Podcast interview: Paloma Gonzalez-Bellido, Hanchuan Peng, and Apostolos P. Georgopoulos

PNAS: I’m Sandeep Ravindran and welcome back to Science Sessions. Today you’ll be listening to Paloma Gonzalez-Bellido, Hanchuan Peng, and Apostolos Georgopoulos, who along with co-authors Jinzhu Yang and Robert Olbert won the 2012 PNAS Cozzarelli Prize in biological sciences. They received the prize for their PNAS paper describing the neural basis for how dragonflies track and intercept their prey. Gonzalez-Bellido starts by explaining how dragonflies catch prey.

Gonzalez-Bellido: Dragonflies are amazing predators. They actually contrast their prey against a clear sky, and once they’ve seen one they will actually take off after it and they will intercept it. So once they see their prey they must actually detect how far the prey is, and what size the prey is. And if that’s correct, then they just keep track of it, and they keep changing their direction constantly until they intercept it. From an outsider’s point of view it looks like a very complicated problem. This is why dragonflies are interesting, they are ancient animals, and they have relatively small brains and fewer cells, and they do this very well. So it must be easy, at some level, to do this.

PNAS: How did you look for the neural basis of dragonfly prey-tracking?

Gonzalez-Bellido: So in our paper we played or we worked with 16 neurons. We knew that they were direction-sensitive. If you present a target or a small dot that they will actually respond to that movement. So what we wanted to test in this study was how do they work as a group. What are they telling the motor centers, because these cells receive input from the eyes to the brain, and then they actually send that information to the wing. So to record from these cells we actually use a projection screen, and we projected moving dots that were moving randomly. But we always used the same sequence. And so we projected this to every single cell that we found, and recorded their responses through intracellular recordings. Once we had that data we analyzed to which direction and which location they actually were responsive to. And here, professor Apostolos, he took that data and then calculated the vector from that, and what we saw is that they actually code the direction of the prey. And Hanchuan actually did the tracing of these cells so we could actually identify which cells we were working with.

PNAS: Peng describes how he identified the 16 neurons, called target-selective descending neurons, that were involved in prey-tracking.

Peng: My group had developed some sort of like advanced, automated tracing method, to digitize the 3D morphology, and characterize which branch connects to which. And with this detailed morphological information we will be able to compare the 16 neurons in detail. And so we developed a lot of tools for this purpose. And it turned out to be really surprising, that 8 pairs of neurons could accomplish such a complicated behavior. And another interesting aspect of this is how to actually correlate the morphology with respect to their respective receptor field and physiology data as well as the downstream analysis part.
**PNAS:** Geogopoulos talks about his role in analyzing how these 16 neurons coded for the direction of the dragonfly’s target.

**Geogopoulos:** Where I come in is in the, you know, data analysis to try to recover the direction of the stimulus. The data themselves were amazing. You had the intracellular recordings, 2500 plus motions or directional stimuli to work with, which is unheard of in my field, in electrophysiology. And then you have these cells traced so you know exactly what they are. And the method we applied is something that we started in the early ’80s, called the neuron population vector analysis, and that really takes directional tuning information from various cells and puts them together as a weighted directional vector sum, and you get an outcome, you get an output that tells you what the neural prediction is of the population. It turned out that the results here were phenomenal. It was extremely, highly accurate, that actually conformed very well to the behavior of the fly that is very accurate in catching the prey. The explanation for my part is that these cells are hardwired. You know, you have few cells, but over evolution they have been extremely efficient in their relations, their projections to the motor centers. So I’m not surprised in retrospect that this worked, but it was a phenomenal success.

**PNAS:** What are some of the applications of this work?

**Geogopoulos:** Dragonfly is a wonderful system because you know the connections, so you can replicate the whole circuit. Let’s say if you have sort of unlimited funding, you can take and replicate a dragonfly, you know, and you can get down to making say, not exactly a drone, but a robotic sort of equivalent that can serve all kinds of purposes, for peace, and war, and so on and so forth. Actually the fact that it has not evolved for so many years, it means that it’s pretty adequate. So I think it’s a fantastic potential.

**PNAS:** The Cozzarelli prize is awarded annually by PNAS to acknowledge recently published papers that reflect scientific excellence and originality. You can find more Science Sessions podcasts at PNAS.org.