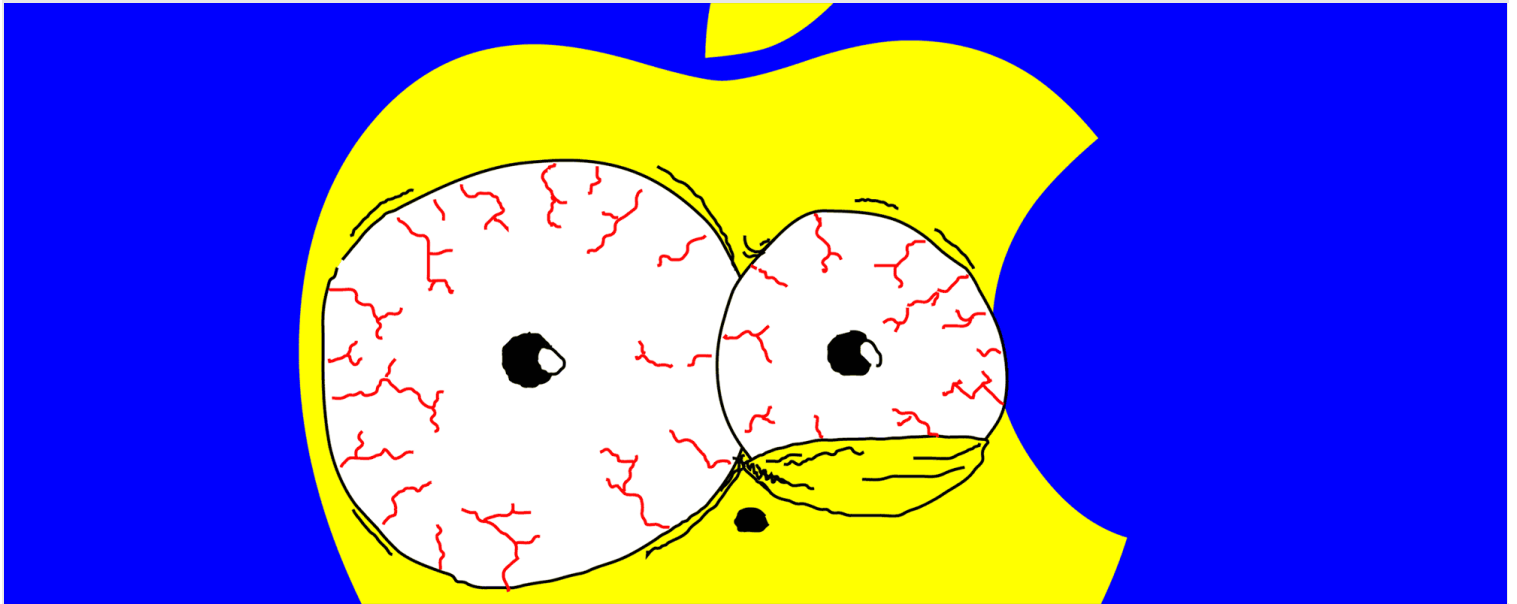


How Apple Built 3D Touch



Apple has made many things over the years, but its process has remained essentially the same: Find something ugly and complicated and make it prettier and easier. Prettiness, in brushed aluminum, is more or less a permanent state. Ease, however, is constantly evolving, which is why a few days before the geek hootenanny known as Apple's September Event, Jony Ive's focus isn't on a new version of Apple TV or an iPad the size of a doggy door, but on a feature. It's called 3D Touch, and it makes using an iPhone even easier. "Ultimately, *this* is our focus," says Ive, squeezing a [new iPhone 6S](#). "This is what galvanizes our efforts right across the company." And 3D Touch, he adds with emphasis, "is something we've been working on for a long time—multi, multi, multi years."



The Apple design studio, like Stonehenge, is more mystical in the imagination than in real life. It's open plan, with thirtysomethings of indiscriminate nationality, and very discriminate grooming, working quietly in front of desktop iMacs. There are long wooden break tables near a small kitchen with a gleaming espresso machine that appears more worshiped than used. The floors are concrete. The music is indie, the lighting crisp. The wall-length bookcase has the meticulously unarranged look of every design bookstore you've ever lost an hour in.

The only hint that this is Apple's magic room is a curtain. Behind it, says Ive, is the industrial design studio, where there are explorations in progress, milling machines, and a few remarkable futuristic things that he cannot, alas, remark upon. 3D Touch came to life back there.

Several years ago the designers and engineers realized that phones contained so many functions—messaging, maps, apps, links, photos, songs—that people were wasting a lot of time retreating to the home button to bounce between them. This is the *ne plus ultra* of First World problems, but Apple exists, unapologetically, to eradicate even the tiniest bit of friction between its products and its users. “Inevitable’ is the word we use a lot,” says Alan Dye, Apple's vice president of user interface design. “We want the way you use our products to feel inevitable.”

In the near decade since its birth, the iPhone has shed the baby fat of its first edition and grown into a sleek adolescent (with a big brother, the 5.5-inch Plus version, introduced in 2014). With the notable exceptions of Siri and Apple Maps, so many features have been added so seamlessly that a meaningful critique is almost impossible. It's like reviewing infinity. But the appreciation of excellence fades when your customers are conditioned to expect it. Refinement doesn't get a standing O. “The bar for functionality is higher with every generation,” says Phil Schiller, Apple's senior vice president of worldwide marketing. “You can't just say, ‘Here it is. It does the same thing 5 percent better than last year.’ Nobody cares.”

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From the iPhone's rounded edges to its imperturbable Genius Bar employees, Apple would like its customers to think of it as an effortless company, where transcendent technology emerges like freshly baked bread from an oven. It's just as much an illusion as Disney's happiest place on earth. “Engineering-wise, the hardware to build a display that does what [3D Touch] does is unbelievably hard,” says Schiller. “And we're going to waste a whole year of engineering—really, two—at a tremendous amount of cost and investment in manufacturing if it doesn't do something that [people] are going to use. If

it's just a demo feature and a month later nobody is really using it, this is a huge waste of engineering talent.”

Schiller believes that 3D Touch is a breakthrough, but the designers aren't so sheltered that they're oblivious to his point. “I mean, it's remarkable that within a corporation that has to deal with so many absolutes ... so many metrics ...” Ive says, trailing off. “You know, it's so very hard to measure [what designers do]. We can be working on something for a long time and still not know quite how it's going to work out.”

Apple design projects have no formal start and no predetermined finish. Months of wrong turns and scenic routes are common, and there are countless schemes going on simultaneously. Which is why no one really remembers when the group rallied around adding 3D to the iPhone, only that they kept asking: What if, instead of swiping through apps or routing all of your browsing through the Grand Central station of the home screen, you could press the glass in one function and reveal a shortcut to another? And what if the phone understood this desire based entirely on changes in the pressure you applied?

Everyone knows Apple is a design-first company, but the degree to which this is true has, if anything, been underappreciated. The relationship between the designers and the nondesign executives is a little like the relationship between American Pharoah and his trainer. One side is nominally in charge, but it's conspicuously in service to the other. Craig Federighi, Apple's senior vice president of software engineering, says that at most software companies the designers decide what they want and the engineers respond with what's easy to build. “Every single feature becomes this unholy compromise,” says Federighi, who began his career at Apple and spent a decade at Ariba, a maker of financial management software, before returning in 2009. “With [3D Touch] it was only at the moment where we finally got a design experience that's like, ‘Yes! This is what we want!’ that we [asked] how hard it's going to be to make.”

The answer: really hard. But not as hard as it would be for a competitor. Apple has such unprecedented resources (roughly \$200 billion in cash on hand) that it's been able to

collect many of the world's top specialists, across a variety of fields, and stash them for a rainy day. A former executive not authorized to speak for this story suggested that Apple's \$3 billion acquisition of Beats last year had nothing to do with headphones; it was about buying Beats Chief Executive Officer Jimmy Iovine's savant-like knowledge of the music business. "If you need to solve a particular problem, usually the best person in the world already works here," says Dye.

Still, working backward from a design idea to create a real-world, fail-safe, supply chain-able product for hundreds of millions of people can't be done with resources alone. Apple isn't in the habit of explaining how it makes things work, because the people at Samsung can read, and hold a patent on a similar technology. But in lieu of the usual polite deflection, Federighi picked up an iPhone 6S and explained one of 3D Touch's simpler challenges: "It starts with the idea that, on a device this thin, you want to detect force. I mean, you think you want to detect force, but really what you're trying to do is sense intent. You're trying to read minds. And yet you have a user who might be using his thumb, his finger, might be emotional at the moment, might be walking, might be laying on the couch. These things don't affect intent, but they do affect what a sensor [inside the phone] sees. So there are a huge number of technical hurdles. We have to do sensor fusion with accelerometers to cancel out gravity—but when you turn [the device] a different way, we have to subtract out gravity. ... Your thumb can read differently to the touch sensor than your finger would. That difference is important to understanding how to interpret the force. And so we're fusing both what the force sensor is giving us with what the touch sensor is giving us about the nature of your interaction. So down at even just the lowest level of hardware and algorithms—I mean, this is just one basic thing. And if you don't get it right, none of it works."

For a technology company, there's a surprising amount of pencil-and-paper sketching as people begin their work. Designers are spared a lot of meetings and obligations ("We love our bubble," says Dye), but they mix so intensely with materials specialists and engineers that they've essentially become one amorphous, cross-functional team. Turnover is unheard of, and new staff is brought in only after a courtship that makes

selecting a spouse look careless by comparison. “One joke with the design team,” says Dye, “is that we don’t hire people until we’ve been on family vacations together.”

When the group lands on something promising—and “something” is the right word, because they’re often working with ideas that don’t have terms to express them yet—they program it into a rough prototype. Software prototypes (usually just printouts of proposed interactivity) go on a magnetized wall. Hardware prototypes are often comically bigger than an actual device and are set on a table for everyone to gather around and critique. The core members have been together for so long that feedback “is often sort of preverbal,” says Ive of the exchanges of grunts and nods. At the same time, “we’re not characterized by being reticent with our opinions.”

Dye, who had lead design roles at Kate Spade and Ogilvy & Mather before coming to Apple in 2006, says that most of the designers feel constant low-level anxiety. “I’m scared to death that at some point I’m going to get found out. You know, Tim [Cook] is going to realize the truth about me, which is I’m terrible.”

The only thing that keeps the anxiety from turning to guilt is performance. “If you look at all the interactions we engineered into this phone, none of them ended up where we started,” says Federighi. Working with Corning, Apple created pliable iPhone cover glass. Swipe it, and the phone works the way it always has. But press it, and 96 sensors embedded in the backlight of the retina display measure microscopic changes in the distance between themselves and the glass. Those measurements then get combined with signals from the touch sensor to make the motion of your finger sync with the image on screen.

Some of this technology was first revealed in the Apple Watch, which has a feature called Force Touch. But 3D Touch is to Force Touch as ocean swimming is to a foot bath. Screen size makes a difference, but the software on the iPhone 6S has a liquid ease. Apply a tiny bit of pressure anywhere you want to explore something—a restaurant link inside a text, an 11 a.m. meeting invite buried in an e-mail—and a peek at the restaurant’s Web page or a window into your calendar hovers expectantly in the middle

of the screen while everything else blurs into temporary opacity. Press a little harder, and what you've been peeking at pops fully into frame. Release your finger, and you're right back where you started. Presto chango, no home button required.

Of course, this is the exact opposite of how things work in the physical world. When you press a real object it's obscured, and it's the things surrounding it that come into sharper focus. The designers concede they were far down a rabbit hole until they remembered, as Federighi says, that while the hardware was measuring force, the software needed to measure intent. To make what is counterintuitive feel normal, each on-screen "peek" and "pop" is accompanied by a 10-millisecond or 15-millisecond haptic tap, little vibrations that say "good job" to your fingers when an action is complete. (The precise timing of those taps is a cosmology all its own.) For the years of effort, 3D Touch will be judged a success only when its existence fades completely into a user's subconscious. It takes about four minutes.

Apple is feeling confident enough that it's integrated 3D Touch into everything on the iPhone 6S and 6S Plus—the phone, the weather app, iTunes, messaging, and the Web. Facebook and Instagram plan on incorporating it into their iOS apps shortly after the phones arrive in stores on Sept. 25 (at the same price as last year's models), and a slew of other developers are waiting for a chance to open up the software. "This is probably the biggest innovation since the phone first came out," says Andy Wafer, CEO of Pixel Toys, which created the acclaimed zombie shooter game Gunfinger. Because the screen senses force, and responds with taps, we may be on the verge of great leaps forward in the destruction of virtual flesh. "Of course, everything is shooting things," says CEO Tim Cook with a wry smile during a brief stop in the design studio.

Apple starts planning its keynote events four months in advance, and as September approaches Phil Schiller is sweating over just how long this one might go. "We're trying hard to keep it under two hours," he says. "I think we're going to be over." This, too, can be pinned on the designers. "We've never released a feature to make a date," says Ive. They also don't hold features back. Things are ready when they're ready, and this season

is swollen with new ideas.

Sure enough, by the time OneRepublic finished singing, [the show](#) had clocked in at 2 hours and 20 minutes. Aside from 3D Touch, [there's a new Apple TV](#) (\$149 for a 32GB version) that app-ifies video, has a remote for gameplay, and gets close to a universal search function that finally brings order to the chaos of streaming services and broadcast options. There's also [a 12.9-inch iPad Pro](#) (starting at \$799, and available in November) with a sleek stylus called Apple Pencil (\$99). More stage time was devoted to [new Apple Watch bands](#), iPhone camera upgrades, iPhone hardware upgrades, enhanced iPhone video and video editing, the A9 microchip (70 percent faster than its predecessor), and the introduction of Live Photo, which is neither picture nor video but something in between, like a living memory. Each presentation was discretely impressive and cumulatively exhausting.

“The biggest worry for me is, are we getting too locked in a formula?” asks Schiller. He recalls the 2002 Worldwide Developers Conference, at which Steve Jobs delivered a eulogy for Mac OS9, complete with cheesy organ music, a smoke machine, and a casket rising through the middle of the stage. “We haven’t done anything quite that outlandish in a long time. It may be part of being a bigger company, not this small upstart. We feel a little uncomfortable being too strange and getting too far away from ourselves.”

When Ive’s promotion to chief design officer was announced in May and his deputies were given more day-to-day authority, the cottage industry of Apple gossip sites surmised this was the beginning of a slow fade. Ive was said to be too impatient for a company of massively integrated product lines. There’s no evidence this is true, and the relationship between Ive and Cook is close and mutually admiring. But Ive is vigilant in guarding against the creative dangers of Apple’s enormity. “There’s a tax that comes with interoperability and what can be seen as complexity, which is it can actually be an impediment to innovation.”

He regularly asks himself, “Are we developing stuff to make things easy for ourselves, or are we developing products to move this forward? I have no interest, and I don’t think

anybody here has interest, in just designing something that will fit into a family and behave itself.”

Ive is proud of 3D Touch because it improves the experience of owning an iPhone, but he’s also proud of what it says about Apple. He can’t think of another company that would have put so many resources into such a seemingly subtle, yet potentially profound, change.

“Why would we spend this many years working on 3D Touch when you can do some of these things with a button? Well it’s, it’s just such a fluid connection with your content,” says Ive, a little dreamily. “And not everything is binary, is it?”

Apple’s faith in design helped make it the first company to reach a market cap of more than \$750 billion. It also means that every few years it has to bet its future on the instincts of a few people with strong opinions about how things should work. Ive would rather be sentenced to life with a flip phone than subject his designs to focus groups, so when the company makes a change like 3D Touch, its business plan, basically, is to trust that he and his team are right.

For all that’s changed at Apple, that faith is what links it most strongly to its roots. In January 2007, when the first iPhone was announced but not yet on shelves, Jobs escorted the device on a voyage through America’s media outlets. In the middle of a drab conference room on a high floor of a New York City office tower, he placed the device into the hands of journalists who would, presumably, write that it was as world-changing as he claimed. Jobs dropped the phone to prove that the glass wouldn’t shatter. He activated the speaker to demonstrate call clarity. It seems obvious now, but the minimalist Jobs had even pared away the physical keyboard, and that had to be sold, too. He asked a volunteer to tap on the virtual keyboard that had replaced it on screen. He was in full seduction mode, and about to reach his crescendo—

“It doesn’t work.”

Jobs paused and tilted his head, not unkindly, in the direction of the disturbance.

“I keep getting typos,” the volunteer said. “The keyboard’s too small for my thumbs.”

Jobs smiled and replied: “Your thumbs will learn.” **B**