



TEXAS ADVANCED COMPUTING CENTER

THE UNIVERSITY OF TEXAS AT AUSTIN

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Remodeling the Mind

Cognitive Psychologist David Gilden uses Lonestar to explore vision, cognition and attention

What is wonder? What does it mean to look for something? How does the brain create the present moment? These may not sound like questions that require a supercomputer, but David Gilden, professor of psychology at The University of Texas at Austin, is using the computational power at the Texas Advanced Computing Center (TACC) and a toolbox of cognitive tests to probe the workings of the brain more fully than ever before. In the process, he is settling long-standing debates in his field, and spawning new ones.

Gilden is unusual in the field of psychology. Originally trained as a theoretical astrophysicist, his eclectic interests eventually drew him into the mathematical end of experimental psychology. By bringing computational methods to psychology, Gilden is able to test models of human cognition in ways that were not possible prior to the advent of supercomputing. In doing so, he joins a revolution that is transforming the social sciences.

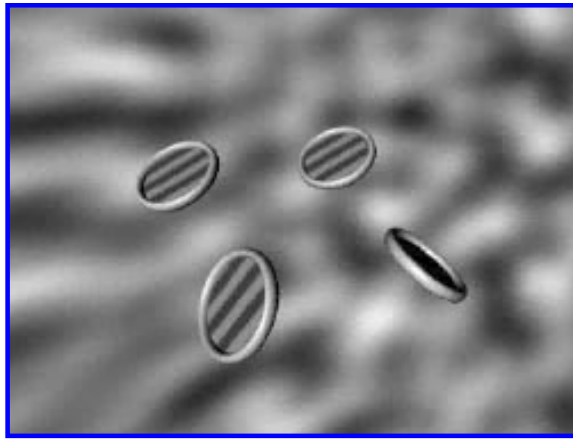
“Computational science has largely been associated with the physical sciences and engineering,” the President’s Information Technology Advisory Committee reported in 2005. However, “expanding methods for collecting and analyzing data have enabled the social and behavioral sciences to record more and more information about human social interactions, individual psychology and human biology.”

Among the first questions that Gilden tackled in experimental psychology was how humans conduct visual searches and whether the process is serial, parallel, or some context-specific combination of the two.

“What is the attitude of mind when you are looking for something? It’s a very ambiguous problem statement in itself, but everyone understands because everyone’s experienced it,” Gilden explained. “We’re trying to give some formalization and quantification to that question, and determine whether, when you’re looking for something, you’re getting multiple inputs of information or a single input and whether that depends on what you’re looking for and how camouflaged it is.”

“Expanding methods for collecting and analyzing data have enabled the social and behavioral sciences to record more and more information about human social interactions, individual psychology and human biology.” — The President’s Information Technology Advisory Committee.

Site Map



an example of a visual search test showing four disks rotating in depth

cognitive psychology's unwillingness to apply advanced computational methods to their data, and began prying the problem apart with creative supercomputing approaches.

"There were characteristic signatures in the reaction time trends that determined what types of process people were using," Gilden said. "But my collaborator, Tom Thornton, and I determined that all those reaction time signatures were incomplete because people had never taken into account the speed/accuracy trade-offs. And the reason they don't — and I say this in a chastising way — is that the field largely lives outside of the culture of computation."

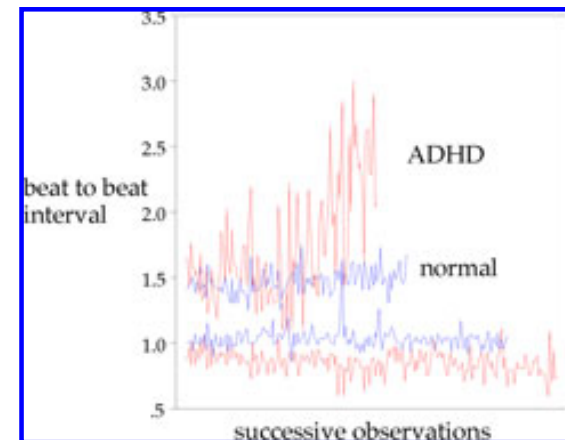
Settling Free Parameter Searches

Gilden faced another, more intrinsic problem, which reached beyond the serial/parallel distinction and exposed the shaky assumptions underlying many of the most hotly-debated questions in the field.

One of cognitive psychology's main analytical tools is the free parameter search, in which researchers create predictive, but non-specific, formulas and then adjust the parameters to fit the data. The best fit predicts the best theory, so the idea goes. The only problem is that, often, two competing theories "fit" the data equally well, without any way to determine which is most true. Gilden, himself stuck in a "goodness of fit war," found this method of settling cognitive questions "unprincipled," and set about creating a way to choose between competing free parameter models.

In the 1970s, cognitive psychologist, Ann Treisman, developed a theory of object understanding that was based on an experimental method that seemed to distinguish between serial and parallel allocations of attention. However, it was ultimately shown by James Townsend that the distinction could not be made on the basis of any of the visual search methodologies in current practice. Eventually psychologists decided that the serial/parallel distinction was hopeless and started describing attention on a graded continuum of efficiency.

But Gilden didn't think the question was unsolvable. He suspected the impasse reflected



results from drumming exercises showing the rhythmic intervals of

Gilden and Thornton have just completed a decade-long quest to simultaneously settle the serial/parallel debate and find the right way to approach model comparisons in general. The "right" way, according to Gilden, is to use Bayesian principles that expose not only the best fitting instances of models, but what the experimental situation would look like generally were a given model true. This requires full computational specification of model across their entire parameter space.

By the standards of the high-performance computing (HPC) world, Gilden's simulations are small — for the serial/parallel problem, eighteen nodes working for twenty-four hours each — but they provide the field of cognitive psychology with a new method and standard for analyzing existing data. "It sets the table and says, 'If you're going to do this kind of research, you have to examine your data first within a methodology that has sufficient power to expose the distinction that you're interested in.'" Gilden said.

He chose the Lonestar system at TACC primarily for its ability to resolve his modestly scaled problems with incredible speed. "My research develops over weeks and months, not over half years, so I need feedback, I need to see if my research makes sense, I need to correct errors," Gilden said. "These problems couldn't have been approached without vast computers that can give you decent feedback on a reasonable timescale. And once you begin to see how well these models can be articulated, then you really want to push it."

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TACC User Services personnel prioritized Gilden's need for fast production turn around on supercomputing resources. "Although the simulation time required for this project was small in terms of our computational resources, we recognized the need for more complete and easy to use user environment, which is why we recommended the Lonestar system," explained Evan Turner. Turner, who is the User Services Coordinator at TACC, aided Gilden's project on the Lonestar system. "This project sets a benchmark for future support activities at TACC. Gilden took a simulation from an allocation request to publishable research in one school

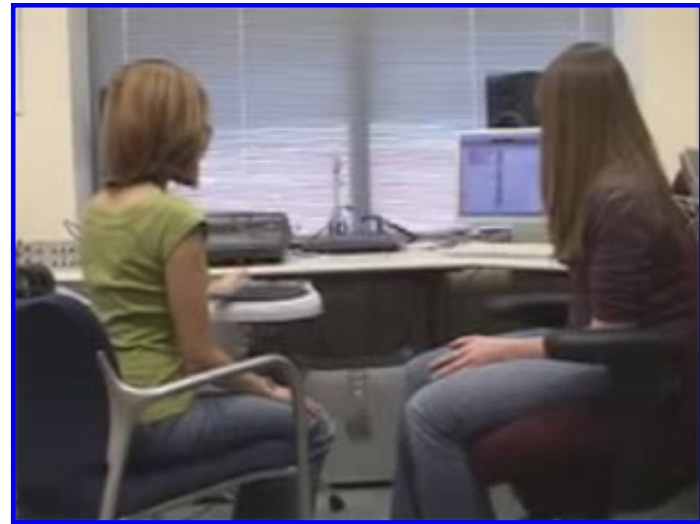
semester, which is phenomenal. I am looking forward to see what this group accomplishes in the new year."

ADHD and Computational Analysis

Taking the insights and methodology from his previous computational modeling tests, Gilden has moved on to another "timely" research topic: event structure and timing in cognition, and specifically whether individuals with attention deficit hyperactivity disorder (ADHD), diagnosed in about 1 in 20 children, might have a different structure to their internal timing.

Bucking the prevailing idea that ADHD is about

attentional control, Gilden has created a class of drumming experiments that find distinctions in the timing of ADHD and non-ADHD subjects. His studies suggest that ADHD is not a behavioral problem, but a difference in timing. "We showed that the range of tempos at which people can produce rhythms is somewhat contracted in ADHD. Typically, the slowest setting on a metronome is 40 beats per minute. This tempo is accessible to so-called normals, but at 40 beats per minute, ADHD people do not produce competent rhythm," Gilden said. "This has led us to understand that there's something different about the way ADHD people are experiencing time."



Gilden's theory has been well received by the science community, prompting him to develop scaled-up, fine-grained simulations to conduct on Ranger, the most powerful supercomputer for open science research in the world, which is set to launch in February 2008.

"I think our theory is going to pave the way for determining what kind of cognitive experiment is the right kind to diagnose ADHD, and it's going to be a timing experiment, not an attention experiment," Gilden said.

relevant, this is it."

**by Aaron Dubrow
Science and Technology Writer
Texas Advanced Computing Center
01/10/2007**

From the parallel processing mind, to model comparisons, to new tests to predict and accommodate individuals with ADHD, Gilden's application of the ideas and power of HPC systems are a harbinger of how cognitive psychologists will do research in the 21st century.

"I think our theory is going to pave the way for determining what kind of cognitive experiment is the right kind to diagnose ADHD, and it's going to be a timing experiment, not an attention experiment," Gilden said. "If I ever do anything that's socially

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