Edward Boyden

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Ed Boyden: Well, my dream is that we could make a biophysically realistic computer model. So a piece of software, let's say, that could simulate a thought or an emotion that is also — ideally, there's no guarantee that it will be, but ideally — human understandable. So, we would really understand what a thought is, what an emotion is.

And so my dream is that this would help us become more enlightened as a species, because we would know why we do what we do, and we would know why we feel the way we feel, because we would be able to peer inside and see the mechanisms of that.

I also think that this means that we need certain technologies. We need to see what's going on inside the brain. We have to be able to make maps of the brain, and we have to be able to control what's going on in the brain. And so as a byproduct of that quest, my hope is that we can develop all sorts of treatments for diseases which are ... almost all brain diseases, currently, they're intractable.

Well, I don't know how unusual it is, but it does seem, doesn't it, that a lot of people have an area of expertise, and then they look around with their hammer and say-

Julia Galef: They inch outward from it.

Ed Boyden: Hey, where ... Is there a nail I can hit with it?

Julia Galef: Yeah, yeah.

Ed Boyden: Whereas we try to be the opposite. We can pick a big problem. We can try to survey all the different disciplines of science and engineering. Chemistry, physics, math, computer science, electrical engineering.

And that's helped two things. One is that, as I alluded to earlier in the conversation, I had a very broad based education in chemistry and in physics, and electrical engineering and so forth. That's kind of nice.

But then also, I find that people love to collaborate, and there are lots of experts in different areas where you might meet somebody who's the best person in the world at quantum dot engineering, or the best in the world at a certain kind of computer science, or a certain kind of chemistry, and we can connect with them.

And so the third step is what I often call constructive failures. We try lots of things out, and although a bunch of it fails, we don't just chill off the failure. We try to extract wisdom from it. We've now seen something nobody's seen before, and even if it's not directly solving the problem, it might tell us what to do next.

And then finally is what I call designer discovery, where we go forth and actually make the real design of the technology, or we make the actual discovery of what we want. And those kinds of things happen a lot. It happened with optogenetics. It happened with expansion microscopy, where there was sometimes a multi year gap between having an idea and then going through the failure phase, and realizing the actual path we wanted to go down.

Ed Boyden: Maybe we can help clear up the backlog a little bit by digging one level deeper.

Julia Galef: I've heard that the process of developing new tools is under-incentivized in science in general. Meaning that it's pretty valuable on the margin to have new and better tools - but nevertheless, for whatever reason, people don't get very much prestige or funding for doing so.

Is that your impression too? And if so, why do you think that is?

Ed Boyden: It's changing. I think your assessment is overall correct, in part because for a long time, tools were a little bit invisible. If you discovered crescent proteins or created a new sequencing reagent, maybe millions of people would use it, but ultimately what the public sees is a cure or a diagnostic, and the tools that yielded it sometimes go unheralded.

But a couple things have been changing. First of all, and this is more recent than most people think… Departments of bioengineering, or at MIT we have a Department of Biological Engineering, it's only a little more than a decade old. This is a fairly new idea that we should go forth and build tools that confront biological mysteries, and that allow the engineering of biological systems, right? So it's not an old idea, necessarily, at many places.

The second thing is that tools have become visible. And I think it's in part because some of the tools have spread so quickly. I think everybody's heard of CRISPR as well, that they have become visible in their own right in the way that previous toolsets were not, necessarily.

In my own life I've seen this change a lot. One reason why my home base is at the MIT media lab is because a lot of traditional departments at universities turned me down for faculty positions.

This expansion microscopy technology that I mentioned earlier — the first time, 10 times we submitted government grants, on peer review. I think nine times out of ten, the grants were rejected. And so that was kind of depressing, 'cause how can we get the money to fund the project?

And then what came to the rescue was the Open Philanthropy project.

Ed Boyden: Yeah. So this is analogous to the strategy that Karl and I took toward optogenetics, where we were just going through all the laws of physics, mechanical, magnetic, and optical and so forth.

The basic idea is, okay, you got a big problem. Great. That's a good start. Think backwards from that problem, and survey all the different disciplines of science and engineering, and try to think of every possible way to solve the problem. Now how can you do that? Well, the answer is, you can take the space of possible solutions and split it into two sets, and then keep splitting the sets into smaller and smaller sets, until you finally end up with individual ideas.

So for example, suppose you want to take the space of all possible energy systems. Okay, you could split it into renewable and non-renewable. Then you could take renewable and split it into two subsets, like solar and non-solar. And already things are getting interesting, right? Because how often do you think about a non-solar renewable system? So already we'll gonna have to stretch our imaginations. Maybe there's geothermal. Maybe there's the tides of the oceans caused by the moon.

And so eventually the goal is to split these categories into subsets so small that they are individual ideas that you could then test experimentally, or through calculation. But it's a very powerful way to think about it.

For brain interfacing, you could try to digitize the brain information inside the brain and then beam it out. Or you could try to beam out the information in some other way like an Interlog form, and digitize it outside. And by doing these sort of binary chops, which of course results in this tree-like diagram, which is why we call it a tiling tree. The diagram looks like a tree, but at each level of the tree, the different nodes of the tree should tile the space of all possible ideas. Like, tiles on the bathroom floor.

It's a very useful exercise in idea generation. And we used it a lot in my classes as well as in my research group.