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ONE FISH, TWO FISH, DUMB FISH, DEAD FISH

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Written by Jennifer Evans

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TODAY'S ISSUE IN PDF FORMAT

In the war for survival, it pays for males to choose their battles wisely, especially when food and females are involved. The poor guy who makes the mistake of picking a fight and losing is unlikely to attract many mates. For animals, the ability to determine one's rank among competitors without direct contact reduces needless fighting and wasted energy. Now, Stanford scientists say fish are capable of deducing how they stack up against the competition by simply watching fellow tank-mates duke it out.

The Stanford discovery is the first to show fish use known information to deduce unknown relationships, using a type of reasoning called transitive inference. Most humans develop TI reasoning skills by the age of 5. According to Charles Kalish, UW-Madison professor of educational psychology, our earliest inferences tend to focus on concepts of "greater than" and "less than."

"If Julie has more toys than Sarah and Anne has more toys than Julie, then [a child] will recognize that Anne has more toys than Sarah," explained Kalish. "Transitive inference allows children to see where a new thing fits into a known sequence."

To test if fish possess the ability to demonstrate TI, Logan Grosenick, Tricia S. Clement and Russell Fernald, three Stanford scientists, chose to stage fights between male A. burtoni fish. Although A. burtoni are small—on average, 4 inches long—these males know how to fight, and will frequently engage in saltwater battles to determine dominance within the groups.

According to Deric Bownd, UW-Madison professor of molecular biology, the relationships displayed among the A. burtoni males are common in the animal kingdom.

"In many social species, a behavioral hierarchy establishes itself which regulates who gets first access to food and mates," wrote Bownd in an e-mail.

Taking advantage of the aggressive nature of the A. burtoni males, scientists created a series of four territorial, one-on-one fish fights in separate compartments along the periphery of a fish tank. For the matchups, fish A squared off against fish B, B vs. C, C vs. D and D vs. E. Scientists fixed these fights so that fish A was always victorious against fish B, B beat C, C defeated D and D beat E. While the rival fish were slugging it out twice a day, one lone fish spied through a tank window.

After witnessing days of the fish fights with identical outcomes, the researchers put the bystander to the test by placing him between two former rival fish, which he had never observed in battle. While sandwiched in a tank between Fish B and Fish D, as well as other previously unmatched rivals, scientists observed the amount of time that the bystander fish spent near each former competitor. According to Fernald, previous studies suggest that the bystander will spend more time near the rival that he perceives to be less dangerous.

By measuring the time the bystander spent next to former rival fish, the researchers showed the bystander was able to rank the competitors from strongest to weakest (A>B>C>D>E)—using transitive inference.

Fernald explained that while other species have demonstrated TI in laboratory settings, these fish learned the hierarchy without outside interference.

"The fish can infer the hierarchy of relationships from watching a series of pair-wise fights," said Fernald in an e-mail. "They were able to do this from observation alone ... they did not receive any reward or reinforcement."

The TI abilities of the bystander fish were also tested in a new tank setting. Again, the bystander was placed between a pairs of rivals that he had never directly watched fight—only this time, he was without the spatial clues from the old tank.

"In the novel context—a tank the [fish] had not been in before—the bystander could only cue to the different rivals, since no spatial cues were available," wrote Grosenick in an e-mail.

In the novel context, how well bystanders did in comparing Fish B to Fish D rested heavily on how much Fish C lost to Fish B and won against Fish D. According to Grosenick, without spatial information, the bystanders' behavior depended on how clear the fight outcomes—how severe the beatings—were during the previous fish fights.

"These fish have sophisticated social lives and exploit information to make the best of it just as other social animals do—this puts them in a new category," Fernald said. "I view [transitive inference] as one of the many things they do with information gained by 'eavesdropping' on social scenes." Fernald explained that by spying on the social encounters of others, fish are better able to determine what to do in the future.

"These fish have brains the size of large raisins," Grosenick said. "Yet, they evolved this ability because winning is critical to their reproductive success, and knowing who is a stronger or weaker opponent without having to fight them directly is incredibly valuable information to them."

While the human brain may be far greater in size than the fish brain, the Stanford study suggests that when it comes to transitive inference of dominance, size really doesn't matter.

"The theory behind evolutionary psychology is the notion that our brains are a collection of special purpose organs that aid in solving very specific problems," Kalish said. "Fish don't have as many tools [as the human brain]." However, the fish from Stanford clearly have the brain tools to determine the dominance hierarchy by observation alone.

"Thinking about the skills of these animals raises the bar for other experimenters seeking to figure out the range of abilities that other species have," Fernald said.