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SFU professor Max Donelan begins measurements of elephant nerve conduction velocity.

SCIENCE

SFU study may explain why bigger animals are slower

Because signals must travel farther from nerve to brain in big animals, responses take longer

BY CHAD SKELTON
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It takes an elephant's muscles roughly 100 times longer than a shrew's to respond to its environment because of the extra distance signals have to travel from its nerves to its brain, according to a new study by researchers at Simon Fraser University.

The finding may explain why larger animals move so slowly.

And it might mean big animals need to be smarter, too, because they must anticipate changes in their environment with delayed and often sketchy information.

SFU kinesiology professor Max Donelan and PhD student Heather More determined the speed of the shrew's muscle responses by giving the animal small electrical pulses in the lab.

Measuring the elephant was a bit more complicated.

Donelan outfitted Lucy, an Asian elephant at the Edmonton zoo, with a device on her leg that measured muscle activity.

He then hit her foot with a tendon tap — essentially the same thing your doctor does to your knee — to measure how quickly her muscles responded.

"You do wonder whether or not you're going to get your foot stepped on," Donelan said of the experiment's risks.

The tests found the electrical impulses travelled along both animals' nervous systems at about the same speed.

But because of Lucy's size, it took about 100 milliseconds for her brain to get the message and tell her muscles to respond, compared with just one millisecond for the shrew.

To put that in perspective, said Donelan, 100 milliseconds is about half the length of time an elephant's foot stays on the ground when it's stampeding.

So by the time a running elephant realizes something is wrong — like it has stepped on a sharp rock — it's too late to do much about it.

Donelan said this may explain why large animals tend to avoid running, preferring slow, deliberate movements that give them time to react if something goes wrong.

In contrast, shrews can respond almost instantaneously to their environment, allowing them to scurry around in safety. "The shrew has the ability to change things as they're happening," Donelan said. "In a large animal you don't, so you have to really think ahead."

Donelan said the speed limit on animals' muscle reactions is not a law of nature, but a consequence of the inherent tradeoffs in the nervous system.

In some ways, it's like trying to watch a YouTube video on a bad Internet connection.

You can either watch a grainy video right away or wait for the high-definition version to load. An animal's nerve, like an Internet connection, has only so much bandwidth.

The speed can be increased by making the nerve bigger, but there are limits.

For example, Donelan said, if an elephant's nervous system was as fast and precise as the shrew's, its sciatic nerve would be about 30 metres wide.

So if large animals get such delayed and imprecise sensory information, how do they survive?

Donelan thinks large animals have bigger brains, allowing them to anticipate what might happen based on the sketchy information they receive.

"The bigger you are, the better you have to be in taking in delayed sensory information and predicting its consequences," he said. "In a way it's like predicting the weather a week in advance rather than a day in advance."

It's even possible that the brainpower larger animals have developed to navigate their physical space might give them an edge in other areas.

"Because they need to be able to predict things better with their movement, they might also be able to predict other things better," More said.

"That could be one of the reasons they're often more intelligent."

Donelan and Moore's study was published in the most recent edition of the *Proceedings of the Royal Society B*.

cskelton@vancouversun.com