DON HOFFMAN INTERVIEW PART ONE

Hello Ars Technica listeners. My name is Rob Reid, and welcome to Season Two of "Ars on your lunchbreak." In this series, we take episodes from my podcast - which is called The After On Podcast - and break them into two or three segments of roughly a half hour each, which you can listen to over the course of a few days while having lunch at your desk, or just avoiding your inbox.

My show dives deep into complex issues in science, tech and society which we should all probably understand a bit better. Each episode's built around an in-depth interview with a world-class expert in the relevant field**.** And I really mean world-class. For examples, the first season of this series - which ran on Ars in June and July - included a deep & wide-ranging conversation George Church. Who many consider to be the world's leading bioengineer, and pretty much everyone would put in the top 5, I think. We also had Rodney Brooks - who's the progenitor of countless robots, including the Roomba. And arguably the world's leading roboticist, and certainly in the top 5. And also Tim O'Reilly - who's been one of the most influential commentators on, and participants in the tech scene since the early 90s.

I do 20-30 hours of up-front research and preparation before sitting down with my guests. And I structure my interviews carefully, so that their information density hopefully feels a bit more like TED talk than a meandering long-form interview. Ideally, I try to bring my listeners from a glancing familiarity with the day's subject to a top-percentile understanding of it in the course of the 60 to 90 minutes that most of my episodes run.

A brief word on my own background, in case you're curious: I'm a recovering serial entrepreneur. The best-known company that I started back in the day built the Rhapsody music service, which created the unlimited on-demand streaming model that most people now associate with Spotify. These days, my main job is writing sprawling science fiction novels for the Del Rey imprint at Random House. And, also of course, I podcast.

The episode installments that we'll be posting here on Ars will each run with a mini-article that'll give you a sense of what we're talking about in the day's audio segment. Also an embedded player, which will let you to hear the sucker. And a transcript, if you'd rather read the thing.

If you like what I do, I hope you'll consider subscribing to my podcast and listening to some of the episodes in archive - all of which were designed to have long shelf lives, and none of which have gone stale yet. You can find my full archive of roughly 35 episodes at after-on.com. Or by simply typing the words After On into the search window of your favorite podcast player.

Today's episode is the first of three installments of a truly mind-bending conversation I had UC Irvine quantitative psychologist Don Hoffman.

Rob Reid: Don has spent the last few decades honing an extraordinary theory about the nature of reality. It will violate every intuition you have about the physical world you inhabit. For instance, Don will say this:

Don Hoffman: Three dimensional space, as you perceive it right now, is just your desktop, and physical object like tables and chairs, the sun and the moon, are just icons that are in the desktop. They're not the objective reality. They don't resemble objective reality. They're just symbols that let us interact with whatever objective reality is while we're completely ignorant about the nature of that objective reality.

Rob Reid: You're going to be like, "What?" Now, if you're new to the show, welcome. It features in depth conversations with world class experts about their domains of knowledge. In each episode, I try to bring you and myself a serious grounding in something complex and important that we should all probably understand a little bit better. I hope you enjoy this episode. If you do, please browse the show's archives at after-on.com or in your favorite podcasting app. You'll find fascinating conversations with some of the top people in robotics, synthetic biology, neuroscience, and astrophysics, among other fields, as well as the founders of some truly agenda setting startups. Or, another topic, the very nature of reality, which we're discussing with Don Hoffman today.

Rob Reid: Now, however improbable and mind bending Don's theories may seem to you, it's worth the time and brainpower to suspend your disbelief and listen carefully for the next hour to follow his logic arguments, evidence, and his highly evocative metaphors. I don't say this because I'm entirely convinced Don is correct about the nature of reality. I am not, and you probably won't be either.

Rob Reid: But reality's final and accurate description will be at least as jarring, and do just as much violence to our intuitions as anything Don is going to say today. Even if he turns out to be dead wrong about everything, processing his viewpoint will help you prepare to comprehend that endpoint description of reality whenever we reach it. By the way, you should probably also eat right, and get plenty of exercise because getting to our final understanding of reality could take a while.

Rob Reid: But anyway, once again, whatever that final understanding is, it will be horrifyingly strange because it'll have to explain some truly bizarre phenomena that have bedeviled humanity's greatest minds for decades, and in some cases for centuries. These include certain quantum paradoxes, the baffling question of how consciousness can arise from inert matter, the exotic sensory experiences of over 100 million humans, with the condition called Synesthesia. It's impossible to say that normal perception is "right" and the Synesthetes are wrong, so what's going on?

Rob Reid: We'll discuss all these things in the coming hour. Don's account of reality accommodates them all pretty snugly at the cost of violating most of our intuitions about every other aspect of reality. But we already reject some of our strongest intuitions to accommodate facts that every child accepts.

Rob Reid: To take an example, Don points to at the start of our conversation, what could be more intuitive than the idea that the ground is flat and solid, and that there's this single objectively correct direction which we can define as up. Yet, we all accept that we're walking on a sphere that's floating in a boundless vacuum, in which there is no up. This is both utterly counterintuitive and utterly noncontroversial. Don's depiction of realty isn't much more intuitively repellent than that.

Rob Reid: By the way, check out the competition. A few hours marinating in string theory, the holographic universe model, or eternalism, will prove that no one has a monopoly on weirdness. So again, listen to Don's arguments without prejudice, parse them as best you can, and then decide if you accept or reject them.

Rob Reid: That's my own approach to this sort of material, for what it's worth. I could have spent my time with Don debating his points, which would have been huge fun for both of us. But instead, I onboarded his perspective as much as I could, which has given me a lot more to chew on. For what it's worth, Don and I should have plenty of chances to debate things in the future because I happen to get to his hometown of Irvine pretty often. In fact, we've already had lunch once since our interview, and as I record this, our interview was just three days ago.

Rob Reid: With that, let's see what Don Hoffman has to say about the exceedingly strange world that we live in.

Rob Reid: I'd first of all like to say it's great to be meeting you here in Irvine because I do come to Irvine a lot for a New Yorker. I sit on the board of a digital health company here. We also have some other family business here as well. Thank you for being located here, of all places. It's very convenient.

Don Hoffman: My pleasure, and thanks for coming to my office.

Rob Reid: You've been a professor here at UC Irvine for quite some time now, right?

Don Hoffman: Since July of 1983.

Rob Reid: July of '83. Not as far back as June of '83, but July of '83 is quite some time ago. You're a quantitative psychologist. Could you describe briefly what that is?

Don Hoffman: It's doing psychology and the psychology experiments, psychology theories, but being very mathematical about it. Trying to come up with mathematical theories about, for example in the case of perception, how do we see in three-D, how we see the motions of objects, how do we recognize objects. But to have a mathematically precise theory. Then also, to do experiments where we're doing mathematical analyses of the data.

Rob Reid: Now, much of your work contradicts a proposition that I think most scientifically minded people would probably agree with if they heard it. Specifically, that it's

overwhelmingly advantageous to perceive reality more or less as it is from a survival and evolutionary standpoint. If I completely fail to perceive an SUV that's barreling down the road and step in front of it, I'll have a hard time passing my genes along to future generations of pedestrians. Therefore, people might suppose that over thousands of generations, people and animals have evolved to have a fairly accurate perception of reality.

Rob Reid: Now however intuitive that proposition may seem, you believe it's entirely wrong. In arguing this, you quite correctly point out that at many times in scientific history, we've discovered things which seem massively intuitive turn out to be massively wrong.

Don Hoffman: Oh, yes, so we used to think the earth was flat because anybody can just look around see that it looks flat. There are some hills and so forth, but other than that, as far as the eye see it looks quite flat. Until about the time of Pythagoras, a few hundred years BC, everybody pretty much that thought about it thought the earth was flat. It took a real bright group of Greeks to figure this thing out, and figure out, "No, it's not flat. It's more like a sphere."

Don Hoffman: Then for many centuries after that, almost 20 centuries, the very bright people believed the earth wasn't flat. It was like a sphere. But they believed that the earth is the center of the universe and doesn't move, and again because it looks that way. We see the sun and the moon and stars seeming to go around in arcs around us while we stay at the center. We mistook our perceptions for an insight into reality. It even was church doctrine that the earth is the center of the universe. It fit in nicely with the whole world view that they had.

Rob Reid: Galileo famously got into a fair amount of trouble by arguing otherwise, and other scientists as well. It is really true few things seem more intuitive than the flatness of the earth to a person standing at any point on earth.

Rob Reid: When you argue that our intuitions could again be wrong, and our perceptions might just diverge wildly from objective reality yet still be advantageous, you often cite a very powerful metaphor of a computer desktop.

Don Hoffman: That's right. The idea about the computer desktop is that our desktop interface hides a lot of complexity inside the computer. If you're writing an email and the icon for it is blue and rectangular in the middle of the screen, does that mean that the file itself in the computer is actually blue and rectangular in the middle of the computer? Well, of course not.

Don Hoffman: Anybody who thought that just misunderstands the whole point of the desktop interface. It's not there to show you the truth of the computer. It's there to hide all the transistors and software and voltages and magnetic fields. If you had to toggle voltages to craft an email, no one would hear from you.

Don Hoffman: The interface is there, not to show you the truth, but to hide the truth. But even though it hides the truth, it lets you control the truth. It lets control reality by giving you just the reins that you need to control it without showing you what the reality is that you're controlling.

Rob Reid: Now when we move from the computer desktop to reality as we perceive it, we find that our senses sometimes make similarly radical simplifications of the world around us, thereby making it comprehensible. An example you use, that I find quite powerful, is the experience of heat.

Don Hoffman: When you put your hand into a bathtub of water for example, and feel the temperature of it, you just get a simple feeling from very very cold, to lukewarm, to very very hot. But what's going on, the physicist will tell us, is far more complicated. That there are trillions upon trillions of molecules that are bouncing around in all sorts of complicated ways. All we're doing, when we feel something being hot or cold, is a statistical summary of something that's far more complicated. We're getting effectively one or two numbers, but there are trillions of things going on. We have a huge data compression.

Rob Reid: It's a radical simplification again, without which we simply couldn't operate in a world of heat versus cold. That's one sensory simplification of reality that we've all experienced. You argue it goes far beyond sensory mapping to the entire experience of space and time.

Don Hoffman: That's what evolution has done for us. Space time, three dimensional space as you perceive it right now, is just your desktop. Physical objects like tables and chairs, the sun and the moon, are just icons that are in the desktop. They're not the objective reality. They don't resemble objective reality. They're just symbols that let us interact with whatever objective reality is, while we're completely ignorant about the nature of that objective reality.

Rob Reid: The chair that I'm sitting on in this view of reality, it has a certain look and feel, it's got a pretty good UI for me. I know where to put myself. I know how to settle myself into it in order to not collapse onto the ground. What you would argue is this is a radical simplification of something that might be unimaginably complex or might just be unimaginably different. But it is an icon that is as useful to me as the trash folder on my computer. I guess you're going to tell that there is not actually a trashcan sitting inside my computer?

Don Hoffman: That's exactly right.

Rob Reid: That's also a metaphor, got it, got it.

Don Hoffman: That's right. The trashcan icon doesn't mean there's a real trashcan inside your computer, but it is a useful icon to tell you that if you drag your email icon to the trashcan icon, you'll delete that icon. That's also a warning.

Don Hoffman: Or, another example, if you have a paintbrush icon. But there's no paintbrush inside the computer. There is a complex program that you're utterly ignorant of, and it's doing all sorts of thing to pixels that you don't want to know. Yet, by having just that simple paintbrush icon, you can do your drawing or your illustration.

Rob Reid: It would, needless to say, be beyond impossible for any near mortal to do the manipulations necessary within the memory of the computer to have the impact of that paint stroke if we didn't have that iconic layer. When you start applying that to physical objects that we know and love like chairs and spoons and the sun, it starts sounding like you're taking the metaphor a little far. It sounds a little bit radical, although it's definitely uncontroversial to say that we don't perceive all of reality.

Rob Reid: For instance, I believe it's far less than a thousandth of one percent of the electromagnetic spectrum that we perceive. Other creatures that we share this planet with actually perceive other parts of the electromagnetic spectrums. Sometimes this is called the Umwelt. Would you care to talk about that a little bit?

Don Hoffman: In my language, I would say the Umwelt idea is that every creature has been shaped by natural selection to have its own user interface, depending on which niche it's going to occupy. Humans, we create a space time desktop with certain types of physical objects. As you mentioned, we have a certain range of light that we can see, electromagnetic spectrum. But birds have a broader spectrum than us. They can see in ultraviolet, where we can't. Pit vipers can perceive some infrared that we can't. Some fish can perceive electrical fields in the water and we can't. Some birds and perhaps bees can even see the polarization of sunlight. There's all sorts-

Rob Reid: I didn't know they could see polarization.

Don Hoffman: Yeah, there are some I believe birds or bees that can see polarization as well.

Rob Reid: Wow.

Don Hoffman: Different creatures have different interfaces for the niches that they're occupying. Much of the competition between different species is an arms race between interfaces. For example, with mimicry and camouflage you're trying to find the vulnerabilities in the interfaces of your predators or prey and exploit those vulnerabilities. Our interfaces evolved due to all these different selection pressures.

Rob Reid: David Eagleman, I interviewed a few episodes ago, gave a fascinating example. I'm sure I'm going to get this species wrong, but it's something like the stoplight lantern fish or something like that. It's a fish that lives so deep in the ocean that red light cannot penetrate. There's no red light down there. But it emits, it

phosphoresces a red light. It has this very clever chemical trick to actually perceive that very frequency of red light. This particular fish, they can signal each other for mating purposes, for socialization. It's almost like they have their own encryption layer down there because their Umwelt perceives red light.

Rob Reid: It is uncontroversial to say we don't see all of reality. It is uncontroversial to say different critters have different takes on reality. Another thing that is uncontroversial to say is that an enormous of reality reconstruction or perhaps construction occurs within the brain. You make this point in your book about how enormous the visual cortex is. How large it is, is a proportion of the brain and why it has to be that big. All the different tasks that it's carrying out.

Don Hoffman: The standard view that we have intuitively in the case of visual perception, we're just taking a picture of the world, just like a camera. That idea is too simple. A third of the brain's cortex is involved in vision, literally billions of neurons. I would guess 20 to 30 billion neurons and trillions of synapses spring into action every time you just open your eyes and just look around the room.

Don Hoffman: That's far more computational power than you would need just to take a picture. The standard view in my field is that all that computational power is there because they think of the brain as a reality engine. We are in real time creating all the three dimensional shapes that we see, the colors, the motions, the objects-

Rob Reid: 'Cause there are profound physiological limitations to vision. For instance, it's only one or two degrees out of a field of view, which is something like 250 by 150 degrees. It's only the middle two degrees that we truly see in high definition, correct?

Don Hoffman: Exactly, the full field of vision is all that we have of high resolution, which is quite counterintuitive. We feel like we see high resolution everywhere in the visual world, but we don't.

Rob Reid: We do not. The traditional neuroscientists would say that the visual cortex is so large, partly because it's filling in high-def where there's only a tiny speck of it. Tell us what saccades and fixations are because that's quite an amazing thing that the brain has to compensate for as well.

Don Hoffman: That's right. Your eyes jump around two to three times a second, maybe up to four times a second. You're evaluating the whole visual field to see where something of interest might be happening. Things that are flickering, moving, high contrast, we're always looking at those things.

Rob Reid: Not just that, but in normal everyday interactions, our eyes are constantly darting, and even just having a conversation with somebody, your eye is darting from the left side to the right side of their face, et cetera. We'd think it'd be almost like the Blair Witch project, that old movie where the camera's shaking

everywhere. But the brain is correcting for that. Then, of course, also the back of the retina's two dimensional and as you'd said earlier, we're constructing this three-D view. The traditional neuroscientist would say because we've got this tiny narrow bit of HD, we're constantly darting around. We're kind of got this two-D image, and we're taking all those inputs, and pulling it into this big full vibrant wide angle HD image. That's what this third of the brain is doing.

Rob Reid: Who was it that said, "We don't see with our eyes. We see with our brains"?

Don Hoffman: I don't who said that, but it is common in the neurosciences to say effectively that it's the brain that's doing all the hard work.

Rob Reid: Well, the traditional neuroscientific view is the brain is reconstructing reality. I believe you would argue with all that horsepower, there's no reason it can't be constructing reality essentially from whole cloth.

Don Hoffman: Everybody in my field, all my colleagues believe that we're constructing what we see. But that in the normal case, what we construct is a fairly accurate and faithful reconstruction of the true shapes, and colors, and motions of real objects, and I'm saying in some sense something less radical. I'm just saying we construct. To say we construct and that the constructions are reconstructions is a much stronger claim.

Rob Reid: Yeah, the traditional view is that third of the brain, which is visual, is a reality engine. You would suggest that it is a virtual reality engine.

Don Hoffman: Exactly right. We've had the helmet on all the time.

Rob Reid: One thing that might support this is this phenomenon called synesthesia. Could you talk a little bit about synesthetes, which are the people who experience the phenomenon of synesthesia?

Don Hoffman: About four percent of humans are synesthetes, where they have a melding of the senses that most of us don't experience. To be concrete, one synesthete named Michael Watson, everything that he tasted on his tongue, he felt in three-D space in front of him with his hands. He could actually palpate them with his fingers in front of him. He didn't see them, but he felt these objects. So mint felt like a tall cold smooth column of glass. Every time he tasted mint, he could feel with his hands this cold smooth column of glass in front of him. Every time he tasted Angostura of bitters, he felt a basket of ivy. He could feel the texture of the leaves, the shape of the leaves. It was not an abstract idea. It was a concrete perceptual feeling.

Don Hoffman: Here's a case where he's creating a three dimensional object to represent something that's utterly unlike that object. Angostura of bitters in no way resembles a basket of ivy. Mint in no way resembles a tall cold column of glass.

Those objects that he created in his perceptual system were merely icons. They were useful icons to do a job, but they weren't there to resemble anything.

Rob Reid: Was his job, just out of curiosity, mixology? Was he a cocktail maker? 'Cause both of those things sound like things that go into fancy drinks.

Don Hoffman: He wasn't a mixologist, but he was an accomplished cook because every taste had a unique a three dimensional shape. I only gave two examples. Every taste had a three dimensional shape. It was a huge repertoire of objects. He used that to do some fantastic cooking.

Rob Reid: Now that is an extreme case. When you talk about something like that and then say that's one out of 25 people, people might say wait, I've certainly never met somebody like that. But in more mild cases, people will have a very strong association between different numbers and different colors for instance, right? What are some of the more mild manifestations?

Don Hoffman: That's one of the more common one is what they call color graphing synesthesia. Each printed letter or printed number has a specific color. Maybe one is red and two is green and so forth. For each synesthete, that association of numbers or letters and colors is constant over their whole life. It varies from synesthete to synesthete, but it's constant over life.

Don Hoffman: Another kind that's common is to have a visual experience, say of a color, to something that you hear. One extreme case of that is a woman named Carol Steen. Everything that she hears, she actually sees not just a color, but a three dimensional object with a specific shape, and a specific color, and a specific texture to it. She has this sculpture she made ... she's an artist as well ... for the sound Cyto. When she hears Cyto, there is a specific three dimensional shape that she sees. You can look it up. She can see her sculpture and get a feeling for how specific and detailed the objects are that she sees for each sound that she hears.

Don Hoffman: But even that specific static sculpture doesn't quite do justice because she says, "As the word is being pronounced, Cyto, the sculpture is changing. It's moving. It's dynamic." She can only capture one frame of that.

Don Hoffman: This is a very, very rich user interface that evolution is trying out. Who knows? Maybe her interface will be the one that catches on later on.

Rob Reid: As we're talking here, I'm just realizing I might have the mildest, mildest case of synesthesia myself. I hadn't really thought of it until now, but for a dozen and a half U.S. states, I have overwhelmingly powerful color associations. I grew up in Connecticut. To me Connecticut is yellow. Not the state, it's not like the streets and the houses and the people are yellow, but Connecticut summons yellow, Rhode Island summons green, Massachusetts summons sort of like an earth brown, Florida summons a bright orangy-red, and that's as far as it goes with

me. But it's interesting that that exists on a spectrum, and there are these very powerful examples. And this is not maladaptive. These people obviously have not been selected out by evolution, and it actually brings, in some cases that you just cited, tremendous advantages in certain areas.

Don Hoffman: Absolutely. For Michael Watson, it helped him in his cooking, and he had an advantage over the rest of us in his cooking. Carol Stein as an artist has a real advantage. Anything she hears creates such a volume of beautiful visual images that she has this wealth of work.

Rob Reid: It's almost like they both have unfair advantages in these areas of expression that they've chosen, and it's interesting to contemplate. If we go back on the savanna, it would be very advantageous to not get devoured by a lion.

Don Hoffman: I would agree.

Rob Reid: Now imagine we end up in an evolutionary environment in which the survival of the fittest means that you open an awesome restaurant. We've ended up in some evolutionary setting in which only great cooks have lots of kids. In such a world, the genes for experiencing these 3D shapes for different tastes and a very, very rich pallette of them, could be selected for generation over generation over generation, and eventually all humans will have descended from a series of great chefs who all get to have lots and lots of kids, and that would become consensus reality. Of course mint is a cold glass column.

Don Hoffman: Absolutely. That is exactly the right logic of evolution by natural selection. That's why we have the interface that we have right now. It was the vagaries of our evolutionary past, and what happened to work in the niche that we happened to be in. You're absolutely right. In that scenario, there would be selection pressures for us to all have something like Michael Watson's synesthesia.

Rob Reid: And instead we have whatever the really good lion-dodgers.

Don Hoffman: Exactly.

Rob Reid: However they perceived the world, the good lion dodgers are the people who've handed down our genes.

END INTERVIEW ELEMENT OF PART ONE