

ME, MYSELF, AND MY

# ANDROID TWIN



by Erico Guizzo

A JAPANESE ROBOTICIST IS BUILDING ANDROIDS TO UNDERSTAND HUMANS, STARTING WITH HIMSELF.

## THE GEMINOID

As you might expect, Hiroshi Ishiguro, a roboticist at Osaka University in Japan, has built many robots. But his latest aren't run-of-the-mill automatons. Ishiguro's recent creations look like normal people. One is an android version of a middle-aged family man—himself.

Ishiguro built his mechanical twin using silicone rubber, pneumatic motors, powerful electronics, and hair from his own scalp. The robot, like the original, has a thin frame, a large head, furrowed brows, and eyes that (as one observer put it) “seem on the verge of emitting laser beams.” The android is fixed in a sitting posture, so it can't walk out of the lab and go fetch groceries. But it does a fine job of what it's intended to do: mimic a person.

Ishiguro controls this robot remotely, through his computer. He uses a microphone to capture his own voice and a camera to track his face and head movements. When Ishiguro speaks, the android reproduces his words and tone of voice. When Ishiguro tilts his head, the android copies him. The mechanical Ishiguro also blinks, twitches, and appears to be breathing.

It's the perfect tool for Ishiguro's area of research: human-robot interaction. The field is as much about people as it is about



Hiroshi Ishiguro hangs out with his robot double, Geminoid HI-1.

robots. “My research question is to know what is a human,” he tells me. “I use very human-like robots as test beds for my hypotheses”—ideas about human nature, intelligence, and behavior.

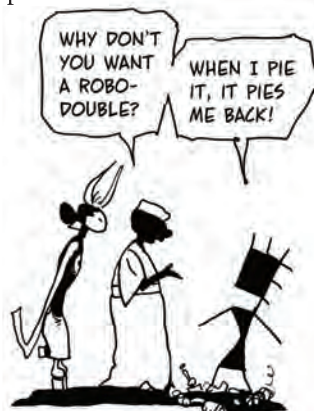
Robots, say Ishiguro and other scientists, are getting ready to move from their current factory jobs into daily life. The hope is that robots will one day help people with a multitude of tasks—they'll do household chores, care for the elderly, assist with physical therapy, monitor the sick at hospitals, teach classes, serve cappuccinos at Starbucks, you name it. But to be accepted

in these roles, robots may have to behave less like machines and more like us.

Researchers have, of course, long been interested in making robots look and act more like human beings. (You can see some examples on the next page.) But these robots are still mechanical looking, Ishiguro says, and our brains are wired to relate to other humans.

We're built for human-human interaction, not human-bot.

That's why Ishiguro builds robots that look just like people. It's part of his work at the Advanced Telecommunications Research Institute International (ATR), where he's a visiting group leader. To describe an android





copy of a particular individual, he coined the term “Geminoid.” It comes from *geminus*, the Latin word for “twin.” Ishiguro named his mechanical brother Geminoid HI-1.

By building human-like robots, Ishiguro hopes to understand what the Japanese call *sonzaikan*—the feeling of being in the presence of a human. Where does the sense of humanness come from? And can you convey those qualities with a robot?

He’s also investigating, with help from cognitive scientists, how a human brain behaves while it’s controlling an android. The idea of connecting a person’s brain with a remotely controlled body seems straight out of science fiction. In the movie *Avatar*, for example, humans control bodies that are alien-human hybrids.

Ishiguro’s “avatar” doesn’t have sensing and movement capabilities as sophisticated as the ones in the movie. But even this relatively simple android is giving Ishiguro great insight into how our brains work when we come face to face with a machine that looks like a person.

## THE FACE OF THE FUTURE

Hiroshi Ishiguro lives a frantic existence. He works at four labs, oversees some 50 students, is a cofounder of a new robotics business, and constantly travels to conferences around the world. No wonder he needs a copy of himself.

Ishiguro, who is 48, started building robots more than a decade ago, after he abandoned the idea of becoming an oil painter. One of the first robots he helped put together, named Robovie, looked like a trash can with arms. Another robot he worked with, called Wakamaru and developed by Mitsubishi Heavy Industries, resembled an overgrown insect. People had mixed reactions to those robots, which got Ishiguro thinking about how important appearance is to communication. And yet, he realized, the connection hadn’t been properly investigated.

Ishiguro wants his androids to look exactly like people, unlike the more vaguely human models you see here. Robonaut 2 (top) is a robotic torso that NASA designed to use tools and help astronauts with tasks that don’t require legs. Honda hopes its ASIMO robot (bottom) will one day be a helper to the elderly and disabled. And NAO (on the cover) is a knee-high companion robot and educational tool made by Aldebaran Robotics.



Just think: the world population of industrial and service robots as of 2010 was about 8.5 million, according to some estimates. That includes manufacturing robots, robots that move pallets, surgical robots, bomb-disposal robots, cow-milking robots, meat-handling robots, underwater and aerial robots, some 4 million home vacuum cleaners, and one that cleans the glass pyramid of the Louvre museum in Paris. That's to say nothing about the vast assortment of robot dogs, dinosaurs, seals, and other robot toys.

It's a fine bunch of helpful, or at least entertaining, hardware. Yet none of it matches the robots that science fiction promised the future would bring: Astro Boy, C-3PO, Data, Rosie from *The Jetsons*. Today's robots look more like other appliances than people. And even the best of them aren't very good company.

Many roboticists believe this is going to change. They have visions of robots that will assist us, talk to us, even care about us. Social robots are coming to life in labs at the Massachusetts Institute of Technology, Carnegie Mellon University, Georgia Institute of Technology, and elsewhere. Though nobody knows what types of robots will catch on first, they may soon be among us.

But do they have to *look* like us?

Some roboticists I spoke to aren't sure whether human-like androids are a good idea, or even necessary. On YouTube, many commenters call videos of the Geminoid "scary" and "freaky."

Ishiguro is unfazed. He acknowledges that in some situations you don't need or want your robot to resemble a person. You don't need an android to vacuum your house if a saucer on wheels can do a better job. And an elderly person being helped out of the tub by a robotic assistant might not want it to have a human face.

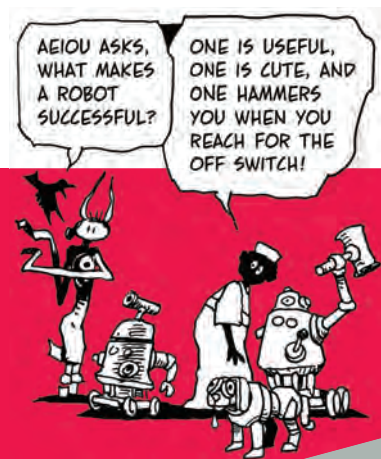
He's also well aware that, although people might connect better with a robot when it resembles another human being, slight imperfections in the technology can make the robot seem more like a zombie or an animated corpse. The Japanese roboticist Masahiro Mori called this creepy effect the "uncanny valley"—it's what happens when something approaches a lifelike appearance but doesn't quite get there.

Ishiguro says even though his creations might creep people out, that won't stop him from "trying to build the robots of the future as I imagine them." He is convinced that human-looking robots are a natural interface for humans to interact with. He also thinks the "uncanny valley" idea may be too simplistic to explain people's reactions to robots. We may simply come to accept lifelike androids as we see more of them and, in the future, rely on them for our care and other needs.

## NAVIGATING THE UNCANNY VALLEY

We visit Osaka University's Intelligent Robotics Laboratory, which Ishiguro directs. Robotic creatures great and small are everywhere—and they appear to be staring right at me. I ask him about a miniature android standing in a corner.

"That is my daughter's copy," Ishiguro says. The robot, which he built in 2001 and called Repliee R1, was based on his then four-year-old daughter. It has nine motors in its head, prosthetic eyeballs, and silicone skin. Ishiguro says that the eyelids looked unnatural and that only the mouth moved, so the robot's facial expressions couldn't change much. When the neck turned, a lack of stiffness in the body would cause the robot to shake. People told him that it gave them a strange, eerie feeling. That includes the robot's model—Ishiguro's daughter.



Who are you calling freaky?



Ishiguro modeled the Repliee RI android after his daughter at age four. His daughter wasn't a fan.

"She was scared very much," he says, "and almost cried." It took several meetings until she warmed up to her double.

Looking at his daughter next to her robot twin, Ishiguro must have been staring into the depths of the uncanny valley. His response was to attempt a flying leap over the chasm—to build a much better android. It is time he modeled it after an adult. Ishiguro shows me the result.

"This is Repliee Q2," he tells me, almost as if introducing a friend. The android has long golden-brown hair, glossy lips, perfect skin, and 42 motors embedded in her petite body. Perched on a stool, she—er, it—can talk about itself and sing Disney tunes.

Ishiguro built Repliee Q2 with help from the robotics company Kokoro, which has plenty of experience with animatronics. Kokoro engineers and Ishiguro's team worked especially hard to duplicate a woman's facial expressions, blinking, and hand movements. And they wrote software to simulate involuntary movements like breathing and subtle head twitches.

"All humans have these," Ishiguro says, "unless they're dead."

For the 2005 World Exposition in Aichi, Japan, Ishiguro replaced Repliee Q2's usual face with a face copied from a famous Japanese newscaster named



Ayako Fujii. Visitors lined up to talk to the robotic impersonator.

"An elderly gentleman came over and asked, 'Where's the android?' and he was standing right next to it," says Karl MacDorman, a former collaborator of Ishiguro's who now directs the Android Science Center at Indiana University–Purdue University, in Indianapolis. "Androids can press our Darwinian buttons—they are perfect

tools to study how our brains work."

Despite its success at looking realistic and capturing the attention of human visitors, this android revealed a serious problem. Artificial intelligence technology is still too primitive to imitate everyday human behavior, like the ability to have a conversation. So the robot's lifelike appearance was deceiving: people expected more than it could deliver.

After some careful reflection on the problem, Ishiguro decided to shift his focus from autonomous androids (those that work on their own) to teleoperated ones (those controlled remotely by a human). For that, he figured he'd start with a copy of a real person, someone he could trust and who'd be willing to become a guinea pig in long, tedious experiments. He'd reproduce himself.

Building on what he had done with Repliee Q2, Ishiguro added even more motors to the Geminoid: 13 in the face, 15 in the torso, and 22 in the arms and legs. His team used a cast to make a perfect copy of his physique. They improved the body-control software to generate even more precise motions and developed a computer vision system to synchronize the Geminoid's lips to the operator's.

So how did people react?

In the three years since completing the Geminoid, Ishiguro has tested the android on dozens of volunteers,



colleagues, and students, as well as his wife and daughter. In his experiments, he observed that people may feel uneasy at first, but they quickly adapt. Most people can have a natural conversation with his replica. No one ran away screaming in horror. He also showed that the Geminoid could be a good salesman, that children were eager to play games with it, and that pet owners were particularly skilled at reading its nonverbal cues.

His main conclusion is that in many situations, people respond to the Geminoid much like they do to other individuals. What's more, Ishiguro says, people who know him could detect his personality. The android, though not perfect, was able to convey Ishiguro's *sonzaikan*—his presence.

For Ishiguro, having a robot clone has practical uses as well—such as being in two places at once. Most of the time the Geminoid resides at ATR, which is in Kyoto, an hour's drive from Osaka. So Ishiguro uses the robot to attend meetings there.

"Very convenient," he says with a smile. "One problem is I can't get salary from ATR if I use the Geminoid. Therefore they still make me go there."

## THE HUMAN TOUCH

It's late at night, and Ishiguro sits in his lab at Osaka University. He's teleoperating the Geminoid, which is lounging nearly 6,000 miles (9,000 kilometers) away at a café in Linz, Austria. The android is there as part of the Ars Electronica festival. Ishiguro is chatting with a group of kids who noticed the robot. When a boy pokes the android's face.

"Yahh, don't touch to my face!" Ishiguro yells (and so does the Geminoid). The kids laugh.

But what just happened was quite profound. Ishiguro says that when the kid poked the robot's face, he felt a tingle on his own cheek. For an instant,

Like Skype with a whole extra body instead of just a computer screen, the Geminoid lets Ishiguro remotely visit other parts of the world. Computers send Ishiguro's words and gestures to the Geminoid, while he sees through its eyes.

Ishiguro's brain mistook his body for another—in Austria.

Ishiguro has experienced this many times in different settings, all with the same result: When someone touches the Geminoid, he feels as though the touch were real. He believes the phenomenon comes partly from watching the synchronization of the android's head and lips with his own. When Ishiguro uses the Geminoid, he sees video from external cameras that show the robot's field of view and also its face. Because he is watching the robot's lips move as he speaks and seeing its head move when he turns his own neck, Ishiguro's brain starts to treat the robot as an extension of his own body.

Even more surprising, Ishiguro says that when other people teleoperate the Geminoid, after a while they, too, may experience the "phantom poke." This means that an android doesn't even have to look like you for you to think of its body as your own!

Peter W. Halligan, a psychology professor at Cardiff University in Wales, who is not involved in the Geminoid project, says the phenomenon "sounds fascinating." He notes that a possible explanation is that humans have mirror neurons that fire both when we are touched and when we observe another person being touched. In normal situations, the sensation is suppressed. Does the act of teleoperating a robot trick the brain?



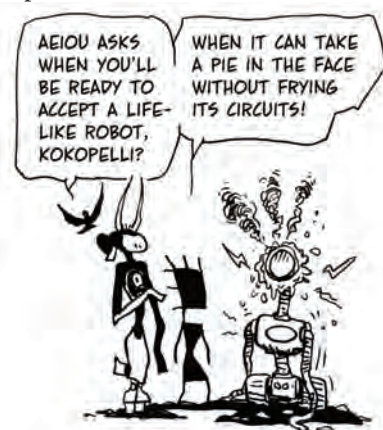


This model, called the Telenoid, is meant to be a generic android that anyone can use to transmit their presence somewhere else. Users young or old, male or female, could speak through the Telenoid just like Ishiguro with his Geminoid.

It's true that the brain fills in many gaps in the signals it gets from our eyes and other sensory organs. And our sense of our own bodies is more flexible than people might think. Recently, Swedish researchers showed that subjects wearing head-mounted displays (so they saw from the perspective of another person, or a mannequin) could experience another body as their own.

Ishiguro is working together with cognitive scientists to investigate the phenomenon. He's planning to use brain scans to find out what happens inside the operator's head when the Geminoid gets poked. He believes his results will show humans can easily adapt to robotic bodies.

Whether each of us will have our own Geminoid in the future remains to be



seen. But lifelike androids are already helping Ishiguro and others explore some of the pressing questions in human-robot interaction. What do people expect from robots? What social behaviors should robots exhibit? And how should they look? In the coming years, researchers will have to answer these questions to come up with design rules for building the next generation of social robots.

Ishiguro, for his part, believes “robotic telepresence” (a human remotely operating an android, like he does at his ATR meetings) will become a major form of communication over the next decade. Eventually, he thinks, human-like robots will become a part of our society—not just in factories or as labor-saving devices but as replacements for someone’s physical presence.

A future where androids may be so advanced that we can't tell them apart from ourselves doesn't frighten Ishiguro. “Humankind is always trying to replace human abilities with machines. That's our history,” he says. “I'm doing the same thing. Nothing special.”

*Erico Guizzo, or a robot that looks and acts exactly like him, lives in New York City and is a robotics editor for IEEE Spectrum magazine.*