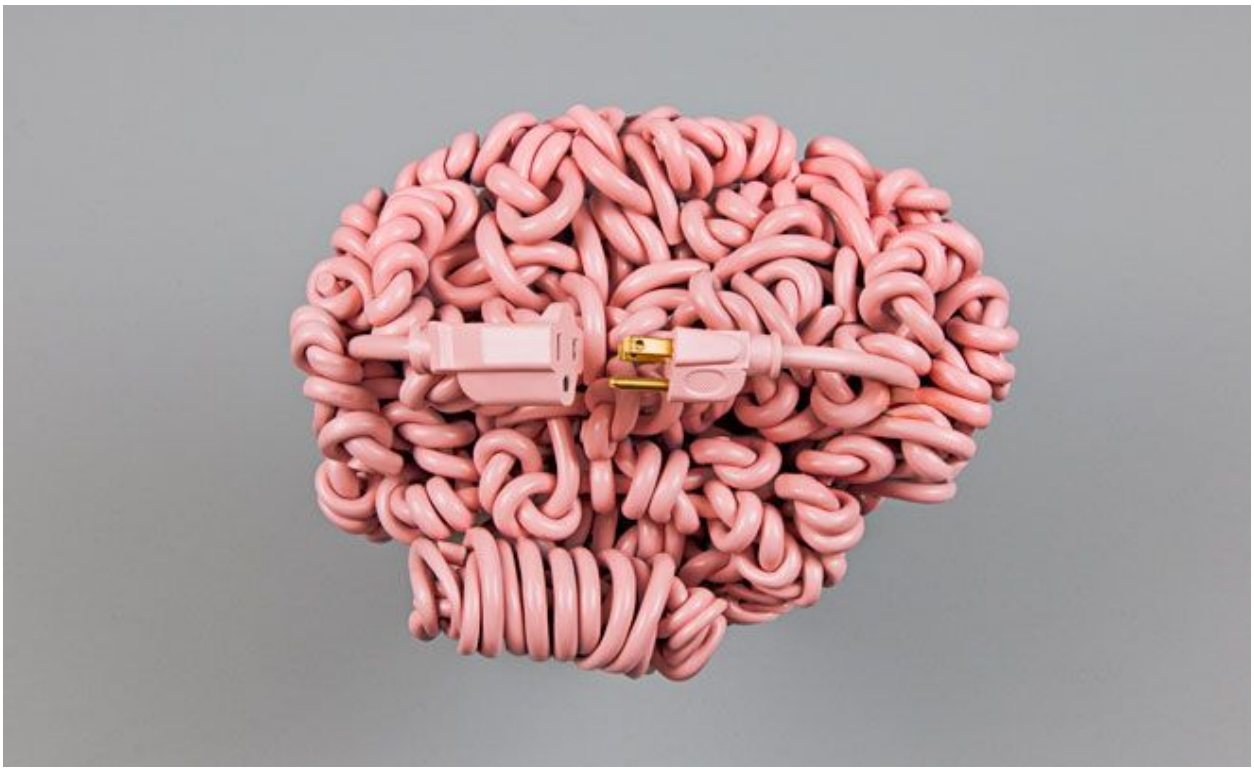
WIRED

06.19.11

Harnessing the Power of Feedback Loops



The premise of a feedback loop is simple: Provide people with information about their actions in real time, then give them a chance to change those actions, pushing them toward better behaviors. Photo: Kevin Van Aelst

IN 2003, OFFICIALS in Garden Grove, California, a community of 170,000 people wedged amid the suburban sprawl of Orange County, set out to confront a problem that afflicts most every town in America: drivers speeding through school zones.

Local authorities had tried many tactics to get people to slow down. They replaced old speed limit signs with bright new ones to remind drivers of the 25-mile-an-hour limit during school hours. Police began ticketing speeding motorists during drop-off and pickup times. But these efforts had only limited success, and speeding cars continued to hit bicyclists and pedestrians in the school zones with depressing regularity.

So city engineers decided to take another approach. In five Garden Grove school zones, they put up what are known as dynamic speed displays, or driver feedback signs: a speed limit

posting coupled with a radar sensor attached to a huge digital readout announcing “Your Speed.”

The signs were curious in a few ways. For one thing, they didn’t tell drivers anything they didn’t already know—there is, after all, a speedometer in every car. If a motorist wanted to know their speed, a glance at the dashboard would do it. For another thing, the signs used radar, which decades earlier had appeared on American roads as a talisman technology, reserved for police officers only. Now Garden Grove had scattered radar sensors along the side of the road like traffic cones. And the Your Speed signs came with no punitive follow-up—no police officer standing by ready to write a ticket. This defied decades of law-enforcement dogma, which held that most people obey speed limits only if they face some clear negative consequence for exceeding them.

In other words, officials in Garden Grove were betting that giving speeders redundant information with no consequence would somehow compel them to do something few of us are inclined to do: slow down.

The results fascinated and delighted the city officials. In the vicinity of the schools where the dynamic displays were installed, drivers slowed an average of 14 percent. Not only that, at three schools the average speed dipped below the posted speed limit. Since this experiment, Garden Grove has installed 10 more driver feedback signs. “Frankly, it’s hard to get people to slow down,” says Dan Candelaria, Garden Grove’s traffic engineer. “But these encourage people to do the right thing.”

In the years since the Garden Grove project began, radar technology has dropped steadily in price and Your Speed signs have proliferated on American roadways. Yet despite their ubiquity, the signs haven’t faded into the landscape like so many other motorist warnings. Instead, they’ve proven to be consistently effective at getting drivers to slow down—reducing speeds, on average, by about 10 percent, an effect that lasts for several miles down the road. Indeed, traffic engineers and safety experts consider them to be more effective at changing driving habits than a cop with a radar gun. Despite their redundancy, despite their lack of repercussions, the signs have accomplished what seemed impossible: They get us to let up on the gas.

The signs leverage what’s called a feedback loop, a profoundly effective tool for changing behavior. The basic premise is simple. Provide people with information about their actions in real time (or something close to it), then give them an opportunity to change those actions, pushing them toward better behaviors. Action, information, reaction. It’s the operating principle behind a home thermostat, which fires the furnace to maintain a specific temperature, or the consumption display in a Toyota Prius, which tends to turn drivers into so-called hypermilers trying to wring every last mile from the gas tank. But the simplicity of feedback loops is

deceptive. They are in fact powerful tools that can help people change bad behavior patterns, even those that seem intractable. Just as important, they can be used to encourage good habits, turning progress itself into a reward. In other words, feedback loops change human behavior. And thanks to an explosion of new technology, the opportunity to put them into action in nearly every part of our lives is quickly becoming a reality.

A feedback loop involves four distinct stages. First comes the data: A behavior must be measured, captured, and stored. This is the evidence stage. Second, the information must be relayed to the individual, not in the raw-data form in which it was captured but in a context that makes it emotionally resonant. This is the relevance stage. But even compelling information is useless if we don't know what to make of it, so we need a third stage: consequence. The information must illuminate one or more paths ahead. And finally, the fourth stage: action. There must be a clear moment when the individual can recalibrate a behavior, make a choice, and act. Then that action is measured, and the feedback loop can run once more, every action stimulating new behaviors that inch us closer to our goals.

This basic framework has been shaped and refined by thinkers and researchers for ages. In the 18th century, engineers developed regulators and governors to modulate steam engines and other mechanical systems, an early application of feedback loops that later became codified into control theory, the engineering discipline behind everything from aerospace to robotics. The mathematician Norbert Wiener expanded on this work in the 1940s, devising the field of cybernetics, which analyzed how feedback loops operate in machinery and electronics and explored how those principles might be broadened to human systems.

Over the past 40 years, feedback loops have been thoroughly researched and validated in psychology, epidemiology, military strategy, environmental studies, engineering, and economics.
Illustration: Ulla Puggaard

The potential of the feedback loop to affect behavior was explored in the 1960s, most notably in the work of Albert Bandura, a Stanford University psychologist and pioneer in the study of behavior change and motivation. Drawing on several education experiments involving children, Bandura observed that giving individuals a clear goal and a means to evaluate their progress toward that goal greatly increased the likelihood that they would achieve it. He later expanded this notion into the concept of self-efficacy, which holds that the more we believe we can meet a goal, the more likely we will do so. In the 40 years since Bandura's early work, feedback loops have been thoroughly

researched and validated in psychology, epidemiology, military strategy, environmental studies, engineering, and economics. (In typical academic fashion, each discipline tends to reinvent the methodology and rephrase the terminology, but the basic framework remains the same.) Feedback loops are a common tool in athletic training plans, executive coaching strategies, and a multitude of other self-improvement programs (though some are more true to the science than others).

Despite the volume of research and a proven capacity to affect human behavior, we don't often use feedback loops in everyday life. Blame this on two factors: Until now, the necessary catalyst—personalized data—has been an expensive commodity. Health spas, athletic training centers, and self-improvement workshops all traffic in fastidiously culled data at premium rates. Outside of those rare realms, the cornerstone information has been just too expensive to come by. As a technologist might put it, personalized data hasn't really scaled.

Second, collecting data on the cheap is cumbersome. Although the basic idea of self-tracking has been available to anyone willing to put in the effort, few people stick with the routine of toting around a notebook, writing down every Hostess cupcake they consume or every flight of stairs they climb. It's just too much bother. The technologist would say that capturing that data involves too much friction. As a result, feedback loops are niche tools, for the most part, rewarding for those with the money, willpower, or geeky inclination to obsessively track their own behavior, but impractical for the rest of us.

That's quickly changing because of one essential technology: sensors. Adding sensors to the feedback equation helps solve problems of friction and scale. They automate the capture of behavioral data, digitizing it so it can be readily crunched and transformed as necessary. And they allow passive measurement, eliminating the need for tedious active monitoring.

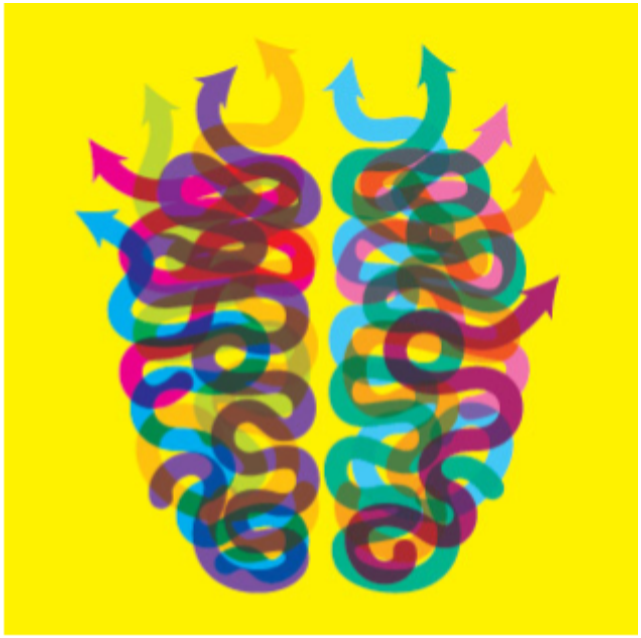


Illustration: Leo Jung

In the past two or three years, the plunging price of sensors has begun to foster a feedback-loop revolution. Just as Your Speed signs have been adopted worldwide because the cost of radar technology keeps dropping, other feedback loops are popping up everywhere because sensors keep getting cheaper and better at monitoring

behavior and capturing data in all sorts of environments. These new, less expensive devices include accelerometers (which measure motion), GPS sensors (which track location), and inductance sensors (which measure electric current). Accelerometers have dropped to less than $1 each—down from as much as $20 a decade ago—which means they can now be built into tennis shoes, MP3 players, and even toothbrushes. Radio-frequency ID chips are being added to prescription pill bottles, student ID cards, and casino chips. And inductance sensors that were once deployed only in heavy industry are now cheap and tiny enough to be connected to residential breaker boxes, letting consumers track their home's entire energy diet.

Of course, technology has been tracking what people do for years. Call-center agents have been monitored closely since the 1990s, and the nation's tractor-trailer fleets have long been equipped with GPS and other location sensors—not just to allow drivers to follow their routes but so that companies can track their cargo and the drivers. But those are top-down, Big Brother techniques. The true power of feedback loops is not to control people but to give them control. It's like the difference between a speed trap and a speed feedback sign—one is a game of gotcha, the other is a gentle reminder of the rules of the road. The ideal feedback loop gives us an emotional connection to a rational goal.

And today, their promise couldn't be greater. The intransigence of human behavior has emerged as the root of most of the world's biggest challenges. Witness the rise in obesity, the persistence of smoking, the soaring number of people who have one or more chronic diseases. Consider our problems with carbon emissions, where managing personal energy consumption could be the difference between a climate under control and one beyond help. And feedback loops aren't just about solving problems. They could create opportunities. Feedback loops can improve how companies motivate and empower their employees, allowing workers to monitor their own productivity and set their own schedules. They could lead to lower consumption of precious resources and more productive use of what we do consume. They could allow people to set and achieve better-defined, more ambitious goals and curb destructive behaviors, replacing them with positive actions. Used in organizations or communities, they can help groups work together to take on more daunting challenges. In short, the feedback loop is an age-old strategy revitalized by state-of-the-art technology. As such, it is perhaps the most promising tool for behavioral change to have come along in decades.

In 2006, Shwetak Patel, then a graduate student in computer science at Georgia Tech, was working on a problem: How could technology help provide remote care for the elderly? The obvious approach would be to install cameras and motion detectors throughout a home, so that observers could see when somebody fell or became sick. Patel found those methods unsophisticated and impractical. "Installing cameras or motion sensors everywhere is

unreasonably expensive," he says. "It might work in theory, but it just won't happen in practice. So I wondered what would give us the same information and be reasonably priced and easy to deploy. I found those really interesting constraints."

The answer, Patel realized, is that every home emits something called voltage noise. Think of it as a steady hum in the electrical wires that varies depending on what systems are drawing power. If there were some way to disaggregate this noise, it might be possible to deliver much the same information as cameras and motion sensors. Lights going on and off, for instance, would mean that someone had moved from room to room. If a blender were left on, that might signal that someone had fallen—or had forgotten about the blender, perhaps indicating dementia. If we could hear electricity usage, Patel thought, we could know what was happening inside the house.

A nifty idea, but how to make it happen? The problem wasn't measuring the voltage noise; that's easily tracked with a few sensors. The challenge was translating the cacophony of electromagnetic interference into the symphony of signals given off by specific appliances and devices and lights. Finding that pattern amid the noise became the focus of Patel's PhD work, and in a few years he had both his degree and his answer: a stack of algorithms that could discern a blender from a light switch from a television set and so on. All this data could be captured not by sensors in every electrical outlet throughout the house but through a single device plugged into a single outlet.

This, Patel soon realized, went way beyond elder care. His approach could inform ordinary consumers, in real time, about where the energy they paid for every month was going. "We kind of stumbled across this stuff," Patel says. "But we realized that, combined with data on the house's overall draw on power"—which can be measured through a second sensor easily installed at the circuit box—"we were getting really great information about resource consumption in the home. And that could be more than interesting information. It could encourage behavior change."

By 2008, Patel had started a new job in the computer science and engineering departments at the University of Washington, and his idea had been turned into the startup Zensi. At Washington, he focused on devising similar techniques to monitor home consumption of water and gas. The solutions were even more elegant, perhaps, than the one for monitoring electricity. A transducer affixed to an outdoor spigot can detect changes in water pressure that correspond to the resident's water usage. That data can then be disaggregated to distinguish a leaky toilet from an over-indulgent bather. And a microphone sensor on a gas meter listens to changes in the regulator to determine how much gas is consumed.

Last year, consumer electronics company Belkin acquired Zensi and made energy conservation a centerpiece of its corporate strategy, with feedback loops as the guiding

principle. Belkin has begun modestly, with a device called the Conserve Insight. It's an outlet adapter that gives consumers a close read of the power used by one select appliance: Plug it into a wall socket and then plug an appliance or gadget into it and a small display shows how much energy the device is consuming, in both watts and dollars. It's a window onto how energy is actually used, but it's only a proof-of-concept prototype of the more ambitious product, based on Patel's PhD work, that Belkin will begin beta-testing in Chicago later this year with an eye toward commercial release in 2013. The company calls it Zorro.

At first glance, the Zorro is just another so-called smart meter, not that different from the boxes that many power companies have been installing in consumers' homes, with a vague promise that the meters will educate citizens and provide better data to the utility. To the surprise of the utility companies, though, these smart meters have been greeted with hostility in some communities. A small but vocal number of customers object to being monitored, while others worry that the radiation from RFID transmitters is unhealthy (though this has been measured at infinitesimal levels).

Politics aside, in pure feedback terms smart meters fail on at least two levels. For one, the information goes to the utility first, rather than directly to the consumer. For another, most smart meters aren't very smart; they typically measure overall household consumption, not how much power is being consumed by which specific device or appliance. In other words, they are a broken feedback loop.

Belkin's device avoids these pitfalls by giving the data directly to consumers and delivering it promptly and continuously. "Real-time feedback is key to conservation," says Kevin Ashton, Zensi's former CEO who took over Belkin's Conserve division after the acquisition. "There's a visceral impact when you see for yourself how much your toaster is costing you."

The Zorro is just the first of several Belkin products that Ashton believes will put feedback loops into effect throughout the home. Ashton worked on RFID chips at MIT in the late 1990s and lays claim to coining the phrase "Internet of Things," meaning a world of interconnected, sensor-laden devices and objects. He predicts that home sensors will one day inform choices in all aspects of our lives. "We're consuming so many things without thinking about them—energy, plastic, paper, calories. I can envision a ubiquitous sensor network, a platform for real-time feedback that will enhance the comfort, security, and control of our lives."

As a starting point for a consumer products company, that's not half bad.

If there is one problem in medicine that confounds doctors, insurers, and pharmaceutical companies alike, it's noncompliance, the unfriendly term for patients who don't follow doctors' orders. Most vexing are those who don't take their medications as prescribed—which, it turns out, is pretty much most of us. Studies have shown that about half of patients who are

prescribed medication take their pills as directed. For drugs like statins, which must be used for years, the rate is even worse, dropping to around 30 percent after a year. (Since the effect of these drugs can be invisible, the thinking goes, patients don't detect any benefit.) Research has found that noncompliance adds $100 billion annually to US health care costs and leads to 125,000 unnecessary deaths from cardiovascular diseases alone every year. And it can be blamed almost entirely on human foibles—people failing to do what they know they should.

David Rose is a perfect example of this. He has a family history of heart disease. Now 44, he began taking medication for high blood pressure a few years ago, making him not so different from the nearly one-third of Americans with hypertension. Where Rose is exceptional is in his capacity to do something about noncompliance. He has a knack for inventing beautiful, engaging, alluring objects that get people to do things like take their pills.

A decade ago, Rose, whose stylish glasses and soft-spoken manner bring to mind a college music teacher, started a company called Ambient Devices. His most famous product is the Orb, a translucent sphere that turns different colors to reflect different information inputs. If your stocks go down, it might glow red; if it snows, it might glow white, and so on, depending on what information you tell the Orb you are interested in. It's a whimsical product and is still available for purchase online. But as far as Rose is concerned, the Orb was merely a prelude to his next company, Vitality, and its marquee product: the GlowCap.

The device is simple. When a patient is prescribed a medication, a physician or pharmacy provides a GlowCap to go on top of the pill bottle, replacing the standard childproof cap. The GlowCap, which comes with a plug-in unit that Rose calls a night-light, connects to a database that knows the patient's particular dosage directions—say, two pills twice a day, at 8 am and 8 pm. When 8 am rolls around, the GlowCap and the night-light start to pulse with a gentle orange light. A few minutes later, if the pill bottle isn't opened, the light pulses a little more urgently. A few minutes more and the device begins to play a melody—not an annoying buzz or alarm. Finally, if more time elapses (the intervals are adjustable), the patient receives a text message or a recorded phone call reminding them to pop the GlowCap. The overall effect is a persistent feedback loop urging patients to take their meds.

These nudges have proven to be remarkably effective. In 2010, Partners HealthCare and Harvard Medical School conducted a study that gave GlowCaps to 140 patients on hypertension medications; a control group received nonactivated GlowCap bottles. After three months, adherence in the control group had declined to less than 50 percent, the same dismal rate observed in countless other studies. But patients using GlowCaps did remarkably better: More than 80 percent of them took their pills, a rate that lasted for the duration of the six-month study.

The power of the device can perhaps be explained by the fact that the GlowCap incorporates several schools of behavioral change. Vitality has experimented with charging consumers for the product, drawing on the behavioral-economics theory that people are more willing to use something they've paid for. But in other circumstances the company has given users a financial reward for taking their medication, using a carrot-and-stick methodology. Different models work for different people, Rose says. "We use reminders and social incentives and financial incentives—whatever we can," he says. "We want to provide enough feedback so that it's complementary to people's lives, but not so much that you can't handle the onslaught."

Here Rose grapples with an essential challenge of feedback loops: Make them too passive and you'll lose your audience as the data blurs into the background of everyday life. Make them too intrusive and the data turns into noise, which is easily ignored. Borrowing a concept from cognitive psychology called pre-attentive processing, Rose aims for a sweet spot between these extremes, where the information is delivered unobtrusively but noticeably. The best sort of delivery device "isn't cognitively loading at all," he says. "It uses colors, patterns, angles, speed—visual cues that don't distract us but remind us." This creates what Rose calls "enchantment." Enchanted objects, he says, don't register as gadgets or even as technology at all, but rather as friendly tools that beguile us into action. In short, they're magical.

This approach to information delivery is a radical departure from how our health care system usually works. Conventional wisdom holds that medical information won't be heeded unless it sets off alarms. Instead of glowing orbs, we're pummeled with FDA cautions and Surgeon General warnings and front-page reports, all of which serve to heighten our anxiety about our health. This fear-based approach can work—for a while. But fear, it turns out, is a poor catalyst for sustained behavioral change. After all, biologically our fear response girds us for short-term threats. If nothing threatening actually happens, the fear dissipates. If this happens too many times, we end up simply dismissing the alarms.

It's worth noting here how profoundly difficult it is for most people to improve their health. Consider: Self-directed smoking-cessation programs typically work for perhaps 5 percent of participants, and weight-loss programs are considered effective if people lose as little as 5 percent of their body weight. Part of the problem is that so much in our lives—the foods we eat, the ads we see, the things our culture celebrates—is driven by feedback loops that sustain bad behaviors. But we can counterprogram this onslaught with another feedback loop, increasing our odds of changing course.

Though GlowCaps improved compliance by an astonishing 40 percent, feedback loops more typically improve outcomes by about 10 percent compared to traditional methods. That 10 percent figure is surprisingly persistent; it turns up in everything from home energy monitors to smoking cessation programs to those Your Speed signs. At first glance, 10 percent may not

seem like a lot. After all, if you're 250 pounds and obese, losing 25 pounds is a start, but your BMI is likely still in the red zone. But it turns out that 10 percent does matter. A lot. An obese 40-year-old man would spare himself three years of hypertension and nearly two years of diabetes by losing 10 percent of his weight. A 10 percent reduction in home energy consumption could reduce carbon emissions by as much as 20 percent (generating energy during peak demand periods creates more pollution than off-peak generation). And those Your Speed signs? It turns out that reducing speeds by 10 percent from 40 to 35 mph would cut fatal injuries by about half.

In other words, 10 percent is something of an inflection point, where lots of great things happen. The results are measurable, the economics calculable. "The value of behavior change is incredibly large: nearly $5,000 a year," says David Rose, citing a CVS pharmacy white paper. "At that rate, we can afford to give every diabetic a connected glucometer. We can give the morbidly obese a Wi-Fi-enabled scale and a pedometer. The value is there; the savings are there. The cost of the sensors is negligible."

So feedback loops work. Why? Why does putting our own data in front of us somehow compel us to act? In part, it's that feedback taps into something core to the human experience, even to our biological origins. Like any organism, humans are self-regulating creatures, with a multitude of systems working to achieve homeostasis. Evolution itself, after all, is a feedback loop, albeit one so elongated as to be imperceptible by an individual. Feedback loops are how we learn, whether we call it trial and error or course correction. In so many areas of life, we succeed when we have some sense of where we stand and some evaluation of our progress. Indeed, we tend to crave this sort of information; it's something we viscerally want to know, good or bad. As Stanford's Bandura put it, "People are proactive, aspiring organisms." Feedback taps into those aspirations.

The visceral satisfaction and even pleasure we get from feedback loops is the organizing principle behind GreenGoose, a startup being hatched by Brian Krejcarek, a Minnesota native who wears a near-constant smile, so enthusiastic is he about the power of cheap sensors. His mission is to stitch feedback loops into the fabric of our daily lives, one sensor at a time.

As Krejcarek describes it, GreenGoose started with a goal not too different from Shwetak Patel's: to measure household consumption of energy. But the company's mission took a turn in 2009, when he experimented with putting one of those ever-cheaper accelerometers on a bicycle wheel. As the wheel rotated, the sensor picked up the movement, and before long Krejcarek had a vision of a grander plan. "I wondered what else we could measure. Where else could we stick these things?" The answer he came up with: everywhere. The GreenGoose concept starts with a sheet of stickers, each containing an accelerometer labeled with a cartoon icon of a familiar household object—a refrigerator handle, a water bottle, a toothbrush,

a yard rake. But the secret to GreenGoose isn't the accelerometer; that's a less-than-a-dollar commodity. The key is the algorithm that Krejcarek's team has coded into the chip next to the accelerometer that recognizes a particular pattern of movement. For a toothbrush, it's a rapid back-and-forth that indicates somebody is brushing their teeth. For a water bottle, it's a simple up-and-down that correlates with somebody taking a sip. And so on. In essence, GreenGoose uses sensors to spray feedback loops like atomized perfume throughout our daily life—in our homes, our vehicles, our backyards. "Sensors are these little eyes and ears on whatever we do and how we do it," Krejcarek says. "If a behavior has a pattern, if we can calculate a desired duration and intensity, we can create a system that rewards that behavior and encourages more of it." Thus the first component of a feedback loop: data gathering.

Then comes the second step: relevance. GreenGoose converts the data into points, with a certain amount of action translating into a certain number of points, say 30 seconds of teeth brushing for two points. And here Krejcarek gets noticeably excited. "The points can be used in games on our website," he says. "Think FarmVille but with live data." Krejcarek plans to open the platform to game developers, who he hopes will create games that are simple, easy, and sticky. A few hours of raking leaves might build up points that can be used in a gardening game. And the games induce people to earn more points, which means repeating good behaviors. The idea, Krejcarek says, is to "create a bridge between the real world and the virtual world. This has all got to be fun."

As powerful as the idea appears now, just a few months ago it seemed like a fading pipe dream. Then based in Cambridge, Massachusetts, Krejcarek had nearly run out of cash—not just for his company, but for himself. During the day, he was working on GreenGoose in a office building near the MIT campus—and each night, he'd sneak into the building's air shaft, where he'd stashed an air mattress and some clothes. Then, in late February, he went to the Launch conference in San Francisco, a two-day event where select entrepreneurs get a chance to demo their company to potential funders. Krejcarek hadn't been selected for an onstage demo, but when the conference organizers saw a crowd eyeing his product on the exhibit floor, he was given four minutes to make a presentation. It was one of those only-in-Silicon Valley moments. The crowd "just got it," he recalls. Within days, he had nearly $600,000 in new funding. He moved to San Francisco, rented an apartment—and bought a bed. GreenGoose will release its first product, a kit of sensors that encourage pet owners to play and interact with their dogs, with sensors for dog collar, pet toys, and dog doors, sometime this fall.

Part of the excitement around GreenGoose is that the company is so good at "gamification," the much-blogged-about notion that game elements like points or levels can be applied to various aspects of our lives. Gamification is exciting because it promises to make the hard stuff in life fun—just sprinkle a little videogame magic and suddenly a burden turns into bliss. But as

happens with fads, gamification is both overhyped and misunderstood. It is too often just a shorthand for badges or points, like so many gold stars on a spelling test. But just as no number of gold stars can trick children into thinking that yesterday's quiz was fun, game mechanics, to work, must be an informing principle, not a veneer.

With its savvy application of feedback loops, though, GreenGoose is onto more than just the latest fad. The company represents the fruition of a long-promised technological event horizon: the Internet of Things, in which a sensor-rich world measures our every action. This vision, championed by Kevin Ashton at Belkin, Sandy Pentland at MIT, and Bruce Sterling in the pages of this magazine, has long had the whiff of vaporware, something promised by futurists but never realized. But as GreenGoose, Belkin, and other companies begin to use sensors to deploy feedback loops throughout our lives, we can finally see the potential of a sensor-rich environment. The Internet of Things isn't about the things; it's about us.

For now, the reality still isn't as sexy as the visions. Stickers on toothbrushes and plugs in wall sockets aren't exactly disappearing technology. But maybe requiring people to do a little work—to stick accelerometers around their house or plug a device into a wall socket—is just enough of a nudge to get our brains engaged in the prospect for change. Perhaps it's good to have the infrastructure of feedback loops just a bit visible now, before they disappear into our environments altogether, so that they can serve as a subtle reminder that we have something to change, that we can do better—and that the tools for doing better are rapidly, finally, turning up all around us.

Thomas Goetz (thomas@wired.com) is the executive editor of Wired. His latest book, The Decision Tree, is now out in paperback.