Sensory Transformation:
new tools and practices for overcoming cognitive overload

1 | INTRODUCTION

"Information overload" has become a cliché. We use the phrase half-jokingly to describe the stress associated with the onslaught of media that digital technology has unleashed on us. The sobering reality is that we ain't seen nothin' yet. The vast majority of new information technologies are either built for data acquisition (e.g., sensor networks and camera phones) or information dissemination (e.g., blogs, RSS, location-enhanced media, and aware environments). The suffocation of endless incoming e-mail demanding immediate response, the twinge of guilt from falling behind on your RSS feeds, dread about a TiVo hard drive full of unwatched shows—these are all just a teaser for what's to come. No matter how many computers surround us, collecting, aggregating, and delivering information, we each only have one pair of eyes and ears, and more importantly, one mind, to deal with the data.

On the heels of this data explosion, a wide variety of innovative tools and practices will emerge to help us leverage the information glut to our benefit. These new devices, systems, and mindsets will enable us to alleviate the symptoms of cognitive overload while allowing us to comfortably sip from the information firehose. After all, we can't throw out the baby with the high-bandwidth bathwater. Some of these cognitive aids will be external: collaborative filtering, new paradigms in data visualization and display, reputation-based recommendation systems, productivity software, context-aware mobile devices, social software tools, and systems that leverage collective intelligence. But in the longer term, the tools will likely become internalized too. Increasing off-label use of prescription drugs like Ritalin ("for better focus") and Provigil ("no time for sleep") foreshadow the probable popularity of next-generation memory and concentration drugs. Advances in neurotech enabled by deeper knowledge of the brain could even lead to cyborgian prosthetics that would assist us in navigating the claustrophobic mediasphere through more direct connections with our machines. In this report, *Sensory Transformation: New Tools and Practices for Overcoming Cognitive Overload* (SR-1075), we describe the emerging collection of tools and practices that will be important over the next ten years and some of the implications for business and society.

More, More, More

In a recent *New York Times* article about Yahoo!'s video ventures, CEO Terry Semmel said, "You are not going to have 1,000 channels, you will have an *unlimited number* of channels."

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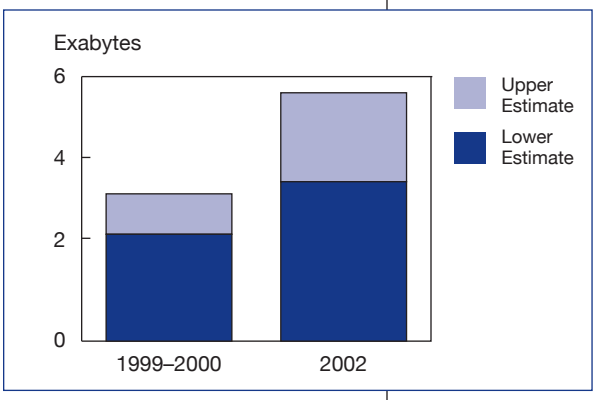
1 Introduction

All hype aside, Semel is quite serious. The technologies of personalized media, from production to distribution, podcasting to life blogs that record the minutiae of everyday living, will lead to one thing for certain: more media. According to a 2003 study by the University of California, Berkeley's School of Information Management, the amount of new information stored on paper, film, magnetic, and optical media doubled in the three years between 1999 and 2002. Print, film, magnetic, and optical storage media produced about 5 exabytes of new information in 2002, about the size of 37,000 Libraries of Congress. Averaged, each person in the world generates roughly 800 MB of recorded information per year. That's about 30 linear feet of books.

New information stored doubled in three years.

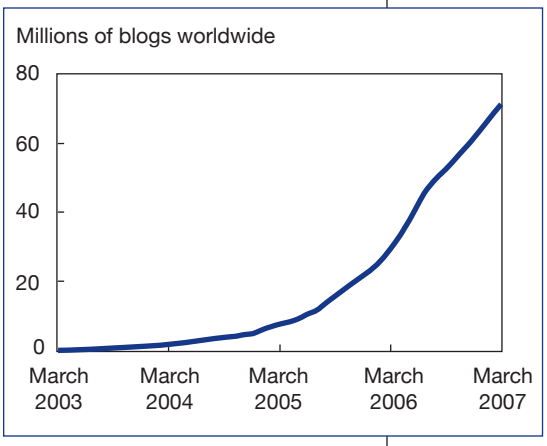


Source: "How Much Information? 2003," UC Berkeley School of Information Management.

Of course, that study was done before the rise of blogs. According to blog-tracking firm Technorati, the blogosphere consisted of more than 70 million blogs in March 2007. That number has been doubling every eight months or so with an average of 120,000 new blogs created every single day.

Meanwhile, the widespread proliferation of sensor networks gathering high-resolution data about our world and our place in it will generate a typhoon of data over the next decade. Kevin Kelly, a founding editor of *Wired* magazine and author of several books on digital culture and technology, talks about the dawn of a new science called "zillionics" where unrelenting rivers of sensory data will flow day and night from zillions of sources, requiring innovative techniques to find the needles in this digital haystack. These sensor networks will also serve as the eyes and ears for context-aware systems and the emerging geoweb that will deliver information tied to a particular place, when we're in that place.

More than 120,000 blogs are being created each day.



Source: Technorati

Yet this abundance of data must still be managed, mined, or thrown out at the risk of losing something of value. A seeming consequence of information abundance is *attention scarcity*. How will we determine what to pay attention to and what gets pushed to the periphery?

FROM COGNITIVE OVERLOAD TO TRANSFORMATION

We are entering a stage where data streams are outpacing our abilities to cope with their output. We have more information available yet the value of that information is diminishing in the shadow of sensory overload. However, new tools are emerging that will enable us to mine, harness, and interact with the data in unprecedentedly powerful ways. We'll wield tools that transform our relationship to information at the same time those tools transform who we are as information gatherers and sensemakers.

2 | NEW TOOLS

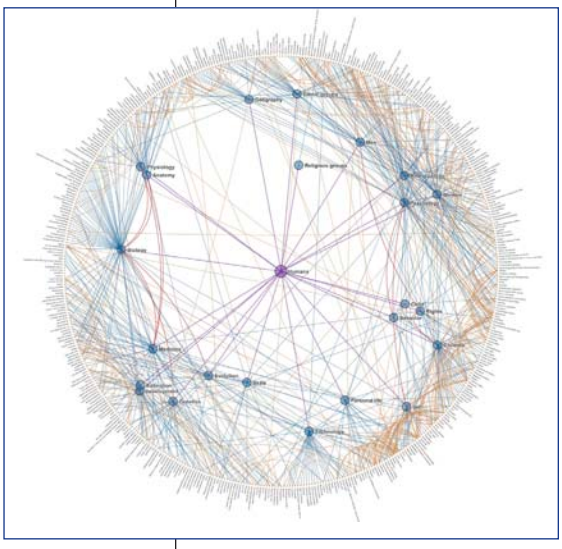
Over the next decade an emerging collection of tools will help us—as workers and members of families and society—to cope with the coming overload of information. These will include data visualizations, ambient displays, social filtering, and agents and interfaces.

Data Visualizations

One could argue that until the last few centuries, visualizations were used mostly to store and communicate models too complicated to keep in mind at one time. Slowly though, they developed into methods of finding patterns as well. One of the more famous breakthroughs in visual pattern-finding is proto-epidemiologist John Snow's 1854 map of cholera cases centered on the public water pump of a London neighborhood. At a time when people still questioned whether illness was caused by evil vapors or because people were poor, Snow's map revealed the cause of the disease—bacteria spread through water contaminated with human waste. Over the 20th century, graphs and charts became standard means to represent underlying causal relationships, conveying the rhetoric and authority of science, despite their notorious reputation for manipulation.

We can expect another radical escalation in the role of live, interactive data visualization in our lives over the next decade because of a convergence of technological developments, decreasing costs of sensors, displays, and computing power, and a need to compete in a richly visual media landscape. With the addition of real-time streams of sensor data and the ability to dynamically rearrange content on a screen and zoom in or out by levels of magnitude, visualizations will become the default in understanding our world.

Network diagrams are useful in finding patterns in thickly-connected datasets, such as this one that shows the structure of Wikipedia category pages and their interconnections.



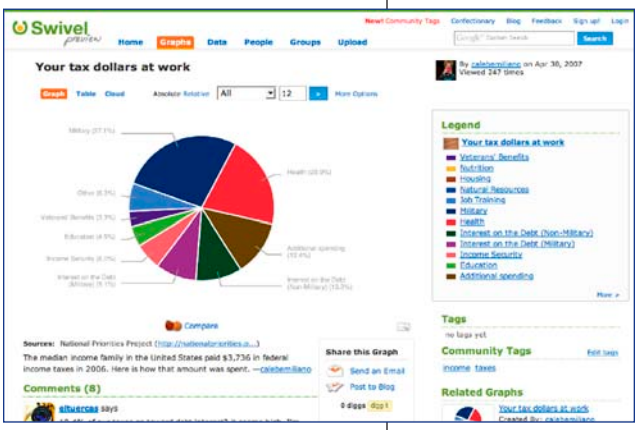
Source: ChrisHarrison.net, 2007.

While we can't foresee exactly what new forms of visualization will emerge, we can look to the most innovative examples at the moment. Network diagrams have proven especially useful in finding patterns in thickly-connected datasets, like social networks, interactions of sections of genes, and corpora of documents linked by semantic proximity. Already, new methods of clustering and interacting with network diagrams are emerging, enabling users to dive in local sections of a network or zoom out to see the big picture.

Another relatively new development in visualization involves encouraging users to share their reactions to the data—letting them add comments that reference sections of the data, take snapshots, or create distinct URLs for specific states that can be shared. Often the most interesting pattern finding or sensemaking is not prepackaged, but instead the visualization affords visitors the chance to interact with the data and find patterns collectively. As Jeffrey Heer, Fernanda Viégas, and Martin Wattenberg argue in a recent paper on col-

laborative information visualization, "Sensemaking is often also a social process. People may disagree on how to interpret the data and may contribute contextual knowledge that deepens understanding." Two free user-generated content Web sites are already offering social interaction around visualizations and datasets: Swivel, described as a "YouTube for Data," and ManyEyes, created by Viégas and Wattenberg's research team.

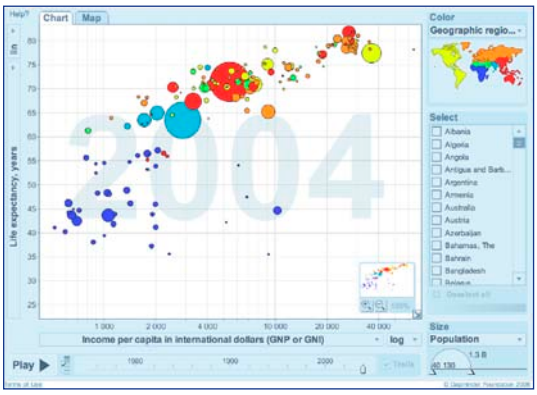
User-generated content Web sites such as Swivel are already offering social interaction around visualizations and datasets.



Source: Swivel.com

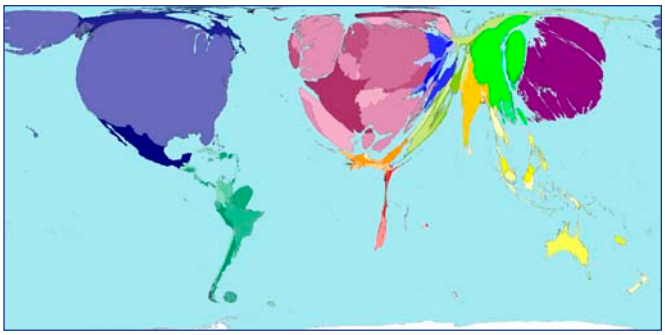
Foundations and altruistic academics are also beginning to notice the rhetorical power of interactive visualizations. Gapminder, Worldmapper, and Google Earth mashups are examples of how a visual interface can bring data to a wider audience. If this freely available data were left in numerical form, it likely would only have been seen by statisticians, sociologists, or economists. The technology behind these projects is quite simple; the real work is in collecting disparate datasets and putting them into a standardized, usable format. Gapminder lets viewers plot any number of variables for all countries of the world and watch them change over the last century. Worldmapper is a set of maps in which the area of each country is distorted to be proportional to any number of variables, with categories ranging from income to health and education. Finally, Google Earth has a simple file format for users to layer all kinds of data (e.g., demographic, environmental) on a 3D zoomable globe and enables viewers to toggle between user-generated layers. These tools bring accurate and important information to the public in accessible formats that can easily be changed to suit specific needs.

Gapminder lets viewers plot any number of variables for all countries of the world and watch changes in them over the last century.



Source: Gapminder.com

Worldmapper is a set of maps in which the area of each country is distorted to be proportional to any number of variables.



Source: Worldmapper.com

What's Next?

Pinpoint Sensor Data in Place

In the near term, we will see advanced versions of sites like Google Earth where the average user can mash-up their own streams of live sensor data from various sources and layer it onto highly accurate 3D representations of their neighborhoods. Users will also create their own indexes based on combinations of variables.

Information-Foraging Tools

New tools will enable groups to divide and conquer previously intractable sets of complex data. Some will divide the set into patches while others sift through the patches, tag with metadata, and reclassify stray nodes.

Meaning Emerges at the Border

Visualizations will become the interface for collaborative, iterative exchanges between machine learning systems and human users. Algorithms will take their best guess at what you're looking for or what you will be interested in, nudged by human responses and constantly reevaluated. Potentially, ambient sensory data such as the length of time that eyes are focused on areas of the screen could be taken into account.

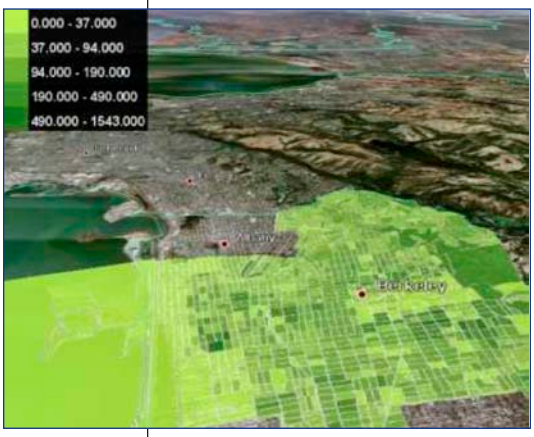
Says Who?

Analogous to the padlock symbol on browsers that indicates an encrypted web connection, standardized practices will emerge for verifying the source of live data on a page and drilling down to into its raw form.

New Priorities

Newly accessible visual information streams will lead to a greater public understanding of world conditions, from the environment to quality of life and economics. Augmented with advanced simulation tools, we'll also be able to better understand and forecast the likely impact of choices and changes we might make both on personal and global scales.

This mashup combines a Google Earth image of Berkeley, CA and population per block data from the U.S. Census.



Source: http://gecensus.stanford.edu/gcensus/index.html

2 New Tools: Ambient Displays

AMBIENT DISPLAYS

While data-visualization tools empower users to interact with complex datasets, ambient displays translate complex information into a simple presentation. There's no standard definition for an ambient display of information, but the most common elements associated with the technology are:

- Low-fidelity representation of higher-fidelity data
- Glanceable, easy to read when needed, but unobtrusive when not
- Data translation needs to be learned and mentally mapped before use

This umbrella from Ambient Devices glows when the day's weather forecast calls for rain.

Source: Ambient Devices

One of the earliest ambient indicators was a project called Live Wire, created by the technology artist Natalie Jeremijenko. She mapped the vibrations of a plastic cord hanging from a motor to the Ethernet traffic over an office network. Live Wire set the pattern for many ambient displays to follow—simple representation, unobtrusive, and not immediately obvious. However, Live Wire was most notable for what Jeremijenko didn't do: keep the lower-fidelity translation in a digital format, displayed on a monitor. With each vibration, Live Wire mapped an invisible stream of bits to the tangible movement of atoms.

Many ambient displays have followed this leap from digital to physical. An augmented pinwheel from the MIT Media Lab spins faster when its linked data source (like unread e-mails) increases. An umbrella from Ambient Devices—makers of the first consumer ambient product, the stock portfolio monitoring Ambient Orb lamp—glows when the day's weather forecast calls for rain. A prototype photo frame called the Presence Frame, created by researchers at New York University, lights up to indicate the presence of the person in the photo. A fountain at Xerox PARC, built by pervasive computing pioneer Roy Want in 1999, trickled or gushed based on the company's stock price. Similarly, the Datafountain, developed by artist Koert van Mensvoort and collaborators in the Netherlands, indicates the relative strength of international currencies through streams of water—a taller stream means a stronger currency. The creators distinguish between explicit data and implicit data, noting that the day's weather can be learned explicitly by reading a newspaper or implicitly by looking out the window. Financial information has no implicit parallel, and an observation on the Datafountain Web site suggests this vacuum was a catalyst for their project:

> In the morning paper, I can read the weather report as well as the stock quotes. But when I look out of my window I only get a weather update and no stock exchange info. Could someone please fix this bug in my environmental system? Thanks.

The physicality of these displays signals an important shift in thinking about our interaction with digital information. The standard personal computing paradigm has forced us to experience the breadth of our computer's capabilities through a single small display. Compared to how we normally process the world, every indicator and every alert displayed on our screen is equally weighted and equally disruptive. In contrast, ambient displays are usually embedded in the environment and outside the bounds of the desktop, freeing them to take full advantage of a human attention span that can focus on a task in the foreground while maintaining minimal but actionable awareness of information and change in the background.

Researchers at New York University created Presence Frame that lights up to indicate the presence of a person in the photograph

Source: http://www.mathlete.com/portfolio/pFrames.php

The Datafountain, developed by artist Koert van Mensvoort and collaborators in the Netherlands, indicates the relative strength of international currencies through streams of water—a taller stream means a stronger currency.

Source: http://www.koert.com/work/datafountain/datafountain_portret.jpg

What's Next?

More Widespread Use

While the model of presenting data in a simplified and physicalized format is certainly still new, perhaps the most limiting factor to widespread use has been the technologies and protocols needed to create displays that can be both situated in our environment and continuously updated. As these technologies become more cost effective, and as wireless communication settles into inexpensive standards like Wi-Fi and Bluetooth, we'll see more ambient displays designed for the workplace and daily life. Chumby, a "hackable" wireless information display, is along these lines. Slated to ship in the summer of 2007, Chumby aggregates and displays pictures that your friends send you from their cell phones, messages from your IM buddies, and updates from your favorite blogs and social-networking sites. It can also display your daily horoscope and the weather, and a whole community of artists and animators can send their creations around the Chumby network to entertain you."

New Senses Engaged

So far, most ambient display projects have used visual cues like shifting light or subtle motion to indicate change. This leaves a lot of potential for our other senses to be engaged in the future. Wearable technologies will be early homes for ambient indicators, many still using visual cues but some that keep us updated through sound and touch.

"Looking Closer" Reveals More

The technologist Matt Webb has identified a key distinction between our interactions with ambient displays and our typical interactions with more complex objects. When we look at things more carefully we receive more detail—more data—about the thing. In contrast, ambient displays are often so deliberately simplified that they reveal the same level of detail from across a room as they do up close. Next generation ambient displays will balance the inherent need to be simple with some level of interactivity, like real-time links to more information.

Ambient Displays Move Back on Screen

Tangible ambient devices are an effective way to use the full range our attention, but for the time being they're not very portable. Cognitive researchers, like Microsoft's Linda Stone, are developing ambient-like additions for our computer environments that translate noisy interruptions, like receiving a new e-mail, into unobtrusive "glanceable" indicators. We talk more about these in the "Agents and Interfaces" section.

"Spambient" Overload

Like most of these strategies for managing sensory input, ambient devices have the potential to add clutter to the problem they're designed to solve. Imagine a desk covered with colored lights, wavy wires, and glowing widgets emitting subtle nondescript sounds. Each display is effective individually but, when clustered, the scenario quickly devolves into a "spambient" landscape. In conjunction with greater user control and software that better understands human goals, we'll likely see displays that combine multiple data streams into one indicator.

Social Filtering

Chats, discussions forums, e-mails, home pages, online photos, music and videos, instant messages, blogs—all of these add a rich human texture to our networked technology and add equally to feelings of information overload. But even as these digital tracks contribute to sensorial exhaustion, we'll actually turn to other people to help sort through it all. Social filtering—through our collective recommendations, votes, preferences, usage patterns, opinions, and descriptions—will become an essential strategy for distilling signal from noise and moving from sensory overload to transformative benefits.

By definition, social filtering takes place when just one person calls attention to something for others. But a large enough community is generally needed to achieve a usable depth and breadth of opinions and interests. Web 2.0 technologies help make this possible. While the term Web 2.0 encompasses several key developments, the most relevant for social filtering have recast the Web into a flexible collection of atomized components—"small pieces loosely joined," as described by technologist David Weinberger—that can be rearranged and redistributed in unlimited ways.

Del.icio.us was born from the potential that millions of users sharing their collections of interesting links could combine their powers and find and categorize the best things online.

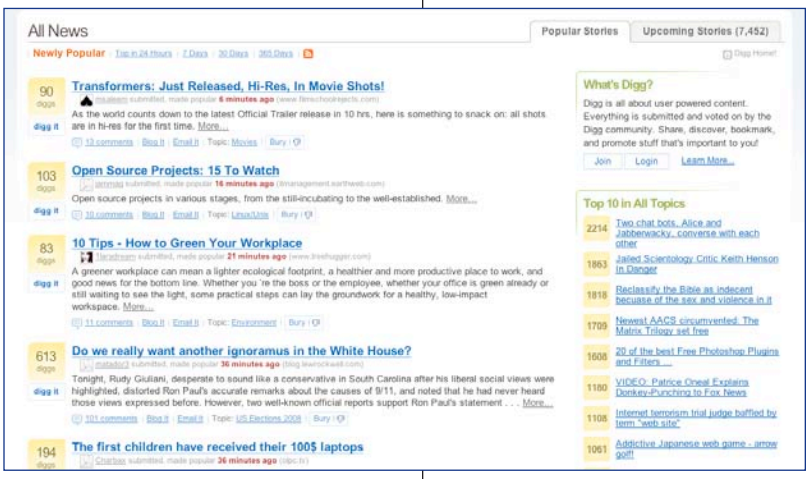
Source: Del.icio.us

The earliest Web browsers allowed us to bookmark sites we found interesting, but these collections were only for personal use, confined to our individual computers. The online bookmarking service del.icio.us was born from the potential that millions of users, gathering and *sharing* their collections of interesting links could combine their powers and find and categorize the best things online. When a del.icio.us user finds an interesting Web site or news article, she'll add the link to the del.icio.us database and assign a few tags. These tags—keywords that describe another piece of data—are one of the infinitely reconfigurable "small pieces" that make up the social web. Tags enable social filtering not only by statically summarizing content, Web links in this case, but acting as links themselves. So a del.icio.us user can browse all links that are tagged "China," or links that are tagged "China" and also tagged "economy," or those same tags but only from a specific user she trusts to post interesting content, or all links posted from that same user. The links she'll get from any of these threads are probably different than the results from a search engine, and point to a future where smart algorithms and human judgment work together. What del.icio.us lacks in precision it makes up for through its human element, the collection of user-generated descriptions that are still better than machines at

cutting to the essential themes of data. Also, human readers can't help but weave in the larger context when dealing with information and we add descriptions that go beyond simple summaries. So social filtering quickly morphs into socially powered exploration; del.icio.us clusters tags by how often they occur together and suggests related avenues to explore.

Del.icio.us is particularly potent for quickly tapping the collective on focused topics, but social filtering also works well as a sheer popularity contest. Any user of the popular sites Digg and Reddit can submit a Web site for consideration by their respective communities. From this pool of contenders, other users vote for the links they find the most worthy. Submissions with the highest tallies make it to the sites' front pages, in either case a highly coveted position and the new media equivalent of appearing above-the-fold in a widely read newspaper.

Digg's users can submit a Web site for consideration by fellow users—and those with the highest tallies make it to the site's front page.



Source: Digg.com

Old media isn't standing still, however. This shift of editorial authority from the hands of a few to the democratic collective will reshape even the most traditional of institutions. The Web site for the *New York Times* now prominently features an updated list of the most popular articles (determined by how often they've been e-mailed, blogged, and searched) right alongside the top headlines carefully chosen by editorial staff. These two lists often overlap but the reader-generated lists usually include a few articles that editors didn't highlight.

A quick word about what social filtering isn't. As a strategy for managing sensory data, it's different from other forms of massively participatory online collaboration like the user-created Wikipedia. Both channel the small contributions of many users into a larger whole. But while the goal of Wikipedia-type projects is creation, social-filtering services like del.icio.us and Digg are structured around scouting, gathering, and categorizing. Imagine a library only made up of books brought in by its patrons, who also stick around to summarize and classify them. Multiple copies of the same title mean it will be featured prominently, but it's still pretty easy to find new books about any subject that interests you.

One downside of many user-driven, social-filtering services is the effort still required by users to get their content, descriptions, and opinions into the system. Other companies are exploring more automatic ways to mine our personal interests and compare us with other users, through collaborative-filtering algorithms. Amazon is the best known commercial provider of this service. Every product's page at Amazon.com includes the now-famous list of products that past buyers also purchased, and personal recommendations are generated

both from a customer's own shopping habits and the shopping habits of customers with similar profiles. Music service Mog works similarly, scanning and aggregating the personal music libraries of its users, but instead of recommending songs or artists, it suggests individuals within the network that you might like to meet because they have similar tastes. This enables you to leverage human guidance rather than depend on a machine's best guess.

What's Next?

Social Filtering in Real Time and Real Space

As the physical and digital worlds begin to blur together, a development the Institute for the Future calls the "end of cyberspace," the stuff of human existence will again be both a flood of information and a trusted strategy for filtering our world. Technologies will build exhaustive profiles of our complete contexts, sensing everything from the food in our context-aware kitchens to the RFID-tagged books on our RFID-enabled bookshelves. So a service like LibraryThing, a Web community where users input their book collections to find socially filtered recommendations from like-minded readers, could become a real-time companion that points out recommended books (in stock, of course) as we pass by a bookstore. Amplify this scenario into a whole chorus of geolocated and context-sensitive suggestions everywhere we go and the need for value judgments and trusted experts is clear.

Today's social-filtering based book-recommendation service Library Thing could evolve into a real-time companion that points out recommended books as we pass by a bookstore.

Source: Librarything.com

Editorial Control Meets Mass Participation

The socially filtered lists on the front page of the *New York Times* Web site point to a new era of hybrid authority, shared between the professional arbiters of quality and the aggregated power of the rest of us. The Korean news Web site OhMyNews was an early pioneer of this model, tapping readers to write a portion of the site's stories and collectively determine which stories get featured on the front page. Professional reporters still write most articles for the site and editors still have final say over prominence, but there's enough input from readers to reflect the audience opinion. This balance will certainly be uneasy at times but can lead to sensory experiences built on both quality and collective representation.

AGENTS AND INTERFACES

In our earlier work on context-awareness (see *Many Faces of Context Awareness*, SR-1014), we defined a spectrum of applications with top–down agents, sensors, and formal ontologies at one end, and bottom–up systems of collaborative intelligence at the other. Social filtering exemplifies this latter side, bringing a human perspective to bear on our increasingly data-rich world. But there's still a lot of effort required by users to add ideas into the system and get aggregated filters out. Social filtering as a sensory management strategy isn't going away but it will begin to work more with top–down tools that are automatic. These systems will know more about what we're doing, about our long-term goals and short-term tasks, and they'll combine discrete bits of information to make informed decisions and behave proactively. Many of these advancements will be driven by increases in computational power, but also by improved models of human activity that combine knowledge of our digital tracks with continuous readings about our context from pervasive smart sensors.

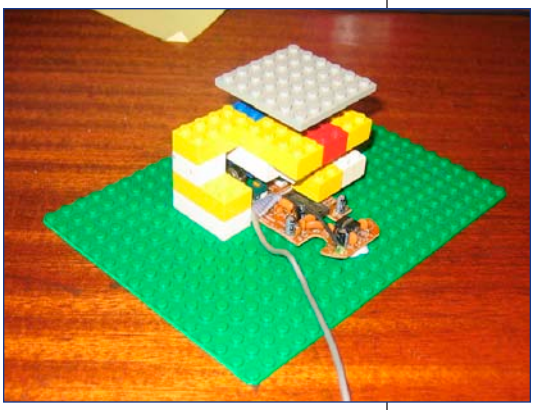
Mary Czerwinski is a cognitive scientist at Microsoft Research studying the computing habits of knowledge workers with an eye toward the role of that interfaces play in mediating our sensory experiences. After installing an activity monitor on participants' computers, Czerwinski and her team found that a window (e.g., e-mail, Web page, word processor) was open for only about 20 seconds before the subject switched to another. Making matters worse, these interruptions led users to forget what were working on. The role of interface in these situations can't be underestimated. While ambient devices and physical indicators are a promising way to engage our full attention with sensory data, we'll still be working via virtual desktops experienced on (relative to the world) small displays. Czerwinski's work is slated to appear in a future version of the Windows operating system through features that keep the user's current task prominently displayed and by translating sensory interruptions, like a new e-mail, into calmer ambient indicators that update.

The art and science of sensory management, or "interruption science" as some call it, isn't just about modifying the traditional computer interface. As significant as the work of Czerwinski and fellow researchers could be, particularly when deployed on millions of personal computers, these tweaks are still the tip of the iceberg. The work of the Affective Computing Group at the MIT Media Lab is an example of research looking even further out, to a day when the technology in our lives knows when our attention is wandering—fairly easy to determine when we switch windows every 20 seconds—or we're in an intense state of concentration, or when we're overwhelmed. Through sensors that detect biometric readings like galvanic skin response, eye motion, or even fidgeting, these researchers are building tools that help us accomplish our goals while taking into account our frame of mind. Early work suggests a world of empathic software "teachers" that will stop to explain a

concept in a different way when a student is frustrated, and context-aware phones that automatically divert a call to voicemail if we're on a roll writing a report. Technologies like these will take on the role of trusted mediators, delivering the most relevant content when we'll be most open to receiving it.

The computer screen is a fruitful area for research by interruption scientists, but it's not the only interface being mediated. The car will also be reshaped by smart software and pervasive emotion detectors. As the next environment for intervention, our time behind the steering wheel makes perfect sense. Not only are we being bombarded with sensory information hurtling past at 65 miles per hour, but we're continually adding new channels and screens and devices to stream even more data inside the car. And unlike our computer screens, one interruption too many in the car can mean the difference between life and death. Research on mediating sensory-rich environments got its start through information design for fighter-plane cockpits. Cockpits were reshaped first by effective design and layout of analog indicators and, most recently, through software agents and biometric sensors in development that build a real-time model of the plane's context and the pilot's frame of mind to gauge how to present information. Car dashboards have long been designed with sensory management in mind, but only recently have the technology advancements used in fighter planes been explored for driving. Toyota is reportedly developing a context-aware car that reads the driver's current state and changes the sensory environment, sometimes through additional data like easier traffic suggestions or calming music, and even sometimes by deprivation, cutting out everything that isn't directly related to the road.

Technology hacker Greg McCarroll created an alarm clock to wake him up only after checking to see if the routinely late train he takes to work is on time.



Source: Greg McCarroll, http://www.flickr.com/photos/gmccarroll/sets/1109249/

Even the way we tell time, unchanged for hundreds of years, is up for a transformation. Technology hacker Greg McCarroll created an alarm clock to wake him up only after checking to see if the routinely late train he takes to work is on time. Ambient Devices is prototyping a clock that keeps the traditional hour and minute hands but also includes a simplified layer based on a user's calendar, the distance to her next appointment, and the traffic she'll likely encounter. So while our daily 9:00 meeting still starts at the same time, we may need to care about it earlier today because the freeway is congested.

Ambient Devices is prototyping a clock that keeps the traditional hands but also includes a layer based on the user's calendar, the distance to her next appointment, and the traffic she'll likely encounter to help her make plans given current conditions.

Source: Ambient Devices

All of these new interfaces, filters, and agents have the potential to realign life around our most personal goals, but we'll first need to become comfortable with reduced information when even something previously as simple as time is filtered through the sensorial world.

What's Next?

Sensory Mediation Helps More People

The same technologies and agents that help us stave off sensory overload will help some people engage in even more basic interactions with the world. The Affecting Computing group at MIT is developing a prosthetic device that helps its wearer identify and make sense of nonverbal cues in others, like facial expressions and tone of voice. For people with conditions like autism, for whom these cues are often undecipherable, the real-time sensemaking offered by these technologies has the potential to fill in for their disabilities. These tools may even become so unobtrusive that we all wear them to improve our interactions with others. As an early start, Accenture Labs has developed a mobile-phone application, called a Personal Performance Coach that helps people who routinely dominate conversations by detecting turn-taking or (the lack thereof) and monologues during calls and cueing the participants appropriately.

Toyota's dashboards of the future will incorporate context-aware technologies that can read the driver's current state and change the sensory environment.

Source: Toyota

Interfaces That Decide How Information Is Presented

We'll trust our sensory mediating agents and interfaces to determine not only when we need to know something but *how we should be told*. Research on information presentation through ambient indicators like heat, touch, light, and sound compared to standard alerts on a computer screen is promising. As we interact more often with technologies capable of expressing information through our different senses, new filters will also be developed that gauge the importance of sensory data and engage us accordingly.

Semantic Web Adds Intelligence to Information Itself

While the Web we're familiar with is in natural language, understandable by humans, the Semantic Web adds meta-level descriptors to the data that can be understood by software agents seeking out information on your behalf, sharing it, and combining it in sensible ways. According to World Wide Web inventor Tim Berners-Lee who is leading the development of Semantic Web standards and design principles, the technology will make computers "capable of analyzing all the data on the Web—the content, links, and transactions between people and computers. A 'Semantic Web,' which should make this possible, has yet to emerge, but when it does, the day-to-day mechanisms of trade, bureaucracy and our daily lives will be handled by machines talking to machines. The 'intelligent agents' people have touted for ages will finally materialize."

3 | CHANGING YOUR MIND

In addition to the new tools that will be available to help humans overcome cognitive overload, we will see new practices enter our daily lives including life hacks and brain hacks that will also alleviate some of the pains.

The information explosion will require new cognitive abilities and mental tricks to stay sane in the face of sensory overload.

LIFE HACKS

As we develop external technologies to help us sort, filter, and process information, an internal transformation will occur as well. The information explosion will require new cognitive abilities and mental tricks to stay sane in the face of sensory overload. As we change technologies, the technologies will also change us. Multitasking is no longer a rare skill but is second nature for many, almost an evolutionary adaptation to cognitive overload. Yet multitasking emerged in the 1990s not so much as a coping mechanism, but rather a way to boost productivity and efficiency by doing things simultaneously that don't require much brainpower—filing papers while on a conference call, for example. At least one of the things we do while multitasking is automatic, not requiring much conscious attention or thought. This is very different than what social computing researcher Linda Stone, a former Microsoft vice president, calls "continuous partial attention."

To pay continuous partial attention is to pay partial attention—*continuously*," Stone writes. "It is motivated by a desire to be a *live* node on the network. Another way of saying this is that we want to connect and be connected. We want to effectively scan for opportunity and optimize for the best opportunities, activities, and contacts, in any given moment. … We pay continuous partial attention in an effort *not to miss anything*. It is an always-on, anywhere, anytime, anyplace behavior that involves an artificial sense of constant crisis. We are always on high alert when we pay continuous partial attention. This artificial sense of constant crisis is more typical of continuous partial attention than it is of multitasking."

As you might expect, young people are better at paying continuous partial attention than adults. Just watch a teenager carrying on six instant messaging conversations at once while updating her MySpace page and watching YouTube videos. The interactions aren't synchronous, Stone says, but they're not a-synchronous either. These young people are connecting semi-synchronously, and just because they're paying attention to everything it doesn't mean they're missing anything.

"Managing time is all about lists, optimization, efficiency, and it's *tactical*," Stone writes. "Managing attention is all about *intention*, making choices as to what *does* and *does not* get done, and it's *strategic*. Managing time is an action journey. Managing attention is an emotional journey."

At the intersection of time management and attention management lies life hacking. Technology writer Danny O'Brien coined the term "life hack" in 2003 after noticing that prolific computer programmers develop mental and technical tricks and short-cuts that help them boost productivity and cut through the data glut. The term has since expanded beyond the realm of software programmers and Web developers to include non-obvious solutions to everyday problems and time sinks, with at least a dozen popular blogs devoted to sharing hacks. Think of it as over-clocking your workflow to squeeze the most out of every moment and optimize your organization skills.

Many life hackers are devotees of, or at least inspired by, David Allen, author of the book *Getting Things Done*. Allen's approach to action management is decidedly low-tech, centering on a file of 43 folders to categorize and remind you of action items to be done. He also argues that any task that takes less than two minutes should be done immediately. Techies have devised various ways to bring Allen's techniques into the digital realm and also developed their own life hacks. For example, O'Brien famously wrote a piece of anti-procrastination software that when he's surfing the Web interrupts him every ten minutes with a message asking if there are other things he should be doing.

While life hackers are currently a niche subculture, their methods of managing information overload will likely become an in-demand skill set for tomorrow's workplace. Indeed, the University of Texas at Austin recently added a course in life hacking to its curriculum. And in 2007, Merlin Mann, the blogger behind life hacking site 43folders.com and O'Brien's frequent writing partner, was named on the Forbes list of Web celebrities.

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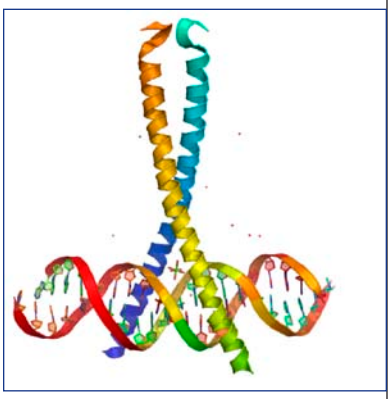
"In fairness, I think we bring some of this (information overload) on ourselves," Mann has said. "We'd rather die than be bored for a few minutes, so we just surround ourselves with distractions. We've got 20,000 digital photos instead of 10 we treasure. We have more TV shows TiVo'd than we'll ever see. ... Unless you're working in a Korean missile silo, you don't need to check e-mail every two minutes."

However, while technologies like ambient displays, social filters, and others will help us deal with massive amounts of information, and a regimen of life hacks might eek out a little more productivity or efficiency from our brains, you can't squeeze blood from a stone. The next step? Hack your brain.

Source: http://www.thegooddrugsguide.com

One target of new "smart" drugs is the CREB protein, a molecule that helps form long-term memories.



Source: http://en.wikipedia.org/wiki/CREB

BRAIN HACKS

Not surprisingly, we are already seeing the use of analeptic compounds—chemicals that stimulate the central nervous system emerge as a coping strategy for maintaining alertness in a rapidly accelerating world. In recent years, analeptic pharmaceuticals like methylphenidate (a.k.a. Ritalin, Concerta), dextroamphetamine-amphetamin (a.k.a. Adderall), and modafinil (a.k.a. Provigil) are increasingly used by college students and teens to gain an edge in highly competitive academic settings. In the last ten years, the number of Ritalin prescriptions in the United Kingdom increased ten-fold from 20,000 to over 250,000. The United States Drug Enforcement Agency claims that more high-school seniors abuse Ritalin than take it as a prescribed medication. In contrast to the use of psychedelics in the 1960s as a way to illuminate societies dulled by drab conformity, analeptics will likely be extensively abused by future generations to gain some clarity in a chaotic world awash in sensation. Modafinil was developed for the treatment of narcolepsy as a way to keep sufferers awake without the eventual crash of traditional amphetamines. According to the manufacturer Cephalon though, more than 90% of all prescriptions for it are for "off-label" uses. An even newer compound, called CX717, not only improves alertness but, according to a study at the University of Surrey "improved performance in healthy male subjects that became impaired during 27 hours without sleep."

Meanwhile, Helicon Therapeutics and other labs are developing compounds designed from the get-go to increase cognitive performance and memory. One target of these new "smart" drugs is the cAMP response element-binding (CREB) protein, a molecule that helps form long-term memories. Helicon's drug is based on research that co-founders Tim Tully, a professor at Cold Spring Harbor Laboratory, and Jerry Yin, now at the University of Wisconsin, conducted in 1995. By genetically modifying fruit flies to up the amount of CREB in their brains, the scientists produced insects with the equivalent of photographic memories. It took normal flies 10 "training sessions" to learn to avoid a chamber, identified by scent, where they had been lightly shocked. The genetically engineered flies remembered after just one session. "We've shown in animal models that Helicon's drug reduces the amount of practice needed to commit something to long-term memory," Tully says.

It'll be a decade or more before such treatments are available for healthy people, Tully says, because the potential dangers inherent in manipulating the brain go beyond traditional side effects. For example, "maybe you could fill the hard drive," Tully says, "and after a number of years not be able to put anything more in your brain."

In some ways though, the cognitive-enhancement drugs available to today's brain hackers, and even those still in the labs, are blunt weapons in the war against information overload. In the next two decades, the nascent scientific research field of augmented cognition (augcog) could deliver technologies that close the feedback loop through computers that autonomously measure a worker's psychological state and react accordingly. Panic setting in at work? An augcog display will help you focus on the most important tasks.

For example, the Defense Advanced Research Projects Agency (DARPA) is developing the CogPit, a context-aware airplane instrument panel that uses non-invasive brainwave monitoring to alter how much information is displayed on the screen at any moment, and other variables. As with many other information technologies, including the Internet, the military's augcog innovations will likely trickle into the private sector rather quickly.

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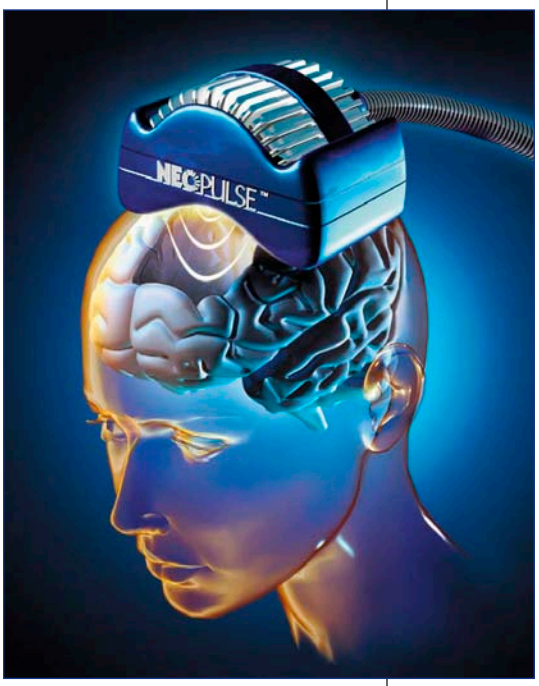
Source: http://www.delta3d.org/article.php?story=20051214154621138&topic=projects

According to Dylan Schmorrow, director of the DARPA AugCog program, the technology will "circumvent fundamental human limitations by engineering work environments that will make it easier for people to encode, store, and retrieve the information presented to them [and] develop interfaces that are context-sensitive by presenting material in relation to the context in which it is encountered. This will be accomplished by embedding information in distinctive, image-able, and multi-sensory contexts, so as to provide memory hooks that naturally engage the human mind."

DARPA has also sponsored the work of neuroscientist Mark George and colleagues at the Medical University of South Carolina who have designed a lightweight electromagnetic coil that could someday be mounted inside a pilot's helmet to clear the tired and sensory-overloaded aviator's head. This transcranial magnetic stimulation (TMS) machine delivers microsecond pulses of energy a few centimeters into its wearer's brain, inducing electrical activity in brain cells. Studies have shown that triggering a magnetic pulse right before a person has to hit a button in response to a sound can improve reaction times by 5–10%, "as if you've primed that part of the brain to act," George says.

When combined with functional magnetic resonance imaging (fMRI), which provides a 3D picture of the brain's activity, TMS can target a specific region of neurons. George's team has shown that a weekly rhythmic stimulation (called rTMS) of the prefrontal cortex, a part of the brain that appears abnormal in many depressed patients, can alleviate their symptoms. (A study is in progress that may lead to the approval of rTMS for depression.) TMS researchers also hope to develop techniques for penetrating the brain's core, which could lead to treatments for disorders like Parkinson's. George is even willing to entertain the possibility that such methods could someday stimulate the brain's pleasure centers.

TMS is a lightweight electromagnetic coil that could someday be mounted inside a pilot's helmet to clear the tired and sensory-overloaded aviator's head.



Source: http://www.musc.edu/fnrd/tmslinks.htm

From there, it's only a few inches through the skull to jack into the brain directly. Last year, scientists and doctors at Massachusetts General Hospital reported that they had implanted a young paralyzed man's brain with a tiny chip that enables him to control a robot arm with his mind. The neural implant, called a BrainGate, was invented Cyberkinetics Neurotechnology Systems, a private company commercializing sensors and stimulators for "novel communication interfaces" between the brain and computers. Meanwhile, biomedical engineer Theodore Berger at the University of Southern California in Los Angeles is developing an artificial hippocampus; a silicon substitute for the part of the brain that scientists believe encodes experiences as long-term memories. To do this, Berger built mathematical models of neuronal activity in a rat's hippocampus and then designed circuits that mimic those activities. The next step is to implant the devices in rats to see if they can process the electrical impulses associated with memory and then communicate them back to the brain for long-term storage. Joel Davis at the Office of Naval Research, a sponsor of Berger's work, said, "Using implantables to enhance competency is down the road. It's just a matter of time." Think of it as a hard-drive for your head, upgrading your brain to keep pace with the sensory explosion.

4 | IMPLICATIONS: FROM OVERLOADED TO TRANSFORMED

One reaction to cognitive overload is to develop new coping mechanisms, either through technological tools or psychological skills. But perhaps a better way to manage the information explosion is by understanding how it's transforming us. Only then can we take the action steps necessary to harness its power. To that end, here are some implications to consider when planning for the transformation coming over the next decade.

COMMUNICATIONS, DESIGN, AND MARKETING | Emphasize sensemaking

People with new information design and communications abilities that emphasize the interpretation and translation of raw data into "news you can use" will be increasingly important members of teams. These "sensory interpreters" must be fluent in a variety of modes for information interaction so they can select the right tool for the job, from an ambient display to a social filter an augcog system, to help users of the information make sense of it.

HUMAN RESOURCES | Develop a sensory quotient

A "sensory quotient" to help evaluate an individual's ability to deal with various levels and kinds of sensory input will become an important metric for human resources departments. Potential employees will be evaluated on their unique "sensory quotient" in the context of the kinds of information that they will be responsible for interacting with. An employee may be well-positioned, for instance, to extend her abilities using technology while another excels when limiting his data intake to focus on specific tasks. Still another may be a professional pattern seeker—a human filter that seeks out trends in sensory data and makes connections between disparate data points and sources. Of course, controversies may surround such measures of performance. What's the baseline, for example, when some employees choose to augment themselves?

EDUCATION AND TRAINING | Teach sensory literacy

To maximize the power of the tools of sensory transformation and help people cope with potential overload, there will be a need for new educational and training programs around sensory literacy to be developed—for all age groups. The skill set is more about *how to learn* than what to learn, involving trend spotting, pattern recognition, synthesis, filtering, media deconstruction, and, overall, how to identify and engage with sensory inputs that add value to your life. While software agents will certainly aid in these tasks, the most powerful information processor we have is still our own minds.

4 Implications: From Overloaded to Transformed

SOCIETY | Level the playing field

Along with today's rift between technology-haves and have-not, there is potential for a divide between the augumented and unaugmented. Society has the opportunity now to pre-emptively deal with the reality that some individuals will be augmented to engage more actively and successfully in the information explosion, while others may not have the means or desire for augmentation and, as a result, fall behind. Businesses can help bridge the gap by supporting educational programs that provide new skills, and through training and providing appropriate tools to individual workers.

NEW SKILLS | Recognize overload

We must beware that sometimes solutions lead us right back to the problem again in a vicious circle. Information, no matter how well its filtered, displayed, aggregated, and synthesized, when combined can easily become just too much of a good thing. We need to beware of "solutions" designed to reduce cognitive overload but that actually aggrevate it. Keeping a keen eye open for potential overload will be yet another new skill required in the next decade and beyond.

WORK STYLES AND ENVIRONMENTS | Watch for backlash

Recently, a Chicago hotel offered an intervention program for vacationing travelers addicted to their devices. The hotel manager promises to lock your Blackberry or mobile phone in the hotel safe and not hand it back until check-out time. While this is clearly a tongue-in-cheek gimmick, it does point toward the larger trend of knowledge workers taking vacations that are "off the grid," forcing total disconnection from e-mail, the Web, and their mobile phones. In that same realm is the "Slow Movement," based on the Carl Honoré's book *In Praise of Slow*, that discourages

us from "hurrying for the sake of it" and instead to do everything "at the right speed." The SLO-GO artifact from the future included in the Technology Horizons report *The New Spatial Landscape* (SR-834) embodies this cultural backlash against always-connected, fast-paced environments and experiences. Employers will likely be seen as the key source of pain associated with this environment and should begin to prepare now. Dealing with such a backlash will require a rethinking of expectations on employee availability, how teams work (especially globally), and metrics for success.

The SLO-GO artifact from the future embodies the cultural backlash against always-connected, fast-paced environments and experiences.

MANAGEMENT | Enable a variety of sweetspots

In between "always connected" and "offline" lies a middle ground that differs for each of us. We must learn where that sweetspot is and how to alter it in real time without suffering undue anxiety or guilt. As employers, companies need to recognize that each employee has a different sweetspot when it comes to being connected. Take Dan Russell, a senior manager at IBM's Almaden Research Center, who ends every e-mail message he sends with this missive: "Join the slow e-mail movement! Read your mail just twice each day. Recapture your life's time and relearn to dream." On a personal level, we may well need to learn to be comfortable with less information, or at least know when to turn the firehose down to a trickle.

Source: Institute for the Future

ABOUT THE ...

Technology Horizons Program

The Technology Horizons Program combines a deep understanding of technology and societal forces to identify and evaluate discontinuities and innovations in the next three to ten years. We help organizations develop insights and strategic tools to better position themselves for the future. Our approach to technology forecasting is unique—we put humans in the middle of our forecasts. Understanding humans as consumers, workers, householders, and community members allows IFTF to help companies look beyond technical feasibility to identify the value in new technologies, forecast adoption and diffusion patterns, and discover new market opportunities and threats.

The Institute for the Future

The Institute for the Future is an independent, nonprofit strategic research group with nearly 40 years of forecasting experience. The core of our work is identifying emerging trends and discontinuities that will transform global society and the global marketplace. We provide our members with insights into business strategy, design process, innovation, and social dilemmas. Our research generates the foresight needed to create insights that lead to action. Our research spans a broad territory of deeply transformative trends, from health and health care to technology, the workplace, and human identity. The Institute for the Future is located in Palo Alto, California.

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