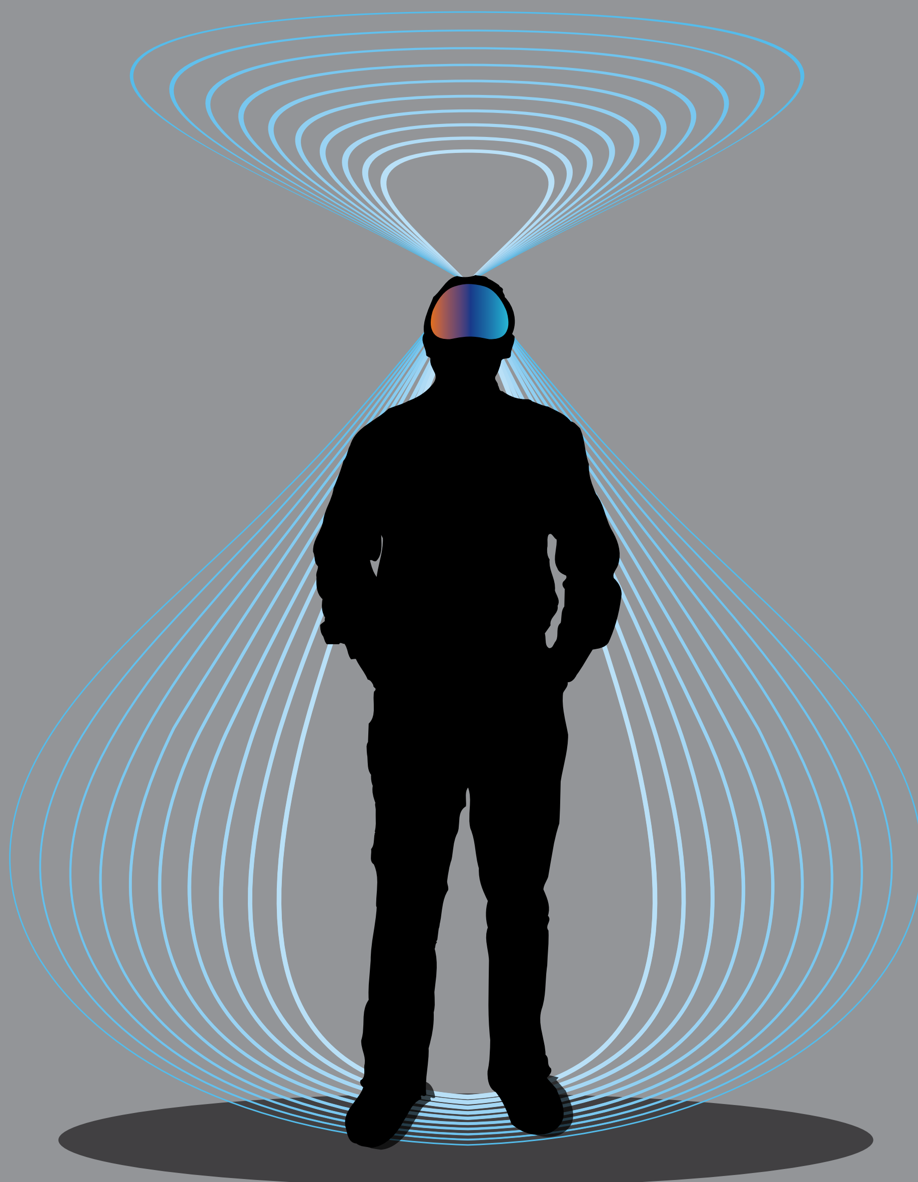
mind in a designed world:

TOWARD THE INFINITE CORTEX



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about the ...

Technology Horizons Program

The Technology Horizons Program starts from a deep understanding of technology and societal forces and evaluates discontinuities and innovations in the next three to ten years. Our approach to technology forecasting is unique—we put people at the center of our forecasts. Understanding humans as consumers, workers, householders, and community members allows us 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 more than 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 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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introduction

MIND IN A DESIGNED WORLD

We are expanding our understanding of the mind, and this new understanding will lead us to redesign the world.

How we think about thinking is changing. Mental processes, once thought to be contained in the head are now seen spilling out into the world. These changes will profoundly affect how we design our institutions, organizations, and communications. In the next decade, we will offload more and more of our cognitive processes to our devices, our networks, and our built environments. Those who take advantage of insights emerging at the intersections of cognitive sciences, behavioral sciences, and human-computer interaction will be able to harness and direct the outcomes of human thought with greater precision and power.[1]

Human history has been defined by our eagerness to merge with our tools, actively seeking out ways to extend the mind. We created writing to make our thoughts concrete and portable. Assistive technologies from glasses to hearing aids have extended our vision, hearing, and all our senses, augmenting our perception of the world. Our machines crunch numbers at rates much faster than we can. We have evolved to coevolve with our technologies: we are "natural born cyborgs."[2]

Most of us intuitively still see our brains and the things in the outside world as independent components that may work in concert, but not as a functional unit. However, the increasing integration of our minds with machines and the blending of our online and offline reality is giving many of us the everyday experience of a kind of cognitive comingling with our technologies.

Today, we stand at the cusp of a new understanding of the relationship between our human identity and the tools and technologies in our environments. Insights from across wide-ranging disciplines—cognitive science, neuroscience, cognitive anthropology, psychology, behavioral economics, and more—are showing just how interwoven our minds actually are with the world around us. They are showing how subtle (and not so subtle) changes can alter our experience of the world, even at a subconscious level. Fred Gage, a neurobiologist who studies and designs environments for neurogenesis (the creation of new neurons), says, "change the environment, change the brain, change the behavior."[3] Over the next decade we will have the opportunity and the means to expand this well beyond the lab, out into our schools, our workplaces, our public spaces, and our homes. We will be able to take more responsibility for designing our technologies and everyday activities; we will come to see our world as a series of extended and distributed cognitive systems.

Our increased awareness of how interfaces and physical experiences shape cognition, as design blends aesthetics and functionality, will enable a critical mode of thinking about how we order the things in our lives, how we engineer relationships and encounters, and how we address problems in our society. Design thinking will move from the domain of office chairs and websites to become an overarching approach to the grand challenges of our civilization, from our basic energy needs to international geopolitics—to the domain of thinking itself.

By engaging in systematic thinking about the mind in a designed world, we will help shape a new approach to brain, mind, and environment that we call a "global cognitive ecology," which will be smarter than any of us, and which will help us meet the challenges of the 21st century.

This report will outline a series of research findings, key insights, and applications that lead us to call for a "comprehensive cognitive design strategy."[4] We begin with an overview of the emerging view of the brain as one node in a larger "cognitive ecology"—a system of brain, body, and world that makes thinking possible. We then look closely at the mind as it is embodied biologically, embedded in the environment, and extended by technological augmentations. We explore the broad implications for society, organizations, and individuals, and offer six core design strategies for creating the environments that are most suited to preferred cognitive outcomes. And finally, we offer a vision of an Infinite Cortex: a seamless integration of mind and world to extend individual capacities and make us a smarter species.

making the mind

THE COGNITIVE ECOLOGY

COGNITIVE ECOLOGY
a system that emerges from the interactions of the brain, our biological body, our culture and life experiences, our technologies and devices, and the natural and built environments

Where do you think best? If you're like most people, you might say "in front of your computer," or "in conversation with smart people," or maybe even "alone in the shower." Now, what if instead the question was: Where does thinking happen? In this case you would be more likely to say "in my head" or "in my brain." But it might be more accurate to answer the second question like the first—to think about thinking not solely as a product of our gray matter, but as a process that includes our brains, our bodies, and the people and things around us.

At its most basic, a *mind* is what we have traditionally called the entity that can think consciously, has free will, and can form a relatively consistent identity. Theories of mind abound, from theological notions of a spirit that inhabits a body to the idea that a mind is the emergent property of biological computation. But a significant new way of seeing the mind is emerging from advances in neuroscience, one that is driving a reevaluation of how we understand ourselves and how we should design our world. Scientists and philosophers are beginning to talk about the mind in terms of a cognitive ecology—a system that emerges from the interactions of the brain, our biological body, our culture and life experiences, our technologies and devices, and the natural and built environments.

This new way of *thinking about how we think* begins with an unconventional definition of the brain. One version of this definition is provided by Lambros Malafouris, an Oxford cognitive archaeologist:

> the human brain ... is an extremely plastic, profoundly embodied, materially engaged and culturally situated bio-psycho-social artefact.[5]

While succinct, this definition contains several radically reorienting (or disorienting) notions about the brain, and how the brain makes the mind. So, let's unpack it.

The brain is "plastic." It is always being shaped by the perceptions and inputs that go into it. It is always learning, making new neuronal connections.

It is "profoundly embodied." The brain exists as a living biological organ, and within a human body. It is not merely embodied within this biological system, but intimately connected with and influenced by metabolic, hormonal, sensory, and other processes.

It is “materially engaged.” The brain uses the physical elements around it to reinforce and extend itself, offloading labor,. The brain is opportunistic, using what’s “at hand.” And it is active, changing the world around it to intentionally augment function.

Finally, it is a “culturally situated bio-psycho-social artefact.” There are biological limitations and affordances to the brain, but these are only part of the story. The brain must be seen as a collaborative creation of experience, culture, biology, psychology, and social context. And it is constantly changing, based on circumstances and context.

Understanding of the cognitive ecology is built, first and foremost, on our better understanding of the brain, that is, the happenings inside our biological gray matter. The brain sciences have exploded in recent years, moving from a marginal scientific endeavor, into “a mature and stand-alone discipline, comparable to physics or chemistry, economics or law, molecular biology or medicine.”[6]

Neural imaging technologies have been instrumental in this advance. EEGs, CAT scans, PET scans, and especially functional magnetic imaging (fMRI) have allowed us to peer inside a working brain with ever-greater precision. We are seeing just how the brain works when it is thinking, feeling, and interacting with the world. It is this ability to understand the brain that is showing us just how essential our bodies and technologies are to how we think.

For example, we are seeing how we represent the behavior of other people at a neurological level. This high-resolution view is in some ways different from our commonsense beliefs. We like to think we judge people based on their actions, but studies have shown that we often make judgments not based on actions, but on the perceived intentions of those actions. As Brian Knutson, one of the co-designers of an experiment to test this phenomenon states, “What we think others are intending is what really matters,” and this view of intentionality changes our actual neural responses to a situation.[7]

We are also beginning to understand, from a neurological point of view, the previously unseen impact of our environment on the kinds of thoughts that are possible and the kind of thinking that is encouraged by our surroundings: how living in a city, taking a hike in the wilderness, or even the height of ceilings can significantly change thought. Many so-called “anchoring effects,” or perceptions that linger and influence our thinking well beyond their context or rationality, permeate our environment as well.[8] For example, negotiators use an anchoring effect when they make an opening bid that is way beyond a “fair” price, as all following bids look more reasonable in comparison.

The cognitive ecology is a way of looking at how a mind is shaped by the things around it, and the totality of the thinking system that includes brain, body, artifacts, and world. We’ve called this a new and alternative view, and for most neuroscientists it is. It is an approach that breaks from the “independent, isolationist” view that the brain makes the mind, and that while the mind uses the world, it is functionally independent from that world.

It is important for neuroscientists and philosophers to understand the cognitive ecology approach, and how it might inform their work, but it is also important to understand at a wider level, at the level of companies, institutions, and the individual. Organizations will need to understand how to design workplaces and processes for greater productivity, creativity, and long-term mental health. Institutions, from schools to prisons, can utilize cognitive design principles to improve the quality of their services for everyone in their system. Individuals can find and employ "mind hacks" to reprogram their bodies, tools, and spaces as cognitive aids to fit their personal needs.

Research from fields across the brain sciences is leading us to view *the mind* as a phenomenon of how *the brain* is **embodied**, **embedded**, and **extended**. The brain is embodied in our biological flesh, it is embedded in the built and natural environment, and it is extended through networked media and communications tools. The following sections will show how these three articulations of the brain come together to create the mind that inhabits the global cognitive ecology we experience today; the design of this ecology will shape the minds that are to come in the future.

MAKING THE MIND: THE EMBODIED BRAIN

We already know that things like stress, exercise, and even posture influence thought. Now, many more aspects of the brain-body connection are being understood, and this connection is stronger and more significant than was previously realized. Our bodies are brain vehicles, and our minds would not go far without them.

The brain is embodied in its biological substrate—our bodies—and this embodiment is essential to how we think. Thought, it now appears, emerges from the relationship between the electrochemistry of the brain and biochemistry of the body. Since the brain is situated in the body, the mind that emerges from the brain-body is highly influenced by the way the body feels and moves in space (proprioception), the kinds of foods and chemicals we ingest or don't ingest, the amount and quality of sleep we get, our comportment, and many other biological factors that shape our emotive and cognitive productions.

New neuroscience and recent psychological findings suggest how the brain-body connection shapes cognition, physical practices, sensory perception, and technologies in ways we are just beginning to understand.

Embodied Cognition

One wouldn't think that the body plays much of a role when we are reading or doing math problems. Those are behaviors we consider purely cognitive. But research is showing that the body plays a significant role in our abstract thinking, in the way we process language, and even in how we do basic computation.

Finding: **SMILE!**

Research from the Laboratory of Embodied Cognition at Arizona State University (ASU) has demonstrated the effects of physical states on the speed and relative capacity for understanding language.[9] The central claim is this: "language about emotions is grounded in emotional states of the body, and simulating those states is a prerequisite for full understanding of the language."[10] In other words, how we feel can unconsciously, but directly, impact how we understand and interpret the emotional content of what we consume.

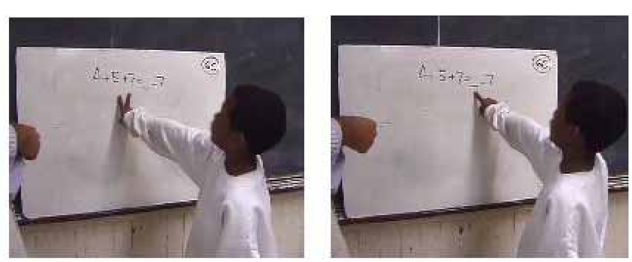
A fascinating study from the ASU lab demonstrated the role of smiling on the ability to understand positive emotions. It tested and initially confirmed the theory that "if we are reading about pleasant events, we should be faster to understand those sentences if we are in a happy state than if we are in an unhappy state." Subjects who were smiling were more readily able to understand sentences that reflect happy or pleasant events. Drawing the conclusions of the study out, we can imagine a series of physical techniques or devices that help us get in the right emotional "frame of mind" to fully understand a piece of content. An email might come with instructions to make certain facial expressions before reading, for example.

Finding: **GESTURES FOR LEARNING**

Gesturing is not just a neutral by-product of active talking; it also plays a role in lightening a person's cognitive load—the amount of actual "work" required by our conscious minds. Gestures can even aid in learning. Dr. Susan Goldin-Meadow has shown that students who are taught to make a "V" shape with their fingers could do mathematical grouping problems more efficiently than those who were taught using no accompanying gestures. Goldin-Meadow found that "students who repeated the correct gesture during the lesson solved more problems correctly than students who repeated the partially correct gesture, who, in turn, solved more problems correctly than students who repeated only the words."[11] It is theorized that the V gesture represents another form of grouping, helping the brain offload the thought, "these numbers belong together," and saving cognitive resources for actual computation. In many jobs these days, synthesizing data and making connections between disparate concepts or facts is essential. A formalized set of gestural techniques might aid that process.

Students practice gestures for learning.

CORRECT GESTURE



PARTIALLY CORRECT GESTURE

Source: http://www.sciencedaily.com/releases/2009/02/090224133204.htm

Embodied Practices

The previous findings show that cognition is linked to bodily actions. There are many traditional physical-control techniques, such as yoga or meditation, that humans have practiced systematically to improve our brain functions. Advances in neuroscience are showing how these techniques can be a useful source for intentional brain-body design in a wide variety of settings.

Finding: **MEDITATION**

Our minds are adjusting to a world of unbundled attention and multiple media streams, and we are devising tools to help us cope. University of California, Davis psychologists have studied how an ancient technology, meditation, can have many positive mental effects, including improved perceptual abilities and sustained attention.[12] Meditation is a way of quieting the body, and thus quieting the mind. Some schools are beginning to integrate meditative practices into their curriculum, and these have been shown to increase well-being in adolescents.[13] Why not make it available at the workplace?

Source: http://www.sciencedaily.com/releases/2010/07/100714121737.htm

Finding: **FASTING FOR BRAIN HEALTH**

A protein called SIRT1 has been shown in animal studies to be associated with improved learning, memory, alertness, and activity levels. The production of SIRT1 can be increased through behavioral practices such as calorie restriction and fasting. Lowered weight and increased activity are known to be good for brain health; and now there might be a demonstration of even more benefit from a carefully designed brain diet.[14] Neurocompetitive advantage in schools and workplaces may not come only from pharmaceutical enhancement, but also from regular fasting and calorie restriction.

« **Meditation has been associated with many cognitive and brain health benefits.**

Embodied Perception

Our physical sense of the world and the boundaries of the body are highly contingent and can be surprisingly easily re-mapped. The "phantom limb" phenomena, the simulation of out-of-body experiences, and the ready incorporation of prosthetics show that our minds are in constant feedback between body and brain. Disturbances, intentional or not, to this feedback loop can lead to fascinating results, including the ability to see with sound, or to map new hybrid senses onto our standard repertoire.

Prototype: **USING SOUND TO SEE**

There are numerous examples of senses being rerouted through atypical inputs, such as seeing with touch, or by using the tongue. A new "sensory substitution" technology, called vOICe, is allowing the blind to see by sound. A camera scans the environment and translates the images into distinct sounds. Eventually, "by discovering how the soundscape of an object varies as the user moves, the experience becomes particularly vision-like."[15] These technologies are being designed for those with disabilities, but are also being developed for military use, for instance advanced "night vision," and could be used in sensorily constrained environments such as underground coal mines.

Source: http://www.seeingwithsound.com/training.htm

« vOICe sensory technology.

Idea: **"SMART PAIN"**

Cognitive scientist Mark Changizi recently raised a thought-provoking question: What if we could design devices to inflict pain as a way to augment our natural sense of environmental risk? His argument is this: pain is the body's way of keeping us from doing things that would otherwise cause more serious injury. What if we could create tools that could "harness" this evolutionary mechanism for the risky parts of our lives where there aren't any natural pain responses? As Changizi notes, "we no longer live in the nature that shaped our bodies and brains, and the dangerous scenarios we now face aren't the same as those our ancestors faced." So, what are his suggestions? How about a suit that gives you a jolt when you get too close to another car while driving? Or a computer screen that shines painfully bright when you are about to download a virus? Or, what about "a wearable device with a video sensor that detects the likelihood that the person you're picking up at a bar has an STD, and then causes severe itching until you flee the bar."[16]

Embodied Technologies

A new generation of technologies, including pharmaceuticals, are being used to treat neurological disorders and enhance cognitive function. These follow our long tradition of introducing "outside" interventions such as caffeine into our bodies to improve mental function. Drugs, from memory-dampening to attention-increasing, are already being used widely. Neurostimulation tools, including the use of magnetic pulses and direct current, are showing significant results in improving cognition as well.

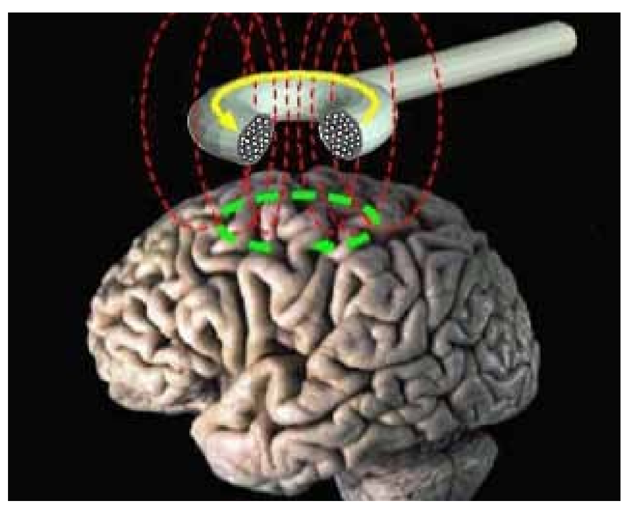
Finding: **MIND-SHRINKING ACID**

High levels of kynurenic acid have been linked to neurological disorders such as schizophrenia, Alzheimer's, and Huntington's disease, and the acid increases in our brain as we age are possibly related to the cognitive decline associated with aging. Researchers at the University of Maryland are experimenting with drugs that block or reduce the production of kynurenic acid as a potential treatment for associated neurological disorders. It might also lead to a pill that acts on the acid for improved cognition in otherwise normal people. "Workers might want to take a pill so they can work harder, and college students would be interested because they already are taking amphetamine-type pills so they will be sharper," said Robert Schwarcz, a lead researcher on the project.[17]

Finding: **TRANSCRANIAL MAGNETIC STIMULATION AND DIRECT CURRENT STIMULATION**

Repetitive transcranial magnetic stimulation (rTMS), the application of strong magnets to the skull to help guide oxygen-rich blood to certain parts of the brain, has already been approved by the FDA as a clinical treatment for depression. rTMS has also been shown to increase the speed of acquisition of motor skills.[18] Now, the use of repetitive direct current stimulation (rDCS), which can disrupt and modulate neuronal signaling through the use of direct electrical current, has also been shown to improve verbal and motor skill learning. These tools may come to augment our traditional learning practices in schools and the workplace.

rTMS may be a cognitive enhancer. »



Source: http://intra.ninds.nih.gov/Research.asp?People_ID=196

MAKING THE MIND: THE EMBEDDED BRAIN

While our bodies are the vehicles for our brains, the brain and body are embedded in the built and natural environment that surrounds us. The brain uses what the developmental psychologist Lev Vygotsky calls “material carriers”—the cognitive furniture (language, media, technologies, spaces, etc.) that we use to help us think. Language is our first and most fundamental mental technology, greatly extending the reach and power of the user. Vygotsky observed how children, when they acquire language, can then direct other people to do things—for example, hand them a toy on a tall shelf—that would be otherwise be beyond their reach. Before language, our desires are difficult to read and respond to, often mere noise in the room.

Throughout our lives, we use our spaces and technologies in a similar way to language—to extend and amplify the reach of our minds and the power of our desires. We also use spaces as facilitators, opening up a room to encourage interaction. Our built environment—from the color of walls to the layout of cities—conditions thought. We’ve known that the environment has a psychological effect on us, but now we are understanding with much higher resolution what those effects look like neurologically. And, over the coming decade and beyond, we will be finding ways to design for optimal neurological effects, in essence programming our minds from the outside in. The “code” of this programming will be written into the framing metaphors of what we touch, into the walls that surround us, and into the institutional mechanisms that shape how we learn.

Our built environment—from the color of walls to the layout of cities—conditions thought.

Embedded Metaphors

Where the body meets the world, we can design interfaces that influence judgment and behavior. These influences have a very literal effect—what is a physical or visual metaphor becomes cognitive reality. Along with linguistic frames, physical artifacts and built environments implicitly "prime" our minds to respond in predictably patterned ways.

Finding: "TACTILE TACTICS"

The metaphorical value of the things we touch is literally translated into frames of thought. Joshua Ackerman, an MIT professor who has been studying the unconsciously perceived effects of our physical environment and artifacts, calls the use of texture, color, weight, and other physical qualities to influence thinking, "tactile tactics."[19] Touch creates a link between symbolic metaphor and concrete thought. According to a recent report, "heavy objects made job candidates appear more important, rough objects made social interactions appear more difficult, and hard objects increased rigidity in negotiations."[20] Incorporating tactile tactics into everyday interactions will radically reshape office design, retail environments, home interiors, schools, and hospitals. What if prison walls were soft?

Finding: A COGNITIVE CEILING

Does the height of a ceiling influence how we think? According to recent research, ceiling height showed a series of strange, but consistent, effects on a group of research participants.[21] In the study, people were asked to rate their current body state or feeling. Those who were in a room with the higher ceilings responded more favorably to words that are associated with the concept of freedom: for example, "being free," "unrestricted," and "open." Those in the lower-ceiling room tended to describe themselves with words associated with confinement. And this effect on mood or feeling was directly transferred to mental processes: the high-ceiling group was more effective at relational thinking, connections, and free recall of facts, while the low-ceiling group was better at item-specific tasks and recall of facts using cues.[22] Office spaces and settings will be examined for their impact on thinking, and designed to influence cognitive outcomes.

Ceiling height affects how we think. »

Source: http://scienceblogs.com/mixingmemory/2007/05/does_ceiling_height_affect_the.php

Embedded Scaffolding

Over the course of our lives, neurons are pruned and tuned by experience. People who work and live in stimulating cognitive environments show much greater cognitive function and resilience to degenerative conditions from disease or aging. How can the design of spaces play a role in creating a scaffold or support system for building and maintaining brain health?

Organization: **ACADEMY OF NEUROSCIENCE FOR ARCHITECTURE**

The Academy of Neuroscience for Architecture is a new organization of architects, neuroscientists, medical researchers, psychologists, and others who are exploring ways to improve architecture based on insights from neuroscience, and how to improve brain function through the use of architectural design.[23] Members of the Academy have been involved in using insights from neuroscience to redesign correctional facilities, hospitals, nursing homes, and work spaces. The growing attention to the connections between space and the mind will be a fruitful area of research and innovation, changing the very infrastructures in which we work, learn, and play.

Source: http://www.anfarch.org/

Finding: **BRAIN IN A CAGE**

Millions of mice are used in scientific experiments, and they are carefully bred and designed to reduce their variability to only the factors that are under study: to look at the impact of one altered gene, for example, or one new environmental factor. Researchers from the University of Colorado have shown just how important differences in the kinds of cages mice are kept in are to their neurological structure. Differences in airflow, light, size, and other factors change the functioning of mice brains, and may impact the conclusions and reproducibility of scientific results.[24] Controlling for variables that affect brain development will lead to more fine-grained understanding of the complex ways our environment influences our minds.

« **Architects and neuroscientists are learning how to design spaces for brain health and benefits.**

Embedded Education

It seems sometimes as if our educational environments, by and large, were designed to thwart learning instead of encouraging it. Industrial logic in an educational setting *might* have worked for an industrial age. In a machine age, we could get away with treating brains like machines, but no longer. Knowledge work, where improvisation, creativity, and synthesis are key skills, needs an educational system attuned to how the mind functions, and how the design of spaces catalyzes learning.

Finding: **NEUROEDUCATION**

Brain-based education incorporates insights from neuroscience into the design of the learning environment and the pedagogical process. Examples include moving school exercise to the morning instead of the afternoon,[25] the creation of a "positive emotional climate," and introducing classical music and the scent of peppermint into the classroom.[26] Recognizing the need for neuroeducation, neuroscientist Ken Kosik of University of California, Santa Barbara, says, "we need neuroscientists in schools. Just like we have teaching hospitals, we need teaching schools."[27]

Finding: **CREATIVE DISSENT**

Folding some surprise into our highly-curated lives is good for sparking new thoughts and making new connections. Science writer Jonah Lehrer laments the "banal predictability of the human imagination," noting that "in study after study, when people free-associate, they turn out to not be very free. For instance, if I ask you to free-associate on the word 'blue,' chances are your first answer will be 'sky'."[28] How to design around this tendency? Lehrer turns to the work of Charlan Nemeth, a psychologist at University of California, Berkeley. Nemath's work reveals the power of "dissent" and even misinformation to improve the capacity for creativity. In an experiment in which participants were shown color slides, a planted lab assistant would shout out the wrong color. When members of the group were then asked to do a free association exercise, their answers were much more creative, or at least more unusual, than those who did not have the wrong color shouted out. As Lehrer notes, "our imagination has been stretched by an encounter that we didn't expect." We will begin to design these encounters more readily and mindfully.

MAKING THE MIND: THE EXTENDED BRAIN

Within our bodies and environment, the brain is extended through our electronic and computational devices. Right now, this is the area that gets most attention in the growing discourse about cognitive extension. Debates rage on whether Google is making us smarter, dumber, less resilient, or more resilient. But as IFTF's recent report on *Blended Reality* indicates, we are becoming more accustomed to sharing our cognitive and emotional loads with people throughout our ambient and ubiquitous networked machines.[29]

And our machines are learning about us as well. Predictive coding, inference engines, and other data-mining technologies are demonstrating a profound understanding of how we think, what motivates us, and how we can be nudged or persuaded to act.[30] Real-time design and communication tools are also allowing us to "think together" with peers all over the world. Most knowledge work now is a process of profoundly distributed cognition, where pieces of a problem are solved in disparate places and synthesized over and above the capacities of any single person.

Extended social cognition is a way to link our minds with others, and to use other people or agents as augmentations for our capacities to understand. Extended behavioral coaching is allowing us to design extra support in our decision-making process through technological assistance.

Most knowledge work now is a process of profoundly distributed cognition ...

Extended Social Cognition

Humans have never been more closely linked to as many people than they are now. Yet, as McLuhan observed, technologies always carry their reversal. As we have become more closely linked through digital networks, many think we are losing some of the interpersonal "mind reading" techniques we've evolved. Now, we are in the process of re-inventing ways to create emotional and intellectual connections to each other through our electronic networks.

Finding: **NETWORK CONTAGIONS**

Other human beings are probably our most basic cognitive augmentations, yet understanding of group cognitive processes is still nascent.[31] There are strange forces moving through our social networks that we are just beginning to observe and measure. Being connected to other people, even people you may have never met, has a demonstrable influence on our behavior, our moods, and our decision making. This effect has been studied by Nicolas Christakis and James Fowler, who have used longitudinal data from a heart study going back over 50 years to show how influential our social networks are on our health. They have linked addiction, happiness—even voting patterns—to the effects of friends-of-friends. And we are just at the tip of the iceberg. Social networking platforms are providing an unprecedented wealth of data for those seeking out the impact of our social connections on individual lives.

Idea: **TELEMPATHY**

Michael Chorost, author of a forthcoming book about the emerging global mind, presented a provocative proposal at a recent IFTF conference. He suggested that as new neuromodulation technologies, such as optogenetics, become available, we may be able to directly link our minds through implanted technologies.[32] By opening a direct communication channel between brains, he suggested that we would be able to experience the "feeling" of another person. The experience of one person would be reproduced on the linked partner or partners, creating what he calls "telempathy." Extended levels of intimacy and understanding with other people will be facilitated by these technological augmentations, not to mention new levels of transparency and loss of privacy.

Michael Chorost suggests we might be able to "feel" someone else's emotions. »

Source: http://www.towerofpower.com.au/dirty-tricks-of-psychology-for-mind-reading-and-the-roots-of-empathy

Extended Behavioral Coaching

Pop-up meeting reminders and digital nudges are the modern versions of the string we tied around our finger to help us remember. New technologies are allowing us to track our experiences, to create "digital mirrors," to help us improve performance and make better decisions.

Prototype: THE RATIONALIZER

We are all subject to bouts of irrationality and poor decision-making. For those in certain jobs, such as financial trade, poor-decision making could create cascades of financial ruin. As a thought-provoking prototype, the Philips Corporation has invented The Rationalizer—a networked device that can read the levels of stress and emotional arousal of users. The level of arousal is then displayed in a bowl-shaped light-emitting device. As emotional arousal increases, the light shines brighter, giving users an ambient read on their capacity to make calculating decisions. It is a form of "emotional mirror" as the makers call it, and a proxy way to measure impulse control, giving us a useful mechanism of control over our behaviors.

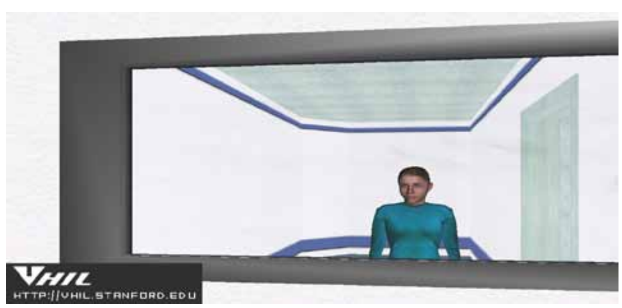
The Rationalizer allows a user to receive feedback on emotional and cognitive condition.

Source: http://www.design.philips.com/about/design/designnews/press-releases/rationalizer.page

Finding: THE PROTEUS EFFECT

At Stanford University's Virtual Human Interaction Lab, researchers are using virtual avatars to help people reduce the effects of traumatic events, and to make healthier decisions about eating and exercise. Avatars are a very effective way for our minds to imagine alternative self-representations. Studies have shown that we have a remarkable ability to radically remap our own identity onto avatars, even to the point of identifying with different genders, races, or various body-types.[33] These avatars will be our virtual "coaches," helping to extend our abilities to make good choices, and "scaring us straight" to avoid the cumulative effects of bad decisions. chnological augmentations, not to mention new levels of transparency and loss of privacy.

Humans have been shown to identify closely with their avatars, creating an extended or alternative self.



Source: http://vhil.stanford.edu/projects/images/proteus.jpg

Extended Union

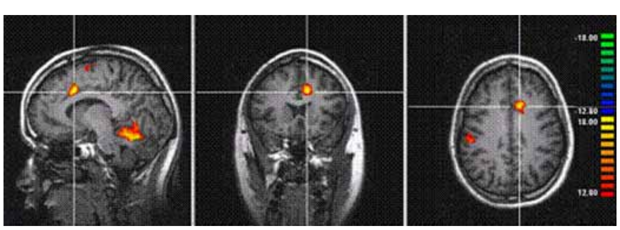
Brain and machine are connecting in unprecedented ways. Neurofeedback and brain-computer interfaces are becoming more sophisticated and being applied in many clinical and non-clinical settings. Neurofeedback places a new "lever" on the functioning of our own minds, giving us the chance for greater modulation of those functions. And, our machines are beginning to learn with us, not only understanding the signals coming from our brains and bodies, but adjusting themselves and changing their outputs to meet our needs.

Finding: **THE BRAIN IS ITS OWN BEST MEDICINE**

Researchers at the Stanford Systems Neuroscience and Pain Lab have been able to reduce patients' subjective experience of pain using neurofeedback imaging and training. Patients in the study were able to reduce their pain rating on a standardized rating scale by an average of 64%. As the researchers conclude, "using real time fMRI, people can learn to strengthen the function of a specific region of the brain and, through that change, the regions associated with the perception of pain. It is similar to exercising muscles, but, in this case, the 'muscle' is an area in the brain."[34] Neurofeedback technologies will be a very appealing treatment option to avoid many of the negative side-effects of drugs or invasive procedures by extending our capacity to "see" our brains in action and self-modulate accordingly.

Prototype: **AUGMENTED COGNITION**

Making a bad decision could be financially calamitous for stock brokers, but could be a matter of life and death for those working in law enforcement or in the military. Dylan Schmorrow and others at the Office of Naval Research have been developing a battery of experimental technologies called Augmented Cognition.[35] These use a brain-computer interface to measure cognitive load, attention capacity, and emotional arousal. Then this data is used to prioritize and curate the information directed at the user, reducing the flow and complexity content when a user's brain is too overwhelmed or overly-taxed to multitask effectively, or safely. These assistive technologies will extend our abilities to control our cognitive environment. They will be coveted not only in high-stakes jobs, but in the increasingly common circumstances of cognitive overload in our work and home lives.



Source: http://snapl.stanford.edu/research/rtfmri.html

« Seeing the effects of pain on the brain helps patients better control it.

forecast

THE MANY MINDS OF THE FUTURE

The mind is getting bigger and bigger, and smaller and smaller, faster and faster. [36]

As we move to more tightly integrate our cognitive and emotional functioning with our bodies, networks, and world, we push our minds further out and expand what is humanly possible to think and do. At the same time, this expansion leaves much of what we once thought as purely the domain of the brain, indeed what we have sometimes used to define our humanity, some place other than inside us. What is left of the human mind when everything we thought of as the human mind is delegated elsewhere? How many layers can we offload and still remain human?

This is the paradoxical push that leaves us both awed and uneasy. But another way of looking at it, one that we have been offering in this report, is that the human mind has always been looking outward, seeking to upgrade its functioning by using what's already available or inventing what isn't. There is no point arguing about what's inside or outside, or what *should be* inside or outside, but rather we should concentrate on inventing and improving brain-body-world interfaces and design.

Recognizing this essentially human capacity, and developing a more intentional intimacy with our biological, cultural, and technological tools, is a scientifically robust shift that points us toward innovation and evolution that could profoundly alter the way we've been conducting the business of civilization. With the following forecasts, we summarize the new qualities of the "mind of the future."

The Filtered Mind

The way we have augmented our natural tendency to filter perceptions and information is leading to two simultaneous, but diverging trends. On the one hand, we have unprecedented access to information from around the world. We are privy to perspectives, opinion, and news from almost anywhere and in real time. Our global perception and empathic capacities are expanding from this information "feed."

Yet, our filters can also cast shadows over our minds. In some ways, we are moving from confirmation bias to confirmation blindness. Confirmation bias refers to the tendency for people to believe arguments, give weight to information, and make conclusions about the world that reinforce, or confirm, their previously held beliefs. As we integrate new informational filters through our computers, networks, and through new technologies such as augmented reality, we may be able to both willfully and/or inadvertently blind ourselves to alternative belief systems and facts that contradict our beliefs. This confirmation feedback loop could shrink our horizons, and lessen our recognition of and tolerance for difference.

The Integrated Mind

Since at least Descartes, the western world has thought of the mind as something housed in the brain, but existing over and above our biological being. This dualist approach sees the self as fundamentally separate from not only the world, but from our bodies as well. The prevailing scientific paradigm of recent times, however, is that while our minds emerge from our brains in a manner that is still largely unknown, our mind is not independent of our brain. We've also discovered just how important our bodies and emotions are to how we think. And even beyond that, more and more research is suggesting that thinking is a process that integrates a mind with everything available around it, from language to other people to high technologies. We will begin to more consciously organize ourselves around the porousness, not the containment, of our minds.

The Promiscuous Mind

Our minds are not only more porous, they are, as Andy Clark describes it, promiscuous. This adjective resonates with many of our experiences of thinking today. There are few times in our lives these days when we aren't either already linked to or reaching out for some technical or media interface. We want inputs and we want thinking partners, lots of them. We want to engage with other people, we want to read, watch video, and surround ourselves with computational and communications technologies, not only because we are social beings, but because thinking itself is in many ways shared, social, and systemic. We need our brains to think, but we want other people and things to think *with*.

The Plastic Mind

"Young brains are malleable, old brains are rigid." This is been the prevailing assumption for some time in our society. All of our educational resources are focused on influencing and training minds at a young age. While this is a smart strategy, recent neuroscience is showing just how capable adult brains are at rewiring. While brains do naturally lose some capacities as they age,[37] cognitive fitness tools and neurofeedback training are helping people keep their brains in better "shape," extending their mental healthspan. A neurological concept called "cognitive reserve" is gaining attention as well. Cognitive reserve states that brains that may look equally diseased—similar, for example, to those with impairment from Alzheimer's disease—may have completely different cognitive capacities and behavioral symptoms of the disease. People who have built a cognitive reserve, usually having more education and experience in very intellectually stimulating jobs, seem to have brains that are more resilient than people who have not.[38]

The Literal Mind

We use metaphors freely, and often loosely: a heavy situation; head in the clouds; feeling blue. But psychologists are discovering just how connected the quality of our perception and judgment is to the tactile, aesthetic, and linguistic environment in which we find ourselves. Words, colors, smells, texture, heft, and other aspects of our surroundings act below the threshold of consciousness to change how we perceive events and people. And this influence is surprisingly literal. Resumes read on heavy clipboards are given more favorable responses than those on light clipboards. People are more flexible in negotiations when they sit on soft chairs as opposed to hard chairs. Our minds are reading clues and subtle nudges in the environment for how and what to think.

implications

THE MANY MINDS OF THE FUTURE

The redesign of our world for better cognition will have far-reaching effects on society, business, organizations, and the everyday lives of people. Our technological devices, personal relationships, workplaces, schoolrooms, homes, medical facilities, and more will be reimagined. Designers, many of whom are lay psychologists already, will need to learn basic neuroscience. Neuroscientists will need to think about how to apply their insights in more and more domains. Social orders and social structures will begin to reorient around this neurocentric world.

How will this play out in the workplace? What will politics and health look like when we take the brain into account? And what are the implications for advertising?[39]

The Rise of Neuropolitics

Part of the story of our leaky, interconnected minds is that they cannot be simply taken for granted as a natural, apolitical part of our existence. The mind and its capacities will be the battleground for a host of social and political issues. Our knowledge about mental capacities will color the debate about personhood, especially at the margins of life (from prenatal consciousness to fuzzier definitions of death). “Cognitive rights” discourse will rise around issues of pharmaceutical enhancement, freedom from surveillance, even high-speed access to the “extended mind” of the Internet.[41] And at the edges, a provocative proposal from bioethicist Julian Savulescu points toward the kinds of legitimate public discussions that we might be having in the near future.[42] He suggests we add cognitive enhancers to the public water supply, much as many municipalities already do with fluoride. Where there are choices, there is politics. “How do we justly govern our minds” will be a key political question in the coming decades.

Organizing Health Around the Brain

The brain will be to 21st century health care what the heart was to the 20th, a comprehensive organizing health strategy.[43] Our understanding of the heart was clinically transformative as well, but it did more than change medicine. We now run a “heart” filter through most of our daily activities, from the food we eat, to how much exercise we get, to the amount of stress we are enduring. Very soon, this kind of filter or perspective will be channeled for the brain and mind. The clinical implications of our increased understanding of the brain will be profound, from the treatment of neurodegenerative disorders to improving mental health and well-being. We will begin to ask how our diets, exercise, relationships, and activities affect the health of our brains, in the near and long term. Food packaging will extol the “brain-health” attributes of the contents. Brain gyms and cognitive fitness, already a growing industry, will be part of many people’s normal health routine.

Brain-based Persuasion and Defense

In many ways we already feel like the entire world is designed to get us to change our behavior: to buy more stuff, to believe in certain causes, to pay attention to this or that important issue. Neuromarketing techniques are making soup cans and magazine covers irresistible. Persuasive technologies are being developed to help us eat healthier food. Internet wizards help us choose new music. And those are just the things we notice.

The subterranean effects of "tactile tactics," framing, anchoring, and awareness of all the cognitively significant elements of our bodies and world seem to imbue every atom with some intention or designed purpose, whether we consciously notice it or not. We documented many of these techniques and devices in our recent report on the *Future of Persuasion*.[44] In the report, we also talk about the rise of a defense response to ubiquitous persuasion techniques, from filtering incoming marketing messages to weeding our social networks. We can also expect a similar response to what many might feel is an overly designed (possibly manipulative) cognitive ecology. Will you ever negotiate a car deal without thinking about the rigidity of the chair again? With absolutely nothing in our lives that remains neutral, will we become exhausted by the implications? Will the anodyne become a cherished commodity?

Workplaces Get Smart About Cognition

The "knowledge economy" is well into maturity, and the "creative economy" not far behind, yet our work processes, places, and spaces, still reflect an industrial design model. As we begin to understand how to best organize workflows *for the way our brains actually work,* we will see radical changes to "normal" business. These might include:

- **Information Hygiene:** We are learning how much our distractions and information overloads inhibit the kind of focus needed for many of the mental tasks we are asked to do throughout the day. Organizations will be looking for ways to reduce these. Automated systems in our computers and communication devices will curate the flow of information in ways that limit the distractions, floods, and annoyances that increase our cognitive load and decrease our productivity.
- **Programmable spaces:** Not all knowledge work is the same. There are times in the course of the day, or course of a project, when certain cognitive skills are needed more than others. We already know the importance of setting the right "vibe" for brainstorming, or critical feedback, or logistical discussions. Our environments will become our cognitive aids in these processes. Businesses and groups will think more carefully about the spaces where certain kinds of thinking are needed, and "program" those spaces accordingly. Cognitive ergonomics will enter the workplace lexicon.

- **Measuring the brain at work:** One of the major trends in business today we call the "Taylorization of knowledge work."[40] This is the idea that, much as the efficiency expert Frederick Taylor created a series of measurements for industrial work, companies are looking for ways to measure and maximize the fuzzy processes and outcomes of intellectual and artistic labor. Neuroimaging and the measurement of cognitive load might be technologies that give some insight into *how* a mind creates, and lead to ways to make it create more efficiently.

six principles of comprehensive cognitive design

FOR THE EMBODIED, EMBEDDED, EXTENDED MIND OF THE FUTURE

Because of the increased understanding of how the brain connects with the world and advances in cognitive interface technologies, mind can now be thought of as a design challenge. To meet this challenge, we suggest these six principles of comprehensive cognitive design that can be applied across bodies, networks, machines, and spaces.

1 | Design for communion: connect mind and world seamlessly

While it is true that we are off-loading much of our cognitive work to other agents and technologies in the environment, thus extending what was once primarily housed in the individual head, the overall intelligence of the system is rising. The key here is to design for ecological balance by making the cognitive integration of our bodies, technologies, and environment as seamless and efficient as possible.

In some ways, minds are lazy, or at least they like to share their work load. They are continuously seeking to exploit available resources in the environment to maximize return on effort. The goal is to make functional connections between cognitive components (the brain and senses) and potential material assistants in the environment, from furniture to browser software. In other words, to make all the parts fit together well. Much of our computational effort can be spread throughout our cognitive ecology, and intelligence can be seen as a product of the overall system, not just the individual brain. Arguments about whether Google is making us smarter or dumber can be better addressed if we reframe the discussion to think about thinking as a system.

> ... mind can now be thought of as a design challenge.

The Rationalizer, mentioned earlier in the report, is an example of a well-designed cognitive system. Sensors automatically read the person's cognitive or emotional state, meaning that there is less mental bandwidth required for successful results. Nor is there a heavy load in interpreting and acting on the data: if the light bowl begins to brighten, then the user knows that he or she is entering a state of sub-optimal decision-making, and can adjust behavior accordingly. The responsibility for sensing, reporting, and understanding the data, and for executing the desired task, is spread throughout the system in a simple and effective way. This real-time, transparent sharing of emotional and cognitive information between the user and the device creates a unity of purpose we call communion.

2 | Design around limitations: build tools to do what brains don't do well

Human brains have inherent functional limitations with attention, memory, and logic, and cognitive designers must account for our biological and cultural biases. Brains do some things well, and other things not so well. We are great pattern seekers, but we don't always think rationally; we have limited and fuzzy memory, and we let superfluous and distracting information impact our decisions. We need to design systems that let human minds do what they do best, and machines and networks do what they do best.

A recent article at the Lifehacker blog lists ten ways our brains are "sabotaging us," from how sale prices fool us to the finite resource of willpower.[45] The article references research that shows that there is a noticeable difference in cognitive performance for those who have had training on the capacities for the brain to learn: "knowing you can get smarter, makes you smarter." In other words, cognitive limitations can be overcome with training and technique. If we apply this insight to designing our embodied, embedded, extended cognitive ecology, we can consciously make ourselves smarter by making our environments smarter. The metaphor of scaffolding is appropriate. We use scaffolding as an edifice from which to build, and to securely reach new heights. (Meta) cognitive scaffolding can do the same.

3 | Design for improvisation: harness the unexpected

There will be a growing need to "mix-and-match" mind and world in ways that could not have been seen or predicted beforehand. There are occasions, especially in highly unstable environments, or when lateral creativity is needed, when the mind will need to be able to roam and learn on the fly. Real-time ad-hoc assembly is becoming more and more common in our world of blended reality. As Andy Clark notes, "something we might have expected to be achieved by a certain well-demarcated system turns out to involve the exploitation of more far-flung factors and forces."[46] And like a good improv troupe, the agents and artifacts available in the environment must say "yes, and" to the promiscuous brain. So, instead of always trying to rid ourselves of extraneous information from our conscious perception, we might use software applications to interject a random tweet into our twitter feed to increase non-clichéd thinking. Or, we might actually increase the source feed of information into our view in order for us to see new connections between items.

4 | Design for mutual plasticity: learning is now a two-way street

Until relatively recently, our technologies and machines were dumb. Once we built them, from pulleys to steam engines, they more or less stayed the same aside from normal wear and tear, or human-initiated upgrades and changes. The learning was almost all one-sided, with humans the sole nodes of plasticity. We could remap our perception to think of the cane as an extension of our hand, but the cane wasn't learning in tandem.

But now we are designing new domains of technologies that are capable of learning along with us. Algorithms are following our digital data trails online, making suggestions, and in some cases predictions, about purchases, social network connections, and work priorities.[47] We have machines that are beginning to pick up connections among multi-sensory inputs, and starting to synthesize intention and build internal vocabularies—a set of learned terms to describe action.[48] And with advanced neuro- and bio-feedback tools, our cognitive extensions will modify themselves to fit and optimize themselves around our patterns of need.

The design of these devices must pay close attention to how brain-body-world interfaces work. Even minimal time lags and feedback delays can alienate a user from the device. A goal for prosthetics and human-computer interaction (HCI) designers, according to Paul Dourish, an HCI professor at University of California, Irvine, is to create "inhabited interaction," where a person feels transparently connected to the machine or device he or she is using. Usually, one doesn't think "I need to move my hand" before moving it. Thought and action are coupled. Good cognitive design needs to have the same quality, where both human and machine are nodes of plasticity—learning with each other to create a relatively seamless link.

5 | Design for literalness: attend to the cues from our environment

All design can now be seen as carrying a hidden agenda, whether created consciously or not. In the next decade we will see growing attention to the cognitive effects of our machines, furniture, wall colors, and other people; this will transform the way we interpret and design our spaces and interactions.

As we've referenced throughout this report, humans are remarkably influenced by subterranean linguistic, haptic, and environmental factors. This influence is also surprisingly literal. A warm cup makes us feel warm about another person, a hard chair makes us negotiate more rigidly. So we need to look carefully at the way our technologies, spaces, and encounters are designed, and what effect they are having on our experiences. Armed with cognitive design insights, we might see the rise of more ubiquitous "tactile tactics," such as car dealerships outfitting their offices with extra-soft chairs to ease negotiations, or job applicants sending resumes on heavyweight paper, with a hefty clip board backing just for good measure. Maybe God had it right by burning the Ten Commandments into stone tablets!

6 | Design with values: with control comes responsibility

What do you really want to think? This question will no longer just be targeted at an individual, but will be applied to our entire cognitive ecosystem. Because design matters in ways more profound than we have ever realized, we must be specially attuned to the values we imbue in the design of our world. Do you want to engage in a creative process? Then what color are the walls, what are the group dynamics, how do bodies move through the space, and what are the tactile qualities of the artifacts being used?

What are we designing for? What outcomes do we want? What do our designs *come with*? Our overall cognitive ecology might be smarter with Google in it, but does that make our own minds less resilient, more dependent, and more brittle? Who are the gatekeepers at the portals to our minds? What values come with our software, with our social networks, with our neurofeedback technologies? These are political questions in the broadest sense. What mind means in a designed world will be influenced by the choices we make way “upstream,” so we must pay close attention to them at the source.

Cognitive design will become a core piece of organizational strategy, and needs to be incorporated into strategic thinking from the start in order to effectively guide the thinking moving “downstream” toward the intended goal.

conclusion

THE INFINITE CORTEX

What happens at the intersections of the embodied, embedded, extended mind? Of course, the categorization used in this report was a tool to help us navigate the landscape of cognitive-oriented design. In the everyday life of the mind, the brain, body, and world are tightly woven into each other. When we design with the goal of supporting and enhancing the whole, situated mind—a comprehensive cognitive design strategy—we can envision a future in which we create what Andy Clark calls the "infinite cortex."[49] This is a learning system where our individual minds can leverage biological, architectural, and technological scaffolding to improve and expand individual capacities. It is also a system that seamlessly integrates the components of a cognitive ecosystem, coordinating machine-to-machine, human-to-machine, and human-to-human processes.

The notion that the Internet is creating a "Global Brain" is well known, but the connections that the Internet enables are but part of the cognitive puzzle, and must include our bodies and our spaces and places.[50] "We are exposing our brains to an environment and asking them to do things we weren't necessarily evolved to do … and there are consequences," says Adam Gazzaley, a neuroscientist at University of California, San Francisco. These consequences range from having trouble concentrating and paying attention in the moment to what is essentially an addiction to the dopamine rush of new and surprising information. The trick is to create a system in which we can program our environments as assistants to thought, and not be squeezed into the procrustean bed of our technologies. Coordinating these dynamics into a holistic thinking process will amplify our minds in a way that does not do violence to any part of the system, or sacrifice the parts of what make us human that we want to maintain into the future. That is the vision of the Infinite Cortex. It is a dream worth pursuing, and a dream scenario for the mind in our designed world.

endnotes

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