn't something our current technology can do. There are no particular trends that stand out among these technologies and interfaces, and of course, they are all highly speculative.

In *The Day the Earth Stood Still*, when the humanlike alien Klaatu is killed, his robot, Gort, carries his dead body into the spaceship and lays him on a special table. Gort waves a hand past some lights, and flips a switch on the

FIGURE 12.32a,b
*The Day the Earth Stood Still* (1951).

FIGURE 12.33
*Torchwood* (2009).

wall (Figure 12.32a). The cradle in which Klaatu's head rests glows with a bright light and he wakes up as if from a brief sleep. The only interface is the glowing cradle and transparent rod pointed at Klaatu's head. (Figure 12.32b) There is no diagnosis and no dispensing of medicine. Because the spaceship is so small, we can assume that this is a general-purpose medical table and not one with the sole purpose of reviving the dead.

In the British TV series *Torchwood*, an alien glove called the "resurrection gauntlet" can temporarily revive the dead for a few seconds—enough time, perhaps, to ask the questions needed to determine a victim's killer. The gauntlet is worn on the hand and is simply placed against the dead person's head (Figure 12.33). The revived person is confused (they don't realize they're still dead), and much of the short time they're revived is spent explaining what's happening. Such objects are often found by the Torchwood operatives, so there are no instructions for the gauntlet, and the agents don't know how to use it well. Still, it showcases a direct, physical interaction and a simple, ergonomic industrial design.

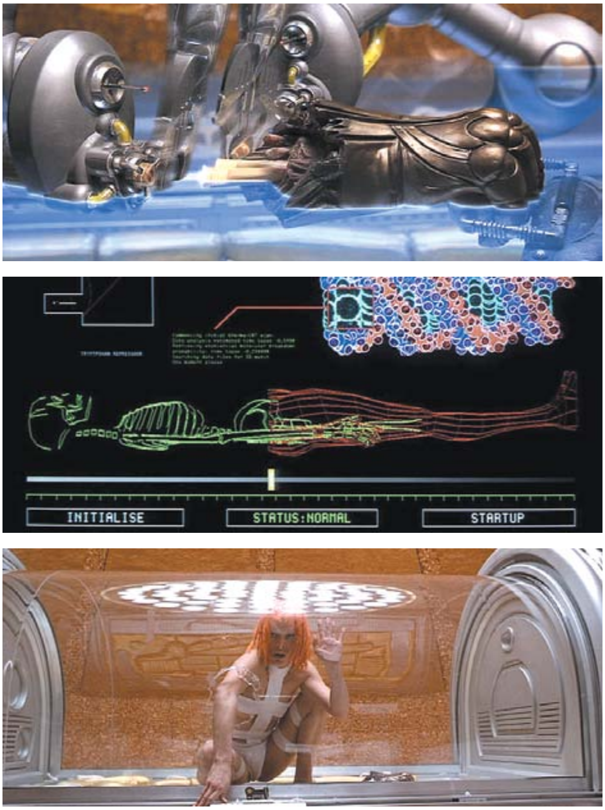



FIGURE 12.34a–c
*The Fifth Element* (1997).

A more extreme example of reviving someone occurs in *The Fifth Element,* when the only remaining part of the character is her hand. It's placed in a chamber in which the rest of her body is reconstructed in its entirety from her DNA (Figure 12.34). This system is completely automated and even includes an abort function in case what is produced is dangerous.

## Signaling Death

If a character has been devoured by a ravenous Bugblatter beast, sci-fi makers don't need to provide any additional signals to the audience to let them know that death has occurred. Sometimes it's a great big text label, like we see in the *Star Trek* reboot (Figure 12.35).

But a quieter, more dignified death requires a character like Dr. McCoy to say something like "He's dead, Jim," or some signal from a nearby technology. Fading lights are the simplest and most common signal. This is indicative of the association frequently seen in sci-fi that life is a light inside of things. When life ends, the light fades.


FIGURE 12.35
*Star Trek* (2009).

A fading light interface appears in the dying biotechnical "bug" that Trinity extracts from Neo in *The Matrix*. After it is removed and tossed on the ground in the rain, its single red light slowly fades (Figure 12.36). The audience needs no other explanation of what has happened.

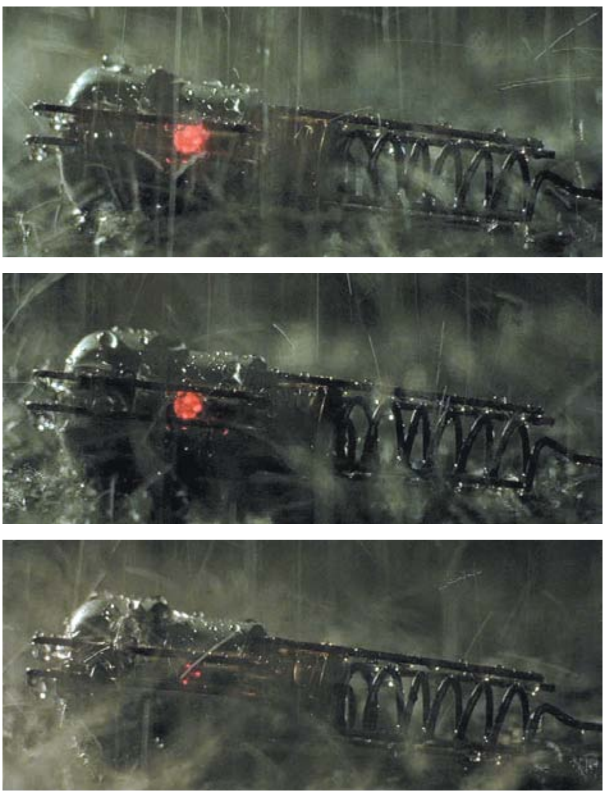
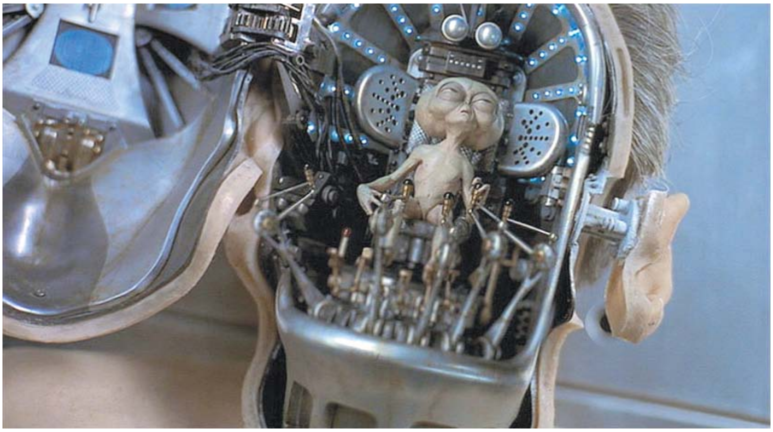


FIGURE 12.36a–c
*The Matrix* (1999).

*Men in Black* had a subtle twist on this notion, as the little Arquillian in the mechanical human disguise dies at the same time as the lights fade. Had it been a failure of life support, we would expect to see the lights fade some time before the little guy passed away. But because it happens simultaneously with his death, either his body powers the robot many times his own size, or it describes a socially sensitive, context-aware interface that dims solely out of respect for the dead (Figure 12.37).



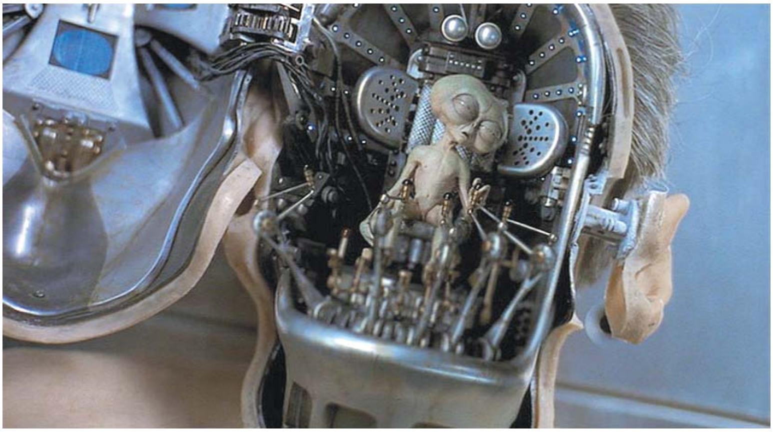


FIGURE 12.37a,b
*Men in Black* (1997).

Another common way that the death of a character is signaled to the audience is one borrowed from medical dramas—waveforms in the monitoring system go flat, and alarms beep until a somber attendant turns them off.

The design of monitoring visualizations determines how death is signaled. So as long as waveforms continue to appear, we can expect flat lines to be the harbinger of the worst news (Figure 12.38).

**LESSON** **WHEN THE CHANCE FOR REVIVAL HAS PASSED, RESPECT DEATH WITH SILENCE**

Medical technology in the real world can often be insensitive to the emotions of patients, caretakers, and loved ones. What good is a persistent alarm long after the chance for revival has passed? Can medical technology take such grim circumstances into account and fade signals that could be distressing to the others present?

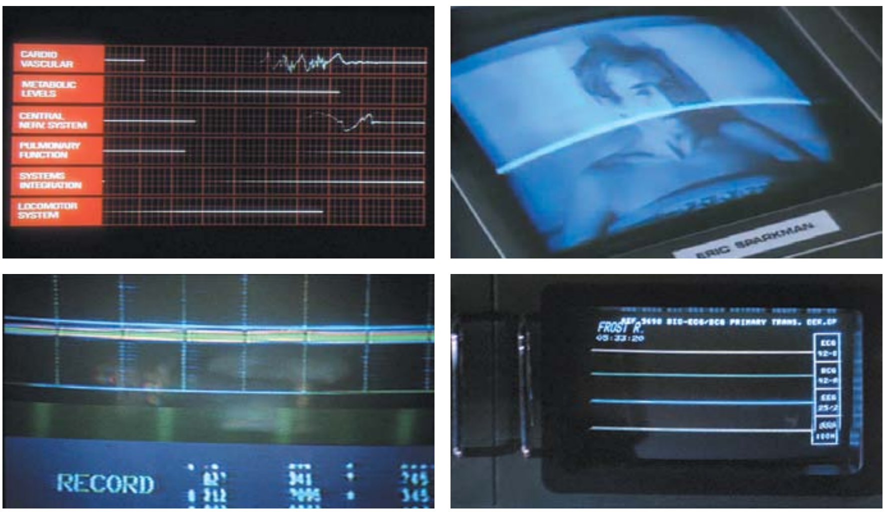



FIGURE 12.38a–d

*2001: A Space Odyssey* (1968); *Space: 1999* (1975); *Brainstorm* (1983); *Aliens* (1986).

## Sci-Fi Medical Interfaces Are Focused Mainly on the Critical Situation

Technology evolves around us at an exponential rate. By comparison, our physiology's evolutionary rate is practically frozen. Even if we eventually zip around the galaxy at speeds faster than light, we'll be doing it with bodies that are similar to what we have now—and we're still going to get headaches. Medicine in sci-fi grounds the stories in that part of the future we can all understand—our bodies.

Perhaps this is why some aspects of medical technology are completely unaddressed in the survey. Maybe sci-fi makers are more interested in the fantastical stuff that does change quickly. It's likely that this is what drew them to sci-fi in the first place.

But sci-fi can't stretch things too far; it can only extend modern paradigms. With medical interfaces, we benefit from this forced nearer-term focus when good design thinking results in interfaces that propose new, feasible, and problem-solving technology that inspire real-world innovation. In this way, sci-fi medicine leads to the very real possibility of making life better here on Earth.

CHAPTER 13

# Sex

FIGURE 13.1
*Creation of the Humanoids* (1962).

Esme explains to her brother that her blue-skinned robotic servant and lover, Pax, is "dedicated to keeping me happy. And I *am* happy." With a hint of disgust, Cragis replies, "You love that . . . that machine?" Esme leans forward for emphasis to explain, "I love Pax" (Figure 13.1).

Sex is a major part of the human experience, so it's no surprise that it plays a role in sci-fi. The sex-related interfaces seen in our survey fall into three primary categories. They can be distinguished by how the technology is related to the people or person having sex.

- Matchmaking: technology helping people meet for sex
- Sex with technology: people having sex with technology with no other human involved
- Coupling: people having sex, with technology either enhancing or mediating the experience

## Matchmaking

Matchmaking technologies help people meet for romance or sex. They either allow users to specify their desired aspects in a mate, or help people meet up with others interested in having sex. We found only four examples of matchmaking in our survey.

In the film *Logan's Run*, Jessica-6 puts herself on the Circuit, a system that teleports people seeking sex from one residence to another until they find a partner. In practice, it works something like a cross between a radio and a *Star Trek* transporter. When Logan-5 wants to finish his evening with someone, he grabs a device that looks like a remote control, turns on

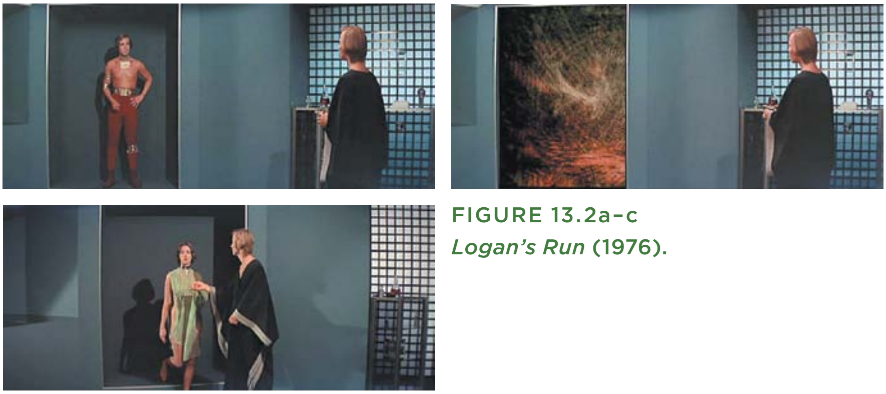


FIGURE 13.2a–c
*Logan's Run* (1976).

the Circuit, and spends a few seconds "tuning" the channel to solidify a candidate in the chamber. The first is a male, but this isn't what Logan is looking for (Figure 13.2a). He "detunes" this candidate and tunes in another one, which turns out to be Jessica. Liking what he sees, he extends his hand and helps her out of the chamber (Figure 13.2b, c).

This early sex-related technology is difficult to evaluate as an interface because, although a device is used to turn on the Circuit and select candidates, we never see it in any detail. The most we see is Logan turning a dial at the top of a remote control–like object. Is he slowly toying with some variable? What would that setting be? Or are offerors broadcasting their bodies to different frequencies like radio stations on a dial, and Logan is just scanning channels? Offerors couldn't be at multiple places at once, so perhaps it is more like the video chat site Chatroulette, which connects people one-to-one but at random. Unlike Chatroulette, however, we see that Jessica-6 has no interface for controlling her end of the exchange, which raises questions about what the experience is like from her point of view.

Additionally, because Logan first gets someone he's not interested in, there's either no ability to set preferences, or the preferences aren't specific enough, or Logan happens to be in a very particular mood and the preferences are difficult to change on the fly. An ideal filtering system should have prevented Jessica from materializing in Logan's apartment since he is a Sandman, a form of law enforcer, in which she has no interest.

In *Weird Science*, two teenagers, Gary and Wyatt, specify the aspects of their ideal woman. To do this, they insert into a scanner clippings from magazines that represent their desired mental and physical traits (Figure 13.3a). The movie does not indicate how the system knows to imitate the legs of the *Playboy* model and the intelligence of Einstein, rather than vice versa, but the scene is a lighthearted montage, so many steps in the process are left to the audience's imagination. The boys are able to adjust some aspects of their ideal woman, such as breast size, with their keyboard (Figure 13.3b).

FIGURE 13.3a,b
*Weird Science* (1985).

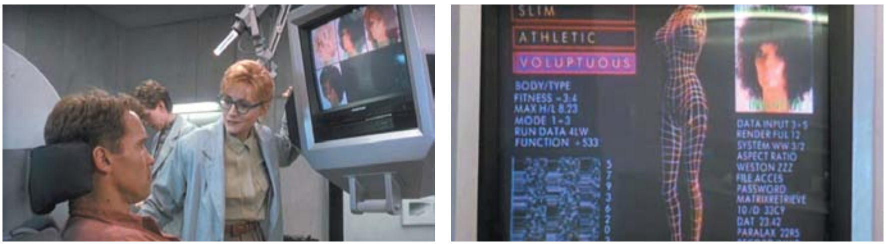



FIGURE 13.4a,b
*Total Recall* (1990).

In *Total Recall*, John specifies the type of love interest he'd like in his manufactured memory vacation by answering three multiple-choice questions about hair color, body type, and sexual aggressiveness. Any user of an online matchmaking system today knows that these feel woefully inadequate to specify an ideal love interest, but perhaps other variables are inferred through John's interaction in the implanted vacation (Figure 13.4).

In the TV series *Firefly*, the character Inara is a companion, a kind of highly trained courtesan whose services to her clients often include sex. To select a client, she sends advance notice about when she will be in a location, and potential clients from that location send her videos to appeal to her to choose them. Her touch-screen interface allows her to review video applications, dismiss those she wants to reject, and make direct video contact with applicants (Figure 13.5). The system includes collaborative filtering by the network of companions so that dangerous clients are excluded.

Why are there so few examples of matchmaking in the survey? All but *Firefly* appeared before real-world online dating sites became commonplace. Once much of the audience had direct experience with versions of these systems, such technology no longer seemed futuristic. Additionally, audiences now know that they have to supply quite a bit of information to get a good match, and this process is just not very cinemagenic.

FIGURE 13.5
*Firefly*, "Shindig"
(Episode 4, 2002).

**OPPORTUNITY** **MAKE MATCHMAKING MODERN**

Given some of the more recent developments in technology, there seems to be plenty of unexplored potential in matchmaking technology. For example, can preferences be respectfully derived from social media streams and public datasets? Can systems help users move past unhealthy partner-seeking habits? Can the system prescreen people by evaluating their friends' experiences or ratings? Using ubiquitous sensors and subtle actuators, how "magic" and subtle could proximal matchmaking become? If a central computer knew that two people were made for each other, could it use ambient or augmented reality technology to help him notice her across a crowded bar by amplifying her laugh, or even by slightly brightening the light above him when she looked his way? Could matchmaking technology, like love, be "in the air"?

## Sex with Technology

Another category of sex-related interfaces consists of people having sex with technology in some form. When such sex technology is physical, it can range in appearance from mechanistic devices to being nearly indistinguishable from sex with a real person.

### Devices

Sex devices are rare in the survey, with only two examples. Both are depicted as dystopian. In the first example, *THX-1138*, the oppressive state has provided technology to address and control citizens' basic needs for sexual release.

At home after a hard day at work, THX-1138 sits down on a couch and turns on a volumetric projection of a woman dancing sensually to percussive music. A machine drops down from the ceiling, latches on to his penis, and mechanically moves up and down for exactly 30 seconds until he ejaculates. Then its tiny red light switches from red to green, the machine retracts back into the ceiling, and he begins flipping through channels to find other entertainment (Figure 13.6).

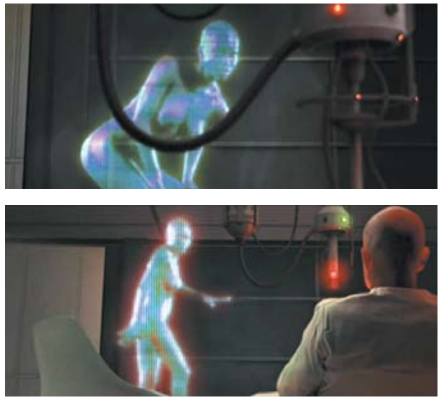


FIGURE 13.6a–c
*THX-1138* (1971).

FIGURE 13.7a,b
*Sleeper* (1973).

The comedy *Sleeper* illustrates how transactional and meaningless sex has become in the future when Luna and a guest decide to "have sex" in a device called the Orgasmatron, which is about the size of a phone booth. To activate it, the two step inside and slide the door closed. A red light at the top illuminates, some moaning is heard, and six seconds later a green light indicates they're done (Figure 13.7). When they emerge, they continue their conversation as if nothing had interrupted it. The closing and opening of the door seem to be the only interface needed.

**LESSON** **SMALL INTERFACES ADVERTISE SMALL-VALUE EXPERIENCES**

The sex machines in both *THX-1138* and *Sleeper* display a small red light while the device is working, and quietly switch to a green light when done. In *Sleeper* it's used for comedic effect and in *THX-1138* to help describe a dystopia, but the message telegraphed by the interface in each is the same. Sex, which for most is deeply engrossing experience, has been reduced to a small and disposable transaction. These interfaces would not speak to this disconnect if they had rich visuals and swelling music. Designers of real-world products and services should take care to avoid this same mismatch. The interface not only enables use but also informs the entire experience. Functional and cold may be right for some applications, but if yours is meant to be rich and engaging, the interface should embody that as well.

There are a lot of analogous examples of sex interfaces in the real world—far more than we see represented in sci-fi. From low-tech masturbation sleeves like the Fleshlight and Fleshjack to more sophisticated devices like the Real Touch and sex machines, a wide variety of real-world products used for sexual gratification are absent from sci-fi, even when sex technology is depicted.

## Sexbots

Sexbots are androids capable of sexual intercourse with a human. Sexbots are by far the most common example of sexual technology in the survey (Figure 13.8).

The reasons for this are many: they are easy to write for, they don't add to the special effects budget, and the sexual appeal of a sexbot does not need much explanation for the audience. In addition, sexbots create considerably less squeamish reactions in audiences than more mechanistic devices. It also means that the largest group of sex-related technology in the survey is not accessed through a visual interface but through a social interface: voice, gesture, and touch backed by some level of artificial intelligence. The one exception to this rule is the LoveBot married to Mr. Universe in *Serenity*, but his remote control for her is only seen in passing (see Figure 13.8h).

In the TV series *Buffy the Vampire Slayer*, the lovelorn vampire Spike has a sexbot created specifically to indulge his sexual and domination fantasies of Buffy (see Figure 13.8f). In one scene, while they are engaged in foreplay, the Buffybot says to him, "Spike, I can't help myself. I love you." Spike, emboldened by the confession, replies, "You're mine, Buffy." After a pause the Buffybot asks, "Should I start this program over?" A troubled look crosses Spike's face and he says, "Shh. You're not a program. Don't use that word. Just be Buffy."

**LESSON AVOID REMINDING PEOPLE OF THE SIMULATION**

Technology can be a good stand-in when the real thing isn't available, but the point of simulation is verisimilitude—allowing a person to suspend his or her disbelief. Exposing the technological truth at the wrong time can draw attention back to the unavailability of the real thing, that the emotions may be ersatz, and seriously spoil the mood. With sexual technology in particular but virtual reality in general, designers should be aware of and respect the natural ebbs and flows of social momentum, and avoid exposing the technology at inopportune moments.

FIGURE 13.8a–h
*Dr. Goldfoot and the Bikini Machine* (1965); *Westworld* (1973); *Austin Powers: International Man of Mystery* (1997); *A.I. Artificial Intelligence* (2001); *The Stepford Wives* (1975); *Buffy the Vampire Slayer*, “Intervention” (Season 5, Episode 18, 2001); *Battlestar Galactica*, “33” (Season 1, Episode 1, 2004); *Serenity* (2005).

## Virtual Partners

Sexbots are physical, but sex partners can be virtual as well.

In the "Blood Fever" episode of *Star Trek: Voyager*, the Doctor prescribes a holodeck remedy to satisfy the *pon farr* sexual needs of the Vulcan crew member named Vorik, because there is no female Vulcan within light years. In a similar plotline from the "Body and Soul" episode of the same series, the Vulcan, Tuvok, satisfies his *pon farr* urges and avoids philandering by having sex with a holodeck version of his wife, who is on the far side of the galaxy (Figure 13.9). In *Star Trek: Deep Space Nine,* the Ferengi merchant Quark often rents out holosuites for sexual purposes. These virtual partners are for all practical purposes the same as sexbots because, to the users, there is no sensory difference.

In *The Matrix,* Mouse salaciously assures Neo that he can arrange a more "intimate" experience between Neo and "the woman in the red dress," who is a character seen in a virtual reality training program (Figure 13.10). We never see this offer accepted or fulfilled, but because the virtual reality is indistinguishable from a real world, we can assume that such an encounter would work almost exactly like one with a sexbot or in the holodeck.

FIGURE 13.9
*Star Trek: Voyager*, "Body and Soul" (Season 7, Episode 7, 2000).

FIGURE 13.10
*The Matrix* (1999).

**OPPORTUNITY** **DON'T DREAM IT, BE IT**

When sci-fi sex technology is virtual—as in *Star Trek*'s holodeck or the Matrix-like virtual reality called the Construct—we see only virtual replacements for humans (or humanoid species). Given the infinitely malleable nature of these systems, a much greater range of sexual experiences and expressions are possible. Could someone choose new shapes, like a swan, or a centaur, or a robot? Exactly how do you want your furry avatar to look?

## Coupling

Coupling technologies help humans have sex in some way. We have identified two distinct subcategories of coupling. The first uses technology to provide subtle clues that help set the mood, as in the case of *augmented coupling*. In the second, *mediated coupling*, people have sex with technology playing an intermediary function.

### Augmented Coupling

In augmented coupling, technology enhances an otherwise purely biological act. Interestingly, this is the one example in the survey that comes from pornography.

In *Sexworld*, a pornographic send-up of the sci-fi movie *Westworld*, Ralph is astonished when sexy music interrupts his conversation with his partner—who is a sexbot—in the bedroom in which he is being seduced (Figure 13.11). He asks her, "Where did the music come from? Did you do that?" to which she replies, "What's the difference? It's here. Hold me."

FIGURE 13.11
*Sexworld* (1978).

Ralph is distracted by the music because it appears out of nowhere and catches his attention. The notion that he's being watched or cued into action probably doesn't help his self-consciousness.

**LESSON** **USE SUBTLE CUES**

When altering the mood of a space through computerized light and sound changes, make the changes slow so they do not draw attention to themselves. Sudden changes pull focus from the task at hand, distracting the user from the experience or their goal.

**OPPORTUNITY** **AUGMENT EVERYTHING**

There are many stimuli that a computer could control through sophisticated actuators to subtly shift the mood to one of sexual arousal: music, temperature, color, luminosity, and scent to name a few. How subtle could these controls get and still be effective? How many of these stimuli can a system control, and to what degree? In the far future, could a seducer have spaces that change, weather that shifts, or landscapes that adjust themselves to help accomplish his or her goal?

## Cyborgs

A cyborg is a human whose body has undergone substantial mechanical augmentation. There is only one example of sexual interaction with a cyborg in the survey.

In the comedy *Space Truckers,* Cindy is simultaneously excited and terrified at the sexual prosthetic sported by the cyborg villain Macanudo. To turn the prosthetic on, he pulls a ripcord like a starter for a lawn mower, and we hear a leaf-blower-like roar as a cold light emanates from his crotch to illuminate both their faces (Figure 13.12). Unfortunately for Macanudo, the device breaks down and he has to spend a few awkward minutes repairing it. Like many sex interfaces in sci-fi, this device is depicted as undesirable and inhuman.

FIGURE 13.12a,b
*Space Truckers* (1996).

## Mediated Coupling

In mediated coupling, two human partners have sex using technology as the enabling media, often precluding any physical contact. This subcategory showed the most interesting and forward-looking examples, as well as some of the most disturbing.

The *Demolition Man* sex helmets are described on page 149 as brain interfaces. The mildly telepathic helmets, invented as a high-tech prophylactic, provide lovers noncontact, sensual visions of each other (see Figure 7.36). This is the one example of consensual mediated coupling we've seen. The following examples from *The Outer Limits* and the *Lawnmower Man* are used more coercively.

*Lawnmower Man* features a scene in which Jobe treats Marnie to a trippy introduction to cybersex. He straps her into a virtual reality suit suspended in a human-scale gyroscope. He then straps himself into a similar device. In the virtual world, Marnie is, at first, delighted at her new embodiment and the strange new ways they intertwine and combine (Figure 13.13). But Jobe is psychotic, and the scene changes from trippy and sensual to unwelcome domination.

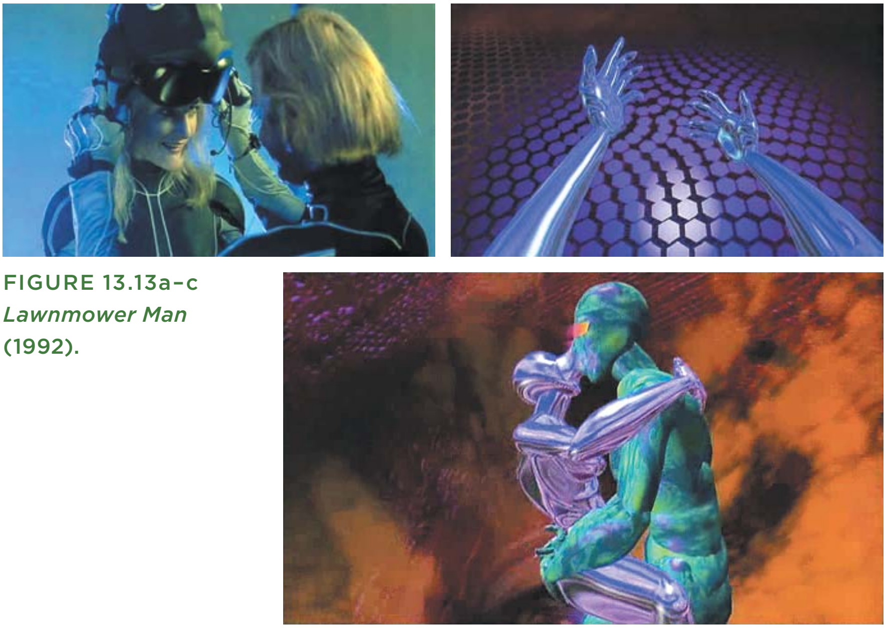


FIGURE 13.13a–c *Lawnmower Man* (1992).

**LESSON GIVE USERS SAFEWORDS**

This practice is already well established in bondage and discipline, sadism, and masochism communities, but it applies to immersive sexual technologies as well. Exploring the edges of sexuality can be fun, but when it crosses the line into something unsafe, scary, or nonconsensual, people need a way to stop the experience and regain a feeling of control. This can take many forms, depending on the technology of the system. In voice-command systems, it can be an actual word or phrase. Ideally this safeword is something that is instantly recognizable, easy to remember, and something that wouldn't be said or done accidentally as a user participates in a scene. New safewords can be hard to remember in the heat of the moment, so standards have emerged. Sarah Smellie's 2011 poll indicated that the top safewords of her readers are *safeword* [*sic*], *banana*, *pineapple*, and *red* (referencing a stop signal).[1]

This lesson can apply to nonsexual interfaces as well. Giving users a persistent, highly accessible control to return to an initial state provides a comforting means of recovery that encourages fearless exploration. Websites have long employed Home buttons that provides this reassurance. Apple's iPhone has a single hardware button on its face that serves the same purpose.

Another unscrupulous use of mediated coupling appears in the TV series *The Outer Limits*. The episode "Skin Deep" shows "ugly" computer programmer Sid donning a handsome volumetric disguise (Figure 13.14). Both he and his roommate use their stolen identities to seduce others who are unaware of their true appearance.

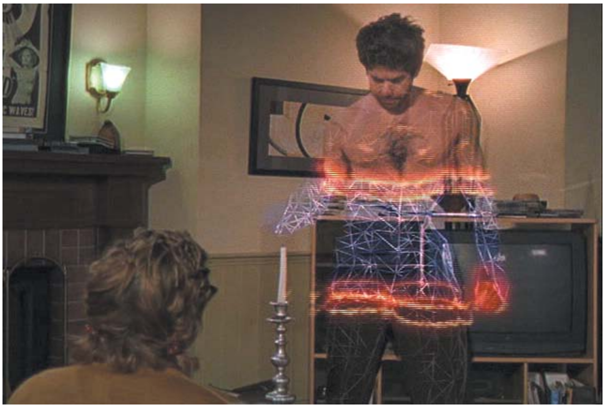


FIGURE 13.14
*The Outer Limits*, "Skin Deep" (Season 6, Episode 3, 2000).

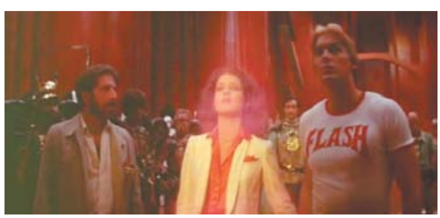
1 Smellie, S. (2011). 2011 sex survey: Safewords. Retrieved from http://thescope.ca/sex/2011-sex-survey-safewords

FIGURE 13.15a,b
*Barbarella* (1968).

Durand-Durand's musical Excessive Machine was first introduced as a sonic interface on page 114, but its main purpose seems to be sexual torture. He immobilizes a naked Barbarella within it (Figure 13.15a), and as he plays its organ-like keyboard, unseen mechanisms stimulate her to the point of agonizing ecstasy (Figure 13.15b).

In addition to being one of the earliest gestural interfaces in the survey, the sex technology in *Flash Gordon* is also one of the few wearable sexual devices. In the movie, Ming first uses his ring to enthrall Dale. Then, while she is under the ring's hypnotic influence, he uses gestures from afar to stimulate her and test her sexual response as a prerequisite for marriage. The interface appears quite intuitive, with Ming moving his hand over her distant silhouette, aligning the perspective to give the illusion that he is a giant caressing her small form (Figure 13.16).

FIGURE 13.16a–c
*Flash Gordon* (1980).



### LESSON USE FORCED PERSPECTIVE FOR REAL-WORLD OBJECT SELECTION

People are good at using their hands for physical manipulations. In gestural interfaces, designers can leverage this facility for identifying or indicating an action on a particular object in their environment. For example, imagine a user specifying a recipient in a crowd for a text message by "tapping" them (in the air) in forced perspective. Such interactions would be concrete, understandable, and well within people's natural expertise. Systems would need to be able to interpolate a user's view and map his or her hand position onto it, and wearable augmented reality seems to be in an ideal position to do just that.

Ming's interface could not work exactly like the film shows us. If the forced perspective is working correctly for the camera, it is not working for Ming. From his perspective, his hand would be off to the side, not caressing Dale. Additionally, forced perspective doesn't work if you have binocular vision and both eyes open. Try it yourself with an object near you to see that the part you're not focusing on appears double, making apparent edge contact impossible. The closer the object, the more mismatched the image from each eye.

This gives us an opportunity for apologetics as described in Chapter 1. Perhaps Ming's teledildonics system is so advanced that the forced perspective is unnecessary. If the system were smart enough, it could watch Ming's eyes to identify his victim, and map his gestures to her shape, regardless of where he held his hand or how accurately they matched her outline. In this conception of the interface, holding the ring in front of him is just a way for the technology to follow his gaze and gestures.

### LESSON "SATISFICE" GESTURAL INPUT

It is difficult for users to trace precise shapes in the air, especially for sustained periods. Relieve the pressure for precision by defining gestures that are quite distinct. This lets the system admit more imprecise input while maintaining confidence of the user's intent.

The last two examples of mediated coupling involve systems that let users experience prerecorded sex with another human.

*Brainstorm* follows the development and commercialization of a sensory recording and playback system. The head-mounted component is called "the Hat." After one of the lab assistants wears the Hat to create an illicit sex recording, the director of the lab takes it home and creates an endless loop, nearly overdosing on the sensory overload (Figure 13.17).

FIGURE 13.17a–c
*Brainstorm* (1983).

In *Strange Days*, Lenny is a peddler of amateur full-sensory recordings that often include sex. As in *Brainstorm,* people recording sexual experiences or playing them back must wear the device. The device is called a SQUID and functions much like *Brainstorm*'s technology, although *Strange Days* was created more than a decade later, so its technology is much smaller (Figure 13.18).

In each case, the interfaces are minimal. Recording and playback are executed with a head-mounted device with little to no interface. Playback is controlled by standard media controls, based on either a reel-to-reel film or a compact disc paradigm. As the main examples of asynchronous sex in the survey, these two movies hint at the possibilities of one-to-many sexual expression and gender swapping.

FIGURE 13.18a–c
*Strange Days* (1995).

## The Interface Is Not the Sex

Looking at all of the sex-related technology in the survey, the most interesting point that emerges is the *lack* of interfaces. There are some remote controls, parametric tools for matchmaking, a helmet or two, and some machines, but the *content* of sexual technology is always other people, as evidenced by the overwhelming representation of sexbots. This makes sense, as the sexual drive originally evolved to increase the likely success of animal reproduction. The human sex drive is understandably optimized toward a connection with other people. Interface designers need to keep this squarely in mind: with sex-related technology, the interface is only an inconvenient means to a pleasurable end, and it should be as usable, integrated, and discrete as possible, so the user can focus on the more important thing at hand.

In addition, the subject of sex poses a difficulty not seen in the other topics in this book. Where we see a mutually influential interplay between design and sci-fi almost everywhere else in the survey, we see mostly the opposite effect with sex technologies and interfaces. In sci-fi, sex tends to divert the viewer's attention from the story, but with sex tech in real life, sex *is* the story (or, at least, the activity). This explains why sex in films and on television is often treated in shallow, titillating ways. Writers and directors are hoping not to derail the narrative but still excite viewers with something unexpected, funny, or surprising. Sex tech developers, on the other hand, are honestly trying to augment or transform sexual experience for themselves or others, so their explorations are more interesting and realistic.

CHAPTER 14

# What's Next?

Getting to the end of this book has been a long, fun journey. We have tried to cover the most well-known, beloved, and influential movies and TV shows, from the earliest silent sci-fi to today's hyper-real, computer-generated epics with scenes dedicated to "interface porn," which put the plot on hold to let us indulge in an interface of excessive coolness.

We've looked at sci-fi interfaces through a number of different lenses. We looked at familiar aspects such as physical controls, various inputs and outputs, the psychological aspect of anthropomorphism, cutting-edge technologies such as brain interfaces, and broad-reaching applications such as learning and communication interfaces.

We've covered well over a hundred lessons, ranging from reminders to get the details right to high-level principles and opportunities for future work.

We didn't even get to all of it. We had to omit some topics for space reasons: investigations of chemical interfaces, weapons, spacesuits, and spaceships, to name a few. Some shows and movies were more obscure, just outside of our domain, or we just didn't have time to get to them.

But now that we're here, let's come out of hyperspace, look at the stars around us, and consider what it all might mean.

## Using Sci-Fi

We've gleaned a lot of lessons from sci-fi, but the first one from Chapter 1 is arguably the most important. Yes, we enjoy sci-fi. (It's safe to say we love it.) But we can also *use* it to improve the practices of interface, interaction, and experience design.

We're aware of the practical limits of this lesson. Sci-fi is incomplete as the sole textbook of an interaction design education. As much as it does tell us, it's not *real* enough to teach us everything. We should keep in mind that sci-fi creates interfaces as a by-product. Its focus is entertainment, and this affects the interfaces that come from it. Only occasionally does sci-fi concern itself with whether a speculative interface might be right for real-world users.

All this said, we've seen repeatedly that if an interface works for an audience, there's something there that will work for users. Finding what that thing is and using it for inspiration in our own work is part of how we can *use* these speculative interfaces.

**LESSON** **IF IT WORKS FOR AN AUDIENCE, SOME PART WILL WORK FOR USERS**

Sci-fi interfaces help create a reality that is coherent and makes sense for audiences. In this way, audiences are a class of users, and the test of a speculative interface is the audience's ability to follow the narrative. Users of real systems follow a narrative of use that needs to be similarly coherent. This similarity makes it possible to learn from what we see on screen despite the different purposes of these experiences. The tricky part is to isolate what is useful only for the narrative but not for the real world, but this is where our experience as designers comes in.

## More Than Sci-Fi

In choosing a nontraditional medium to explore interface design, we've found a process for analyzing "outsider" interfaces in a way that can inform our real-world work. Sci-fi isn't the only such domain, though it is the one that informed this particular investigation. Readers can certainly refer to the process we described in Chapter 1 and apply it to other genres or media. We're confident that the techniques used in this survey and our approach to analysis (including techniques such as apologetics) can prove useful in studies of other domains of speculative technology. We've focused on sci-fi with the most obvious and direct interfaces, but certainly many more remain to be explored.

For example, superhero and spy genres almost always include techno-gadgetry, as with *Mission: Impossible: Ghost Protocol*'s gestural heads-up display for passenger navigation (Figure 14.1a). The steampunk genre also includes speculative technology, despite components that speak to a different era, as in *Sherlock Holmes* (Figure 14.1b). Sci-fi comedies, such as *Spaceballs*, have an additional layer of humor to tease apart from the technology (Figure 14.1c), but anything with speculative technologies is likely to have interfaces worth examining.

Other domains contain speculative technologies, such as video games and, for the brave, the deep pool of text-based sci-fi.

FIGURE 14.1a–c
*Mission: Impossible: Ghost Protocol* (2011); *Sherlock Holmes* (2009); *Spaceballs* (1987).

For that matter, we don't have to stick to the world of entertainment. We can look at the speculative fiction in industrial films and design investigations.

For example, General Motors' 1956 Motorama traveling auto show was one of the first examples of a corporation creating speculative fiction to promote its brand and its view of the future. It included Frigidaire's wonderfully melodramatic industrial film *Design for Dreaming* discussed in Chapter 2 (see page 21). This film didn't portray a real kitchen, but a well-imagined one. Surely there are lessons to uncover here, as well.

A more recent example is Apple's *Knowledge Navigator* films from the 1980s, commissioned by Apple CEO John Sculley to illustrate a vision of technology 20 years in the future, based on ideas from Apple's research and development labs (Figure 14.2a). Interfaces and technologies in the film included voice recognition and response, hypermedia, online media, online collaboration and video conferencing, agents, and more. This project set the standard for technology companies to create their own visions, as Sun did with *Starfire* seven years later (Figure 14.2b).

The truth is that much real-world design is, like sci-fi, fictional. Even when interfaces are designed for actual products and services, they follow a process that is inherently speculative. As designers, we build personas of users that are built on real research, but they're still fictional characters. We create scenarios (stories) for them to inhabit. The scenarios that are developed are fiction, not unlike those in a film or TV series. We then prototype solutions (still fictional) in our attempt to craft solutions that will work for real users, and we iterate much like writers iterate screenplays.

FIGURE 14.2a,b
Apple's *Knowledge Navigator* (1987); Sun's *Starfire* (1994).

FIGURE 14.3a–c
Prototypes in the "Snow White" design language for the Apple II family of products, by Frog Design (1983–85).

Prototypes, like the famous "Snow White" design language developed by Frog Design for Apple's hardware in the early 1980s, tell an influential story of possibility and opportunity (Figure 14.3). Although none of these specific prototypes found their way to market, they had an important influence on the development of the products and services that did. They were design fictions that were crucial to the design process.

Let's face it, most of what we create never gets produced. If we're lucky, one of the iterations makes it past the development phase, to market, and into the hands of customers. Only then does some of this fiction become fact, and the real and imagined join together on the road to creating something wonderful and new.

## And Sci-Fi to Come

New sci-fi stories, visions, and interfaces are being imagined and created as you read this. Some might contradict what we've found so far. The daydreamers in us kind of hope they do. Most, however, will likely build on what has come before. Undoubtedly these new stories will give us new examples to consider, new trends to follow, and new lessons to learn. But as long as we keep an inspired spirit, an analytical eye, and a questioner's mind, we can keep peering out of the portholes, learning lessons, and making it so.

# APPENDIX: COLLECTED LESSONS AND OPPORTUNITIES

**CHAPTER 1**

## Learning Lessons from Science Fiction



**CHAPTER 2**

## Mechanical Controls



**CHAPTER 3**

## Visual Interfaces

**CHAPTER 4**

## Volumetric Projection



**CHAPTER 5**

## Gesture

## CHAPTER 6
# Sonic Interfaces



## CHAPTER 7
# Brain Interfaces



## CHAPTER 8
# Augmented Reality

#### CHAPTER 9

## Anthropomorphism



#### CHAPTER 10

## Communication

**CHAPTER 11**

## Learning

## CHAPTER 12
# Medicine



## CHAPTER 13
# Sex



## CHAPTER 14
# What's Next?

## Meta-Lessons

Some of the lessons that emerged out of separate investigations ended up describing similar concepts. These lessons are called out below with the meta-lesson as its category.

### Use escape commands



### Break stylistic rules to stand out



### Be aware of passé styles



### Interpreters need to correct



### Fit information to channels



### The number of selected objects connotes a mode

## Manipulation fits hands

Use gesture for simple, physical manipulations, and use language for abstractions 104

Make manipulations physical 267

## People like technologies that are like themselves

Conversational interfaces should follow human social conventions 123

The human is sometimes the ideal interface 205

Handle emotional inputs 214

Support emotional learning 254

It should *feel* humane 281

People need people 283

## Guide attention respectfully

Help draw user attention through scale 59

Use motion to draw attention, cautiously 64

Use sound for urgent attention 208

When the chance for revival has passed, respect death with silence 289

## Balance ease of use and error prevention

Balance ease and control in activation 202

Balance ease of use with error prevention 239

# CREDITS

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I'd like to thank my friends and family who've had to suffer with my talking solely about science fiction for five years, and for not making fun of my not having a clue what other media has come out in that time.

—Nathan Shedroff

Thanks to Ben for the love, support, and patience with my turning almost every movie night into a sci-fi night. Thanks to the folks at Cooper for support and lunchtime conversations about ideas in progress. Thanks also to Mom and Dad, friends and family.

—Chris Noessel

# ABOUT THE AUTHORS

**Nathan Shedroff** is chair of the groundbreaking MBA in Design Strategy program at the California College of the Arts in San Francisco. This program melds the unique principles that design offers business strategy with a vision of the future of business as sustainable, meaningful, and truly innovative—as well as profitable.

Nathan is one of the pioneers in experience design and has played an important role in the related fields of interaction design and information design. He is a serial entrepreneur, works in several media, and consults strategically for companies to build better, more meaningful experiences for their customers.

Nathan speaks and teaches internationally and has written extensively on design and business issues. He is the author of *Experience Design 1.1*, and coauthored *Making Meaning* with two members of Cheskin, a Silicon Valley–based strategy consultancy, to explore how companies can create products and services specifically to evoke meaning in their audiences and customers. Nathan is editor of the *Dictionary of Sustainable Management*, a website and now a printed book. He also maintains an extensive set of resources on experience design on his website (www.nathan.com/ed).

Nathan earned a degree in industrial design with an emphasis on automobile design from the Art Center College of Design in Pasadena. A passion for information design led Nathan to work with Richard Saul Wurman at TheUnderstandingBusiness. Later, he co-founded vivid studios, a pioneering company in interactive media and one of the first Web services firms. vivid's hallmark was helping to establish and validate the field of information architecture by training an entire generation of designers in the newly emerging Web industry. Nathan was nominated for a Chrysler Innovation in Design Award in 1994 and 1999, and a National Design Award in 2001. In 2006 Nathan earned an MBA at the Presidio School of Management in San Francisco, the only accredited MBA program in the United States specializing in sustainable business.

**Christopher Noessel**, in his day job as managing director at the pioneering interaction design firm Cooper, designs products, services, and strategy for the health, financial, and consumer domains, among others. In his role as practice lead, he helps manage the "generator" type of interaction designers, helping them build their skills and lead client projects to greatness.

Christopher has been doing interaction design for more than 20 years (longer than we've even been calling it that). He co-founded a small interaction design agency where he developed interactive exhibitions and environments for museums, and he worked as a director of information design at international Web consultancy marchFIRST, where he also helped establish the interaction design Center of Excellence.

Christopher was one of the founding graduates of the now-passing-into-legend Interaction Design Institute Ivrea in Ivrea, Italy, where his thesis project was a comprehensive service design for lifelong learners called *Fresh*. The project was presented at the MLearn conference in London in 2003. He has since helped to visualize the future of counterterrorism as a freelancer, built prototypes of coming technologies for Microsoft, and designed telehealth devices to accommodate the crazy facts of modern health care in his role at Cooper.

Christopher has written for online publications for many years, and was first published in print as co-author of the interaction design pattern chapter in the textbook edited by Simson Garfinkel, *RFID: Applications, Security, and Privacy*. His Spidey sense goes off at random topics, and this has led him to speak at conferences around the world about a wide range of things, including interactive narrative, ethnographic user research, interaction design, sex-related interactive technologies, free-range learning, the Interface Parenthesis and the future of interaction design, and the relationship between science fiction and interface design.