Software on the Brain

BY STEVEN JOHNSON

We first met Steven Johnson in 1996 when we invested in FEED, the online magazine he cofounded with Stefanie Syman. Johnson went on to help create the community site, Plastic.com, which employed a bubble-up reputation system based on the one created by Slashdot. Johnson has long been fascinated by emergent behavior, as reflected in his lucid and entertaining books “Interface Culture” (1998) and more recently “Emergence: The Connected Lives Of Ants, Brains, Cities, and Software” (2001).

“My books seem to have reproduced by spores,” he says. “There was a section on intelligent agents and self-organization in ‘Interface Culture’ that became the seed for ‘Emergence,’ and there was a sub-theme of ‘Emergence’ on brains, [which I felt] was the weakest of the four subjects in the subtitle. So I thought it’d be fun to make up for that neglect with an entire book.” That book became “Mind Wide Open: Your Brain And The Neuroscience Of Everyday Life” (2004), which will be distributed at this year’s PC Forum (where Johnson will be speaking).

This issue of Release 1.0, in turn, covers the brain and software from a more tech-business point of view, illustrating the impact our increasing understanding of the brain has had on improving the power and accessibility of end-user software.

– Esther Dyson

Most of the software you use every day harbors a functional theory of how the mind works. It’s not the most sophisticated theory you’ll find, and it needs some updating, but it’s not without its subtleties. The graphical interface revolution, after all, was predicated on a cru-
cial insight about the way the brain forms and archives memories. Cognitive scientists have long recognized that our visual memory is better than our textual memory, because primates happened to evolve unusually acute visual systems, while written language depends on learned behavior. The shift from the command line to the desktop was, ultimately, a response to that strange property of the brain’s wiring: We are more likely to remember seeing the trash can sitting in the bottom-left-hand corner of the screen than we are to remember the text string “del *filename*. “From that small insight into the brain’s memory, a billion virtual desktops have bloomed.

Since the shift to visual metaphors in the ’80s, a number of refinements reflecting our understanding of the brain’s natural aptitudes have appeared in software design and in the development of technology itself. For instance, focal points were easy to anticipate when the screens were 640x480 pixels and we could run only a single application at any given time. But in an age of permanent multi-tasking and ever-larger screens, attention has become as crucial to interface design as memory was to the Xerox-PARC crowd in the late ’70s. Most of the screen exists in the user’s peripheral visual field, which is notoriously imprecise and which takes in only the most meager information about color or shape. But our peripheral vision does have a good “eye” for motion, so modern interfaces notify us of urgent requests from other background applications not with text or sound but with motion: When your Web browser can’t load a page or your word processor has had trouble locating a file, the icon representing the program bounces in the Dock or blinks in the task bar at the margins of the screen. Even if you’re locked into a small region on the other side of the screen you instantly perceive that bouncing effect.

Despite these advances, for the most part software design has not kept up with our understanding of the brain. Thanks in part to the tremendous advance in brain imaging technologies, as well as a newfound interest in the brain’s emotional systems, cognitive neuroscience has made great progress since the visual metaphors of the graphical interface first appeared on the screen. To a certain extent, that progress came about because researchers finally shed the computational model of mind that had dominated brain science for sev-
eral decades. The brain wasn’t just an advanced calculating machine, it was something far more complex, and more interesting.

As the scientist Antonio Damasio argued in his 1994 book “Descartes’ Error,” even decisions that seem on their face to be governed entirely by logic are made within the brain’s emotional system – a system grounded both in neurochemistry and the wider body itself. (Our “gut instincts” turn out to involve the gut after all.) Memory is no longer seen as a simple problem of storage and retrieval: Emotional states play a significant role in how memories are captured and when they are recalled. We know much more about the kinds of brainwave activity that characterize attentive states – or distracted ones – and we’ve developed simple, consumer-grade tools that can measure those brain waves. We also have a growing understanding of the brain’s dopamine-governed reward architecture – the part of our mind that seeks out rewarding experiences, particularly if they’ve been in short supply.

All of these insights have implications for the software that we use every day, implications that could prove as profound as the primacy of visual over textual memory. For 40 years we’ve been untangling Marshall McLuhan’s insight that our media are just extensions of our central nervous system, but we have spent most of that time focused on the extensions and ignoring the nervous system itself. The new understanding of the brain’s inner architecture gives us an opportunity to remedy that oversight. For too long, our software has worked with an out-of-date – or nonexistent – understanding of the aptitudes and inclinations of the human brain. It’s time for an upgrade.

Emotion: Laughing All the Way

Not long ago, we attended a small retreat on the design of communications software (hosted, as it happened, by Release 1.0 contributor Clay Shirky) that put 20-odd technologists and designers in a room to discuss various ideas face-to-face, while simultaneously letting them converse in a special electronic chat room restricted solely to the people attending the retreat. The chat was projected onto a flat screen visible to everyone in the room, though people typed their comments via their laptops.

The chat turned out to be a mix of follow-up observations and pointers to related reading on the Web...as well as the usual chat-room snarkiness. From one angle, it was a fairly intoxicating mix – carrying on two simultaneous group conversations
with the same group. You felt like you were pulling down a lot of data: The real-world conversations grounded things, and the chat let the room riff a bit more. It was also a little intoxicating in the dizzying sense. Cognitive scientists have long known that our attention buffers max out at following two verbal conversations at once; this experiment made us wonder if the carrying capacity is any different if one conversation is spoken and one is text.

But the most interesting side effect was that the arrangement sucked all the jokes out of the room and into the chat. If someone had a funny throwaway remark to make, they’d simply toss it into the chat environment. You’d see people smile to themselves as the joke scrolled across the screen, but they wouldn’t laugh out loud. This behavior came up as the group was discussing the format near the end of the session, and someone said that having the jokes in the virtual world made it better in a way: The jokes were there for all to see, but they didn’t interrupt the flow of the conversation. That observation was true enough, but only if you think the point of jokes is humor rather than laughter.

Recent brain science has helped us understand the extent to which laughter and humor are separate categories. University of Maryland professor Robert Provine – author of a delightful book called “Laughter: A Scientific Investigation” – believes that from a neurological and evolutionary point of view, the primary purpose of laughter is social connection, not humor. Studies have shown that you are 30 times more likely to laugh in the presence of other people than you are to laugh out loud by yourself. In fact, you are significantly more likely to talk out loud to yourself alone in a room than you are to laugh out loud. (This is why television laugh tracks were invented.)

Several studies have shown that something very different happens when you appreciate a joke without actually laughing at it – the brain’s reward system doesn’t kick in, which colors both your immediate experience of the event and the intensity of your recollection of it later. The physical act of laughing is intimately connected to a series of neurochemical events in your brain: adrenaline levels will predictably rise, without the stress hormone release you would normally experience in a “fight-or-flight” situation; some researchers even believe that endorphins may be involved as well, though there is no clear evidence of this yet. Because our memory system is designed to record emotionally colored experiences more vividly than emotionally neutral ones, experiences accompanied by laughter are more likely to become a fixed part of our recollection than events accompanied by a straight face.
At the end of our retreat, when Shirky asked the group to close our laptops and reflect on the day a bit, the space was quickly reverberating with laughter, which completely transformed the social weather of the environment. The number of jokes per minute probably declined, but the room felt far more collegial and cohesive.

The lesson from this experiment is twofold. First, certain social settings – particularly those that involve virtual communication – may artificially dampen the laughter that would otherwise be generated in a face-to-face encounter. Second, social interaction without laughter produces different brain chemistry, which affects both your background impression of the exchange and the trace memories the exchange leaves in your head. Putting smiley-faces into e-mail to compensate for the lack of verbal intonation helps convey when you’re trying to be funny, but because the recipient of your message is still reading it alone, she won’t be likely to laugh out loud, and the suppression of laughter will make a difference. It will be a happier – and consequently a stronger – memory if she laughs.

The question for software makers (and advertisers) is this: As more and more of our communications become virtual in nature, how can we supplement those experiences so that we can reproduce the range and emotional depth of face-to-face encounters? The subtle micro-semantics of facial expressions and vocal intonation are a huge part of human communication, but because our brains are so precisely wired to evaluate that symbolic language, we often don’t realize how much information is being transmitted by the lifting of an eyebrow or the clenching of a jaw. The proliferation of new communication modes in recent years – everything from e-mail to Usenet to Web bulletin boards to instant messaging (IM) – has created tremendous opportunities for human connection, particularly between relative strangers. But almost all these technologies have ignored the complexity of human emotional expressiveness. Scientists now believe that autistics suffer from a neurological condition that keeps them deaf and blind to the subtleties of facial expressions and vocal intonation: They have to learn to read emotions the way the rest of us might learn sign language. Our communication technologies, impressive as they are, have brought us all a little closer to the emotional blindness of the autistic.

**There.com: Persistence of emotion**

One way around the emotional blankness of communication technologies is to create virtual renditions of the human face – a kind of 3D-rendered version of the old television laugh track. That’s the vision behind the new subscription-based virtual world There.com (see Release 1.0, March 2003), founded by former CNet executive
Tom Melcher and now headed by Steve Victorino, a former venture capitalist and VP at Four11. At first glance, There looks like another installment in what has historically been a failed genre: 3D avatar-based worlds designed for social interaction. 3D avatar-based worlds that are also video games, such as Everquest, have of course been a huge success (see Release 1.0, June and August 1994, October 2002). But virtual worlds as purely social arena – IM with bodies and trees – haven’t caught on, despite a number of well-financed attempts.

Melcher’s idea for There followed a crucial insight about previous avatar-driven spaces. While the software would inevitably allow you customize your onscreen representative with a huge palette of facial types, ethnicities and costumes, the avatar became increasingly irrelevant once you started exploring the world. All the real activity took place in the text chat window, with the avatars floating around uselessly, like a bunch of abandoned puppets. When you met someone for the first time, you might take in some rough information from his avatar’s general look – another Elvis impersonator! – but once the conversation started, it was all about the words.

“We wanted to create a way of communicating such that the avatar was essential to it,” explains Melcher, who still serves on There’s board. “If you didn’t have your avatar, you’d really notice that something was missing.” So the There team created something called Avatar Centric Computing (ACC). Part of ACC involves virtual camerawork: With a single keystroke you can zoom in for a close-up of the person you’re talking to, or you can see your own face. But Melcher and his team focused most of their energy on the expressive range of those virtual faces. Designed by pioneering AI researcher Jeffrey Ventrella, There’s palette of facial expressions draws upon 62 different muscular movements: squinting eyes, furrowed brows, and so on. User-controlled expressions are a specific combination of those micro-movements. There.com launched with hundreds of pre-programmed expressions – dozens of variations of laughter and good cheer, gradations of anger, flirtation, remorse, and so on. Since launching the official product last fall, There has introduced a number of full-body gestures, along with pop culture expressions such as “talk to the hand” and “yadda yadda yadda.” (There is some talk of advertisers sponsoring specific emotions; Melcher suggests that the Budweiser “Wassup?” expression would be an obvious candidate.)

Controlling your avatar’s facial expression is a strange mix of normal IM behavior and a new form of QWERTY manipulation. Shorthand expressions such as “LOL” cause your avatar to, well, laugh out loud. Other emotions are triggered by typing the appropriate adjective modified by special characters for intensity: “‘flirting” is
more over-the-top than “flirting.” The expressions themselves are deliberately exaggerated – more Looney Tunes than perfect photo-realism – but they are undeniably powerful. You find yourself smiling – or even laughing – right alongside your onscreen representative.

As any kid will tell you, if you flip through a series of progressive still-images, the human eye creates the illusion of motion, blurring one image into the next. At more than 16 images a second, the quality of that illusion creates “persistence of vision.” Without it, movies and television shows would be a painfully accelerated slide show, lacking the immersive simulation of reality that makes them so hypnotic. There.com makes it clear that we are exploring a comparable threshold point in our perceptual systems today. Only this time, the illusion at stake is not motion, but rather emotion.

Citing competition in the virtual worlds space (both social environments such as Second Life, and specifically game-based worlds such as The Sims Online) Victorino won’t publicly discuss There’s usage numbers. “Suffice it to say,” he says, “if you go into the community at any given time, there are literally thousands of simultaneous users. The revenue side of the equation is off the charts.” Right now, There users are offered two membership plans: an annual membership for $49.95, or a monthly plan that costs $19.95 to activate and $4.95 per month afterwards. Expect those plans to diversify, says Victorino: “Over time we’ll move much closer to a cellular phone pricing model where there are a number of different price points that span everything from the casual user who comes in once every few weeks to the user who comes several times a day.”

The addictiveness – and therefore the success – of There.com depends on it stirring the brain’s reward and seeking system, discussed in detail below (PAGE 17). Victorino and his team have implemented a social hierarchy in There.com that tries to tap into this system in a distinctly game-like fashion. “Underlying the entire product is a social architecture that provides a set of incentives to improve along a number of different dimensions: You can, say, be a novice socialite, where the more friends you have you level up. You can be a novice buggy racer, or fashionista,” he explains. Increase your talents in your given role, and you’ll be granted new powers and access to new areas or equipment. “When you come in, you’re only allowed to lead a certain number of clubs; as you level up as a socialite, you’re allowed to form more clubs and participate in more of them; at a higher level, you’re given your own clubhouse.”
There’s a reward system also encouraged by its virtual economy, which has blossomed. “Initially, the only things you could purchase with Therebucks [the official currency] were out of the official catalogue,” Victorino explains. “Now we’ve rolled out an auction system that lets people auction off objects that they’ve already purchased. But more importantly, they’re using the auction channels to buy and sell objects that they’ve created. We’ve created developer tools that let people design their own lines of clothing, their own vehicles, furniture, housing accoutrements.” At last count, 93 percent of goods sold in the There.com auctions were user-created.

**Memory: The Scent of a Sentence**

There’s a long history of talking about the computer as an extension of our memory, but what rarely gets mentioned is how little our digital recall resembles the cognitive version. Memory, where software is concerned, is search and retrieval: we know what we’re looking for and the computer finds it for us. Sometimes the object we’re retrieving is very clearly defined (“Where’s that spreadsheet I did on the 3rd-quarter numbers?”) and sometimes it’s more elliptical (“I think I used the phrase ‘ubiquitous computing’ in the opening paragraph.”). Our cognitive memory, on the other hand, rarely works like that. We all have our occasional search-and-retrieval moments where we query the internal database (“What is his phone number? Oh, right . . .”), but memories usually arrive in a completely different form: We don’t call out for them; they come to us. We don’t stop in the middle of the supermarket and think, “Pull up that memory of shopping with Mom when I was seven.” The memory arrives before we even know that we’re “looking” for it. (Some memories, of course, arrive precisely when we’re not looking for them, but that’s another story.) Proust called them *memoires involontaire* for a reason: He didn’t set up an internal query for memories associated with the taste of the cookies he used to eat as a child. He took a bite of a madeleine, and the memories came flooding back involuntarily.

Some software tries to mimic part of this cognitive recall. We have tools that allow us to make connections between various pieces of data, and those connections are automatically re-triggered as we explore the data at future points. This is the model of TheBrain as well as of most hypertext-driven organizational systems such as EastGate Systems’ TinderBox. Once we’ve assembled a complex network of associations, both tools get us closer to the spontaneous connections that human memory provides. But the pre-assembly required by these tools limits their utility in two ways. First, there’s the time commitment: You have to do the heavy lifting of making
PERSONAL KNOWLEDGE MANAGEMENT

With the help of Maciej Ceglowski at the National Institute for Technology and Liberal Education (NITLE) in Middlebury, VT, I have integrated a new kind of writing and research tool into my daily routine, one that has quickly become as essential a resource as the spell-checker or the thesaurus. In fact, it already feels more important, because it is more directly connected to the substance of what I’m writing about. For the past five years, I have been storing in digital form important passages from books that I’ve read. Until recently, I was limited to scanning through those documents by hand, or doing a traditional keyword search if I was looking for something specific. That was useful enough, but only if I had some idea of what I was looking for.

In the past year, Ceglowski and I have developed a tool that scours that data using the textual analysis algorithm called latent semantic indexing (LSI), looking for connections between the various entries based on statistically interesting overlap in word use. LSI, widely used by knowledge-management and other companies to perform enterprise-wide conceptual searches on structured or unstructured text, possesses an uncanny ability to connect passages that are related to each other and rank them in order of their relatedness.

Here’s one example: If you search my database for “prisoner’s dilemma” – the classic game theory thought experiment – you’ll get back a list of passages, ranked in order of relevance. At the top of the list will be a number of passages that use the phrase “prisoner’s dilemma,” appropriately enough. But right below those are passages that don’t use either word, but that do discuss Norbert Wiener’s groundbreaking work on game theory in the ‘40s. You’ll even find a few passages that talk about vampire bats – also without mentioning “prisoner’s dilemma.” This seems like an errant result until you realize that vampire bats are often discussed in the context of prisoner’s dilemma, because their resource-sharing strategies mirror one of the more successful strategies for playing. Only at the very bottom of the list will you find a passage that mentions the word “prisoner” in passing but that has nothing to do with game theory.

LSI can make these assessments because it looks not just at overall frequency of word use, but also at word overlap: what words tend to be used near other words in certain contexts. The vampire bat entry also discussed the “tit-for-tat” strategy used by bats in sharing limited resources: If another bat has shared with them in the past, they’ll reciprocate. “Tit-for-tat” also happens to be the name of a prisoner’s dilemma strategy that won a famous computer-based “iterated prisoner’s dilemma” competition in the seventies. So when the software was searching for documents related to “prisoner’s dilemma” it noticed that unusual words like “tit-for-tat” were showing up both in entries that mentioned “prisoner’s dilemma” directly, and in entries that talked about vampire bats. Meanwhile, the entry that used the word “prisoner” had fewer suggestive overlaps, and so it was demoted.

Like enterprise-class KM systems, the tool can analyze an entire paragraph or document and use that as the basis for a “find similar” request. Those of us who use search engines many times a day are accustomed to the idea of compressing down a search request to the core concepts so as not to attract off-topic results. But with an LSI-based tool, the results actually improve with the length of the initial query (up to a point, of course): A paragraph is an ideal starting point.

The change may be as revolutionary as the original shift from typewriter to word processor, because the tool actually enhances the substance of what I’m writing. I use it as an improvisational tool, allowing the computer to suggest new associations or remind me of related passages that I have long since forgotten. It reminds me of sub-threads I have forgotten, or things that I needed but didn’t fully realize I was looking for. It’s as though I’m following trails of my own memory, trails that somehow now exist on the machine instead of my own head.

In the past six months, NITLE has moved on to a new indexing technology, called “contextual network search,” that detects the same kind of subtle semantic connections between documents. Ceglowski reports that they have just received “a three-year grant to develop something nebulously called the ‘NITLE Semantic Engine’, or NSE, which is supposed to be a standalone desktop version very much like what you had working in the browser, along with some visualization tools. The terms of the project dictate that everything we make will have a General Public License and everyone on the project has to forswear patent claims.” In addition to the research tool that I’ve used, Ceglowski and his colleagues have used the technology to organize blog posts and large collections of historical data, including an archive of Civil War articles hosted by the University of Virginia.
connections yourself. (Which means that new data objects are mostly useless until you’ve wired them up to other entries.) Then there are the limits of your own memory: If you don’t happen to think of one particularly rich association, the software isn’t going to create it or remind you of it on its own. A handful of companies are experimenting with more powerful associative tools, modeled on the brain’s pattern-recognition skills.

Devon Technologies: Needles in a desktop
Devon Technologies, a small software startup out of Bietigheim-Bissingen, Germany, has built a handful of applications around its proprietary free-form database engine, which seems to do an astonishing job of analyzing large quantities of textual information. While the company is discreet about the technical underpinnings of the database, one of the two principals, Christian Grunenberg, says, “DT does not use neural nets or indexing – including latent semantic indexing (see box, page 9). It’s all about storing data the right way. Basically, we’ve been trying to develop a technology as similar to the human brain as possible, and then apply this afterwards to our applications.” It’s an intriguing business model: First build a core technology that recreates the nuanced pattern-recognition skills of the human mind, and then concoct other applications to tap into that intelligence in different ways.

Grunenberg is a longtime programmer who started developing the Devon database system in 2001. Thus far, Devon Technologies has released two applications built on top of the Devon kernel: DevonThink and DevonAgent. Each retails for $35, and Grunenberg reports that they are on target to sell 10,000 copies by the end of 2004. The company has relied largely on word-of-mouth from a developing cult following to build its audience, but with only two full-time employees and two contractors, it doesn’t need to sell many copies to stay solvent. Devon has two new projects in the works: a database management tool called DevonBase and an artificial intelligence project called DevonTalk that “simulates an intelligent conversation with an electronic service agent.”

DevonThink and DevonAgent are somewhat less ambitious in nature, but also more practical. DevonAgent is a desktop application that mimics many of the features of meta-search-engines such as Groxis’s Grokker (see release 1.0, january 2003) and Queryster. Define a query, and DevonAgent will sift through results generated by multiple search engines. The software filters out redundancies and dead links, uses the DevonThink engine to automatically classify the resulting pages, and then organizes and presents the URLs with synopses of relevant text. Set up a permanent
query for “human memory” and the Agent returns a list of 298 pages, augmented with a series of automatically detected sub-categories organized around keywords. One of the sub-categories suggested for “human memory,” for instance, is “search”: if you select “search” you get a dozen or so excerpts from pages that emphasize both “search” and “human memory” - in this case, several documents about the application of cognitive science to online searching, as well as a few dead ends that happened to use the verb “search” in passing.

This kind of intelligent categorization can be helpful, but it’s often not all that intelligent. The “human memory” query also generated suggested categories such as “different” and “three,” neither of which is a useful filter. On the other hand, a few false positives are not a killer when the rest of the results are what you want.

DevonThink Personal Edition is a more complicated story. The application plays two primary roles: as a supplementary file management system and as a more associative, inspirational “tool for thought.” Getting started is easy enough: Drag your work folder into the main DevonThink window and let the software do its magic, analyzing the words in each document. (This usually takes a couple of minutes for a thousand files or so.) Click on any document in the primary pane and the first few lines of text in that document appear in another pane. So far, you might as well be in the Finder or Windows Explorer, but DT has more tricks up its sleeve. Once a user has defined semantic groups by creating a few folders and depositing appropriate documents in them, DT can finish the filing by automatically classifying and grouping documents based on those semantic associations. (Mac interface aficionados will recognize this as a feature called “Views” that Apple touted for years as part of its never-released Copland OS – though some of the indexing technology, originally called V-Twin, continues on as part of OS X.)

In general, automatic classification has its limits as a way of organizing files, largely because when you’re looking for a file, there’s a decidedly non-fuzzy property to the search. You want a very specific document, not a cluster of similar documents. Most of us have hand-crafted categorization schemes that work pretty well: You think, “I’m looking for that presentation from April,” so you open up the “presentations” directory and sort by date. Using software-arranged folders adds a new level of randomness to the process: “I wonder where the software might have filed that one. . . .”
More promising is the “see also” feature that DevonThink offers. Select a document and click on the “see also” button, and instantly you are served a list of related items. (Devon has added image analysis to the latest version.) “See also” suggests a new routine for people who work with text for a living, much like the way many of us use Google as an idea-augmentation tool: We sit down to work on a document, sketch out a few ideas, drop the new document into DevonThink, and “see also.” What comes back is a batch of old items from our digital past: a few PDFs of downloaded articles, some pages grabbed off the Web long ago, and invariably a handful of our own documents, some of which we’ve entirely forgotten.

Where tools like DT really shine is not in organizing files, but in organizing ideas—or better yet, expanding them and triggering new ones. That’s because free association has far more tolerance for fuzzy results than file management does. When you’re poking around for a new idea, you’ll happily sift through a few weak links before you stumble upon some brilliant insight. The fuzziness of the query results has a pleasantly open-ended quality. It feels like thinking.

**Audiotrieve: Finding what to avoid**

While memory and pattern-recognition skills allow the human brain to sense connections between documents (or ideas), there’s a flip side to that talent: the ability to detect documents that aren’t relevant. The brain is good at detecting signal, but often better at detecting noise. Most of us don’t have to scan through a “Free Viagra” e-mail to determine whether it’s junk mail; a quick glance at the subject header will do the trick. The founders of Audiotrieve, a small Boston-based startup, think computers can be trained to make similar assessments. Instead of modeling the brain’s memory architecture, however, they’ve built a spam-fighting tool—called InBoxer—that relies on our understanding of speech recognition.

Founded by a team of former executives from speech recognition company Dragon Systems, Audiotrieve is a self-funded three-person company led by Roger Matus, ex-VP of new products and technology at Dragon. “We originally started the business to do some speech recognition work,” Matus says, “but in the process we decided to apply some of what we knew to the issue of spam.”

Like some speech-recognition tools, InBoxer works by analyzing “tokens” in a message. “We look at the entire message, both the visible and invisible parts, and we chop it up into tokens,” explains Matus. “Many times, a token is the same as a word, but not always.” In a token-based system, the location of the word and the text sur-
rounding it is often as important to determining meaning as the word itself: Text in subject header, for instance, means something very different from a date-stamp. “So if you were to say, ‘Going to write,’ the fact that you said ‘going to’ suggests that you meant ‘write’ not ‘right,’” says Matus.

Other spam blockers also look for patterns of word use to detect junk messages, but InBoxer adds a twist, borrowed from the speech training of voice recognition software. “At installation, we tokenize every single message in your inbox. And we say: That’s what you consider to be good mail. You kept it, you haven’t deleted it – at least 90 percent of it is good,” explains Matus. “We’ve also developed our own set of tokens for what is spam. Every time a message comes in, we compare the tokens of the new message with the good message/spam tokens, and we create a probability score based on Bayesian math. What differentiates us is that it’s not good enough for a spammer to get around the definition of spam; They also have to look like the good mail that you normally get.”

InBoxer’s approach flips most assumptions about spam blocking on their head: Spam is no longer just defined in terms of what it is, but also by what it is not. In the past year or so, there has been an explosion of thesaurus spam – junk messages filled with unusual words (“adaptability branched ibis hyacinth admirations.”) Thesaurus spam works because most spam blockers are on the lookout for words that frequently appear in junk messages, so if the spam is peppered with unusual words, the filter doesn’t see the message as junk. But if a spam filter uses both positive and negative definitions of spam, a string of unusual words won’t result in a free pass; “adaptability branched ibis hyacinth admirations” is not a pattern that suggests good mail. To get around the “good mail” filter, spammers would have to custom-tailor each message to the interests of each recipient – at which point, of course, it would cease to be spam.

After their first sale in July of 2003, Audiotrieve has now sold 5,000 copies of the software. Matus reports that their customers include “one of the world’s largest entertainment conglomerates, one of the world’s largest insurance companies and the State of Wisconsin, where the State Legislature purchased InBoxer and is deploying it to legislative offices and agencies that work with the legislature.” In its six months on the market, InBoxer has already garnered a handful of “editor’s choice” awards for spam products from PC magazines. Audiotrieve plans to extend the technology to detect other kinds of patterns: “Now that we have proven that InBoxer
technology can work, our plan is to expand to other markets such as security threat
detection and Sarbanes-Oxley compliance. We will shortly announce InBoxer cus-
tom filters using the same technology.”

**Direct Links: Look Ma, No Hands!**

There’s a rich sci-fi tradition of mind-computer interfaces that go beyond general-
ized assumptions about how the brain’s visual memory system works. William
Gibson’s term “cyberspace” was co-opted to describe more prosaic conventions such
as the Web or e-mail, but in Gibson’s original vision it involved yoking one’s brain
directly to the network, the ultimate high-bandwidth connection – a vision now
popularized, of course, by the Matrix films. We’re still a long way from cognitive
implants, but in the meantime there has been a flurry of new companies exploring
another kind of mind-computer interface: neurofeedback.

Neurofeedback dates back to the late ‘60s and early ‘70s, during which time it experi-
enced an initial blip of Aquarian hype alongside primal scream therapy and tran-
scendental meditation. Early advocates found that neurofeedback enabled users to
reach meditative states more easily, by encouraging the alpha brainwaves associated
with deep relaxation. The trouble with the first neurofeedback machines revolved
around how cryptic the feedback was. Without modern graphical displays and high-
speed processors, the early units represented your brain activity with squiggly lines
and R2D2-like computer bleeps. While the evangelists talked about using neurofeed-
back to fine-tune the instrument of your mind – the seminal history of the move-
ment is a book called “A Symphony In The Brain” – the technological limitations of
the age made that instrument sound about as sophisticated as a cell-phone ringer.

Neurofeedback works because at any given moment your brain is releasing waves of
electrical activity that can be measured by an electrode on the outside of the skull.
About 75 years ago, a German scientist named Hans Berger discovered that the
human brain cycles through a half dozen or so distinct wave states, each associated
with a certain mode of (un)consciousness: Delta waves appear in non-REM sleep;
alpha waves usually suggests a state of relaxation. Recently, more interest has focused
on the beta and theta waves, which are implicated in attentive states of minds. (High
theta levels are associated with distracted states, while the higher your beta levels are,
the more focused you are, generally speaking.)
Neurofeedback technology effectively treats your brain as another input device, like a mouse or keyboard. Alter the wave information being picked up by the electrodes, and a corresponding change will occur immediately on the screen. Neurofeedback software lets you ride a bicycle, drive a go-cart, or pilot a spaceship, all by altering the electrical activity in your brain.

The commands available in these systems are inevitably simple ones: usually “go faster” or “slow down.” That’s because they are mapped onto very broad changes in brain activity. Because many such systems were designed to treat ADD in children, they are configured to increase beta rhythms and decrease theta. In other words, if the point of the game is to drive the go-cart faster, it will pick up speed only if the software detects increased beta and decreased theta levels in the signal from the electrodes. The objective is to teach children what it feels like to pay attention, using the video game interface to push their brain towards an attentive state – hopefully long enough that they can return to at will when the electrodes are off. One such tool is marketed by a privately held Ashley, NC company called Unique Logic and Technology. Targeted at both ADD treatment professionals and home users, the system is called “Play Attention.”

There is something undeniably magical the first time you try neurofeedback and get comfortable enough to make the technology work. You’re sitting motionless at a computer, and somehow just by thinking a certain type of thought, you make something happen on the screen. It feels like a form of telepathy. But as magical as it sounds, neurofeedback is not yet a consumer technology experience. While a number of companies such as Unique Logic and Technology have released special helmets with built-in electrodes, it can still be a tricky process for untrained users to get a clean signal. Also, the evidence for neurofeedback’s effectiveness in treating ADD is still mostly anecdotal.

**The Wild Divine Project: Training wheels for the mind**

A consumer version of the mind-computer interface uses a more indirect means of gauging mental state: monitoring fingertips. Journey To The Wild Divine, created by Colorado-based The Wild Divine Project, is a new Myst-like exploratory video game with a twist: Rather than simply click around a virtual world with a mouse, the user wears three plastic-encased electrodes like rings around her fingers, all connected to an ordinary PC. The electrodes detect and report back heart rate and the skin conductance levels (SCL) of the fingertips. (This technology is a sleeker version of what is conventionally called “biofeedback.”) Increased SCL and heart rate usually accom-
pany more active, sometimes agitated states of awareness, as in the sweaty palms of the “fight-or-flight” instinct. Lower levels suggest relaxation and deep calm. Wild Divine also looks at heart rate variability (HRV), which happens to be a hot field in the biofeedback world of late; according to the Wild Divine literature, people with greater HRV “tend to live longer and enjoy life more.”

Created by long-time biomedical entrepreneur Kurt Smith and creative director Corbin Bell, Wild Divine functions both as an intriguing game and meditative training wheels. Smith had previously sold two of his companies to medical technology giant Medtronic, and his biomedical background turned out to be essential for bringing the product to market. While the software itself provides an expansive, lushly rendered world to explore, the hardware design – with biofeedback sensors that are intuitive to use and relatively inexpensive – was the trickiest hurdle in creating Wild Divine.

Unlike so many high-octane titles on the video game shelves, Wild Divine is designed, literally, to help you chill out. In fact, you can’t get anywhere in the game without chilling out. As you explore the world, you’re confronted with a series of tests, mostly mystical in iconography – levitating a ball, controlling a flock of birds. Where a traditional game would force you to pass the test either through some kind of puzzle-solving (as in Myst’s elaborate engineering tests) or hand-eye coordination, Wild Divine makes you reduce your SCL and increase your HRV to pass on to the next challenge. Because SCL and heart rate provide a more reliable data stream than brain waves, it’s remarkably easy to train yourself to control the onscreen objects. Playing Wild Divine for a few hours leaves you feeling a bit like you’ve been to a spa for a weekend: You’re more settled, despite the fact that you’ve been staring into a computer screen the entire time.

At first glance, it’s hard to figure out exactly what Wild Divine’s target audience should be. “For a long time,” Smith says, “we were trying to figure out who we were going after: the gamers? the wellness crowd? the new agers? What it really came down to is anyone – whether they’re a teenage gamer, a 50-year-old executive going into a different mode of life, or a 40-year-old woman who is getting into yoga. It’s appealing to the sort of people who are looking for something different in their life, a different sort of answer. . . We call them ‘the seekers’.”

Smith’s long-term goal is to establish the biofeedback hardware as a platform for a wide range of software applications, some created by Wild Divine, others by third-
party developers. (The company has just published a developer’s library.) “Our key metric is the point where we’ve got 100,000 total platforms out there, because at that point you can reach the critical mass where developing follow-on products has tremendous value,” says Smith. As of early February, they had sold 6000 units.

Some of those follow-on products are already in the works: An extension to Wild Divine will be released shortly, and later in 2004 the company plans to roll out a series of “therapeutic online events” featuring downloadable modules geared to different integrative health issues. “We’ll have offerings priced at $4.99 or $9.99,” explains Smith. “They might be focused on meditation, or understanding the Kabbalah, or dealing with pain management.”

Some may be skeptical about the therapeutic potential of biofeedback: Playing Wild Divine is much more interesting – and convincing – than reading the accompanying literature. But it is clear that the Wild Divine system works, though not necessarily on the level of improving your health or deepening your consciousness. It works on the level of teaching you how to control onscreen objects with your mind. Bell explains: “Most players have a kind of ‘aha’ moment after they’ve experienced it for a while where suddenly they can just make things happen...even if they’re not really aware of what they’re doing physically.”

The description rings true. After a few sessions playing the game, you can reliably pass through the hurdles with a little concentration. It isn’t quite as instantaneous and dependable as clicking a mouse, but it’s an impressive feeling nonetheless. You’re clearly training your body to do something using these sensors on your fingers. Watching those birds flocking as you control them by lowering your stress levels, the thought comes to mind: Here we’ve spent all these years thinking about the computer as an extension of our memory, but Wild Divine suggests another model altogether – the computer as extension of our mood.

**Reward: The Carrot and the Stick**

Some video games do more than improve manual dexterity. Anyone who has ever sat down with a manual for one of today’s simulation or role-playing games will testify that these works are extraordinarily complex forms that require a mastery of detail, a knack for resource management, the ability to work within hierarchies of multiple goals, and nuanced pattern-recognition skills. The very existence of game
manuals – and their many supplementary “game guides” available online and in bookstores – is a measure of the games’ complexity. The closest analogue to game manuals is Cliffs Notes, designed to simplify the great works of literature.

The interesting question here is not whether video games are, on the whole, more complex than most other cultural experiences targeted at kids today; the answer to that is an emphatic yes. The question is, why are kids so eager to soak up and process that much information when it is delivered to them in game form? A typical seven-year-old would be asleep in five seconds if you plopped him down in an urban studies classroom, but put him in front of SimCity for a few hours and you can’t help but marvel at his willingness to learn about and manipulate industrial tax rates and alternative energy sources. Somehow the game provides the same information and thinking challenges in a form that doesn’t feel like education. That’s a powerful learning experience, but why does it happen?

The brain sciences can help explain this mystery. Games manage to get kids to learn without realizing that they’re learning because they tap into the brain’s endogenous reward circuitry. In other words, games reward kids for learning in a way that they don’t get in a classroom.

Researchers now believe that there is an entire neurochemical system devoted to the pursuit and recognition of new experiences and surprise, particularly experiences pertaining to reward. This system is largely regulated by the brain’s production of dopamine. Because it plays a central role in several addictive drugs, including cocaine, dopamine is often described as one of the brain’s “pleasure” drugs. But the shorthand description is misleading. First, like other major neurotransmitters, dopamine is widely utilized throughout the brain, including areas with limited connection to pleasure or reward. (The movement dysfunction of Parkinson’s disease appears to be related to reduced supply of dopamine in the motor areas of the brain.)

**Neurochemical accounting**

But the problem with the image of dopamine as pleasure drug has another level to it. Opioids are pure pleasure drugs: Fill your brain with them, naturally or unnaturally, and you’ll feel good. Some of life’s most important behaviors – sexual climax, social bonding – trigger opioid release in the brain. Dopamine, on the other hand, is not so much a pleasure drug as a kind of pleasure accountant. It anticipates rewards that it expects the brain to receive, and sets off an alarm if the reward exceeds or falls below that anticipated level. It’s not unlike what a stock analyst does in watching quarterly
earnings reports: If the company meets expectations, there’s no news. But if the company shows a less-than-expected loss or a surprisingly high profit, there’s something to talk about. If you’re expecting a certain reward – seeing the face of a loved one, landing a new client – and the reward comes through as promised, the dopamine in your system remains level. If you’re denied the reward, dopamine production drops accordingly. And if the reward turns out to be even better than expected – the loved one shows up with a bouquet of flowers, or the client gives twice as much business as originally indicated – your brain releases extra dopamine to signal the good news. Narrative systems – movies, novels, fairy tales – exploit this drive for novelty; we like twists in our stories because our brains have a biologically grounded interest in surprise.

Lowered dopamine levels help activate what “Affective Neuroscience” author Jaak Panksepp calls the mind’s “seeking” circuitry, propelling us to seek out new avenues for reward in our environment. If you’re expecting a three-course meal and you get a pretzel instead, your lowered dopamine levels will send you immediately to the fridge. In chronic form, low dopamine levels induce the cravings of drug addiction or intense hunger – and they may play a role in social addictions as well. In all these situations, though, the key recurring pattern is the dopamine system’s measuring of reality-versus-expectation, and its propensity to push us towards new experiences. As it happens, there is a rich tradition of software applications that exploit the brain’s seeking circuitry: video games.

Playing games
Researchers have long suspected that geometric games such as Tetris have such an hypnotic hold over us because its elemental shapes activate modules in our visual system that execute low-level forms of pattern recognition – sensing parallel lines, for instance. These modules are churning away in the background all the time, but the simplified graphics of Tetris bring them front and center. Most video games do something comparable to the reward circuitry of the brain.

Real life is full of rewards, which is one reason there are now so many forms of addiction. You can be rewarded by love and social connection, financial success, drug use, shopping, chocolate, and watching your favorite team win the Super Bowl. But supermarkets and shopping malls aside, most of life goes by without the potential rewards available to you being clearly defined: You know you’d like that promotion, but it’s a long way off, and right now you’ve got to deal with getting this memo out the door. Real-life reward usually hovers at the margins of day-to-day existence –
except for the more primal rewards of eating and making love, both of which exceed video games in their addictiveness.

In the game world, reward is everywhere. The universe is literally teeming with objects that deliver very clearly articulated rewards: more online life, access to new levels, new equipment, new spells. Game rewards are fractal: Each scale contains its own reward network, whether you’re just learning to use the controller, trying to solve a puzzle to raise some extra cash, or attempting to complete the game’s ultimate mission. Most of the crucial work in game interface design revolves around keeping players notified of potential rewards available to them, and how much those rewards are currently needed. Just as Tetris streamlines the fuzzy world of visual reality to a core set of interacting shapes, most games offer a fictional world where rewards are larger, more vivid, and more clearly defined than in real life.

This is true even of games that have been rightly celebrated for their open-endedness. SimCity is famous for not forcing the player along a pre-ordained narrative line, but the game has a subtle reward architecture that plays a major role in its addictiveness: The software withholds certain objects and activities until you’ve reached certain pre-defined levels of population, money or popularity. You can build pretty much any kind of environment you want playing SimCity, but you can’t build a baseball stadium until you have attracted 50,000 residents. Similarly, the controversial hit game Grand Theft Auto allows players to drive aimlessly through a vast urban environment, creating their own narratives as they explore the space. But for all that open-endedness, the game still forces players to complete a series of pre-defined missions before they can enter new areas of the city. The very games that are supposed to be emblems of unstructured user control turn out to dangle rewards at every corner.

“Seeking” is the perfect word for the drive these designs instill in their players. Players want to win the game, of course, and perhaps they want to see the game’s narrative completed. In the initial stages of play, a user may just be dazzled by the game’s graphics. But most of the time, what hooks her to the game and draws her back in is the desire to see the next thing. She wants to get to the next level to see what it looks like, or try out the teleportation module, or build an aquarium on the harbor. To someone who has never felt that sort of compulsion, the underlying motivation can seem a little strange: You want to build the aquarium not, in the old mountaineering expression, because it’s there, but rather because it’s not there, or not there yet. But you know – because you’ve read the manual, because the interface is flashing it in front of your eyes – that if you just apply yourself, if you spend a little
more time cultivating employers and watching the annual budget, the aquarium will be yours to build and enjoy.

**Seek and ye shall find reward**

Create an environment where rewards are 1) clearly defined, and 2) just barely in reach, and you’ll find human brains drawn to those environments, even if they’re made up of virtual characters and simulated sidewalks. It’s not the subject matter that draws players in; if that were the case, you’d never see 20-somethings playing absurd rescue-the-princess fantasy titles such as Zelda. It’s the reward system that draws those players in, and keeps their famously short attention spans locked on the screen.

There are lessons here that apply outside the video game industry, notably avatar-driven 3D virtual worlds, such as There.com, that are not organized around games. One way of thinking about the difference between a purely social virtual world and something like Everquest is that the latter is practically a treasure chest of rewards. (Everquest, of course, has actual treasure chests in its gamespace.) You know that if you practice your craft as a tailor for another three hours, you’ll get 100 gold coins in return, which will finally let you buy that hut on the outskirts of town. In a purely social environment, the rewards may be more profound in nature – I might find my soul-mate somewhere here! – but they are also far more elusive. There’s a binary clarity to the video game reward architecture: You either get the 100 gold coins, or you don’t.

In some studies of the Everquest economy, such as that of California State Fullerton economics professor Edward Castronova, much has been made of scarcity in these virtual worlds. Purely social environments usually have infinite resources: Anyone can build a house anytime they want. Everquest and Ultima Online, on the other hand, make you work for it. Resources are precious and are dealt out only to people who have paid their dues – hence the thriving aftermarkets on eBay for virtual castles and swords. Scarcity is what makes the environment addictive, the studies say; scarcity is what makes it a game.

This lesson hasn’t been lost on the creators of There.com; they have gone to great lengths to create a virtual economy in the environment. But scarcity is only half the story. Scarce resources are crucial to the success of the multiplayer genre, but only because they’re presented to human brains that are hard-wired to detect and seek out rewards. If we weren’t predisposed to pursue novelty, if we weren’t naturally inclined to see the next thing, scarcity wouldn’t have its hold over us. This is a faculty
of mind that real-world economies – and particularly advertising-driven consumer economies – have been exploiting, and no doubt enhancing, for years. Our “seeking” appetites may be part of our nature, but society has been nurturing them with great intensity for some time.

The brain’s reward architecture helps explain the success of online communities and other user-driven environments that aren’t explicitly positioned as games. You’ll occasionally hear someone dismiss another’s neediness with the expression: “What do they want – a gold star?” But the success of user-rated communities such as eBay and Epinions or Amazon’s reviewer system suggests that, in fact, people do want gold stars, and they’ll happily spend hours contributing their thoughts and labor to a site that pays in that currency. (See Release 1.0, October 2003.)

User trust ratings are usually described in terms of quality filters: You can weed out community members who get negative feedback from the rest of the community. But, as we’ve seen again and again in the game world, the reward psychology of trust ratings may be just as important. People don’t just come back to sites with trust ratings – such as Slashdot’s famous karma system – because the feedback mechanism has made the site more reliable. They come back because they want to earn more points. (Interestingly, if the audience happens to be made up of people who are also avid gamers, trust ratings can become too addictive: Slashdot’s creators ultimately had to switch the Karma ratings from points to a series of five adjectives, because users were obsessively trying to accumulate as many points as possible.)

The fact that the brain’s reward and seeking appetites are so closely linked means that software environments that connect reward with the possibility of new experiences will be particularly appealing. Indeed, many existing reputation-based communities do precisely that: Novice socialites in There.com want to make connections in order to gain a higher social status and be granted access to better powers, areas and equipment. What draws these users in is not some abstract notion of a bottom-up community where the leaders have earned their privileges, but the hope of becoming leaders themselves. They want the same thing that keeps a gamer playing Grand Theft Auto all night until he’s granted access to the next part of the city. They want to see the next thing.

This is, literally, a recipe for addiction. Not necessarily in the bad sense of the word, of course: People probably won’t start holding up
convenience stores for more Therebucks or Karma (though stranger things have happened). But if you create the right mix of reward and new experience in your software environments, you will find users spending amounts of time in those spaces that outside observers might see as somewhat irrational. It’s not a coincidence that dopamine plays a central role in the addictiveness of cocaine.

In a way, this returns us to our observation about emotional and social software. Online communities designed with user ratings – and particularly ratings that trigger new responsibilities as you grow more experienced – may not necessarily satisfy some of the emotional needs that we get out of face-to-face encounters. You may not laugh out loud as much, or discern as much about the emotional complexity of your fellow community members. But the part of your brain that’s always on the lookout for reward – for reward tied to new experiences – will find the experience distinctly pleasurable. So pleasurable, in fact, that you’ll keep coming back for more. 

For further reading:
“Neuroendocrine influences of mirthful laughter” (1989), American Journal of Medical Sciences, vol.298, pp.390-396
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