Humanity 2, Computers 0

Chess champion Gary Kasparov's human imagination beats the brute-force computer tactics of Deep Thought—for now

PERCHED ON THE EDGE of his red leather chair, Gary Kasparov arches over the chess board like a man doubled over in agony. He holds his skull as if to contain the pressure within. He rhythmically purses his lips in and out, while onlookers watch in awestruck silence. At age 26, Kasparov of Baku, Azerbaijan, is chess champion of the world—and by many accounts, the greatest chess player who ever lived.

Suddenly, Kasparov picks up a piece and slams it down decisively. His phalanx of pawns is bearing down on his opponent's poorly defended king like a battering ram.

Across the table, looking pale and very young under the lights, IBM computer scientist Feng-hsiung Hsu types Kasparov's move into a personal computer and sits back to wait. Back at Carnegie-Mellon University in Pittsburgh, at the other end of a long-distance telephone line, a battery of six specially equipped Sun workstations has taken in Kasparov's move and is mulling over its response. Deep Thought, as the system is collectively known, was created by Hsu and four other colleagues* last year when they were all graduate students at Carnegie-Mellon. Deep Thought can evaluate possible lines of play at the rate of 700,000 positions per second. Deep Thought has beaten human grand masters. Deep Thought is computer chess champion of the world.

Deep Thought is getting slaughtered. Finding nothing better to do in response to Kasparov's attack, the program tells Hsu to make a futile, one-square shift in the position of its king.

And so it went, as hundreds of reporters and chess afficianados crowded into the New York Academy of Art to spend the afternoon of 22 October watching the first-ever match between the human and computer world champions. The audience was clearly in a mood to see this upstart machine put in its place. And they were not disappointed. At the end of the two-game match the applause for Kasparov was thunderous: the score stood Humanity 2, Computers 0.

"I'm very happy to have won both games," he told his fans—not that he had ever had the slightest doubt of that. His only slight worry had been that the computer would fail to give him the kind of energy he draws from a human opponent, "like a kind of black hole," he said. "But today I discover a new source of energy: the audience. We had something in common. We're all human beings."

And yet—even in the midst of the post-game vodka and jubilation, the question would not go away: How long before a computer *does* beat the human champion?

It is a question that has haunted people since the first chess-playing computer programs were written in the 1940s. World-class chess is held to be a game of intuition, inspiration, and flair—qualities that computers supposedly cannot imitate. And yet the computers have steadily advanced up the ranks. Kasparov himself was characteristically cocky on the subject: "I believe I'll [still] be able to beat any computer in 5 years and probably at the end of the century."

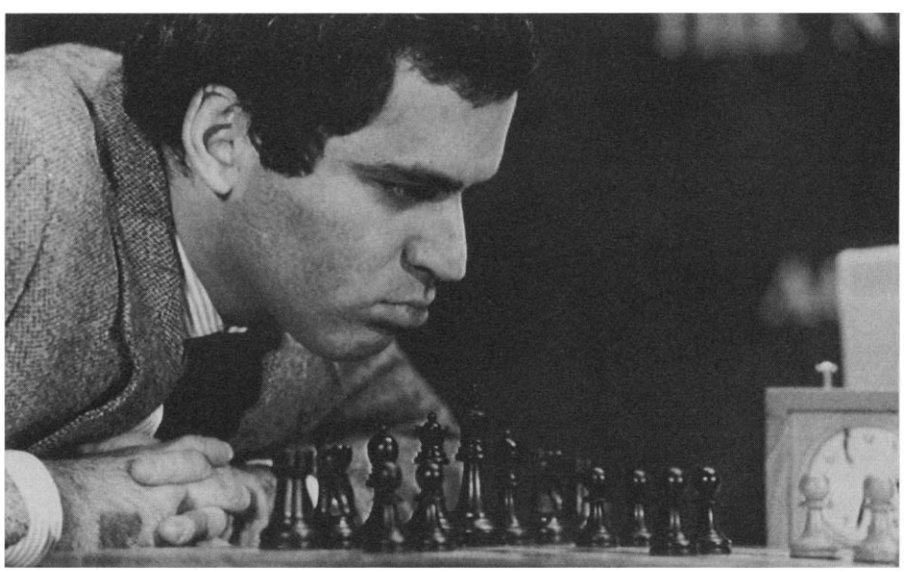
But others are not so sure. "The real drama here is that Gary is facing his fate," said syndicated chess columnist Shelby Lyman, who organized the match. "He *will* lose to a computer within the next 5 to 10 years." That estimate was echoed by Carnegie-Mellon computer scientist and world correspondence chess champion Hans Berliner, who has been designing chess-playing programs for decades: "In my opinion, it'll take about 4 years."

Admittedly, that did not look very probable on 22 October. Once the match began it quickly became obvious that Deep Thought is all tactics, no strategy. Whereas Kasparov was clearly organizing his play around long-term objectives—getting his pieces out early for maximum freedom of movement, for example, and seizing control of the center of the board—Deep Thought was just as clearly ignoring such considerations in favor of quick, near-term advantages.

That's not surprising, considering how the program is designed. Deep Thought makes no pretense of modeling human thought processes. Nor does it use any of the rule-based reasoning techniques made famous by expert systems and other forms of artificial intelligence. Instead, it uses a kind of modified brute force. Starting from the current position, Deep Thought systematically tests each of its possible moves by looking ahead to all the moves and countermoves that could follow. The computer then ranks the results according to an algebraic evaluation function, which gives each piece a rating that depends on its current position relative to other pieces. Finally, it chooses the move that seems the most advantageous.

This brute-force approach is ambitious, to put it mildly. The total number of move-countermove sequences in chess has been estimated to be some 10^{120}, which is a number so vast as to defy all metaphor. There aren't that many elementary particles in the observable universe. But what makes the approach work for Deep Thought is speed. By examining 700,000 moves per second with a special chip designed by Hsu, Deep Thought can look at every possible sequence about five moves ahead on either side. By using the evaluation function to eliminate the obviously bad moves from further consideration, the program can go as far as ten moves deep on either side.

Such thoroughness does allow Deep



Wide World

Surveying the battlefield. *The world champion plans his attack on Deep Thought.*

*Thomas Anatharaman, Murray Campbell, Peter Jansen, and Andreas Nowatzyk.

Thought to show apparent flashes of brilliance and creativity. "It appears to have imagination, because it can look ahead and see moves that nobody would have thought of," says IBM's Murray Campbell, one of Deep Thought's co-creators.

Yet just as often, the program comes up with moves that the experts find bizarre, irrelevant, or just shortsighted. International Grand Master Edmar Mednis, who provided a running commentary on the match from a separate room, was openly contemptuous of the program. Deep Thought is undeniably aggressive, he said, "but what you want are threats that can't be parried, not just quicker threats. . . . It makes moves that seem strong to it, but it doesn't even know where its king is!"

Still, said Lyman in a separate conversation with *Science*, it would not be wise to dismiss Deep Thought. Don't forget, he said, "these guys created Deep Thought on a shoestring," working in their spare time with relatively few resources. Only one of the five students who worked on it—Campbell—is even a moderately good chess player. The program played its first game only 18 months ago in May 1988. And yet, Deep Thought is already so strong that the best human chess player in the world has to take it very seriously. Kasparov prepared for this match with all the care that he takes for his human opponents, studying some 50 of Deep Thought's previous games in detail.

Furthermore, there is still plenty of room for improvement in Deep Thought. The program is now under active development at IBM's Yorktown Heights laboratory, where the company has recently hired Hsu, Campbell, and several other members of the Deep Thought team as part of its basic research program. In particular, says Hsu, it should be possible within 5 years to deploy a new chip that operates about 1000 times faster than the current one. That chip would be able to examine roughly a *billion* moves per second, giving Deep Thought the ability to look ahead as much as 25 moves. And at that point, he says, "strategy becomes tactics for the machine."

So perhaps the day of Kasparov's defeat is not so far off after all. Kasparov himself seemed to find that a melancholy prospect: "How can we live knowing that something is much more powerful than our minds?" he asked.

But then, perhaps the threat is more imagined than real. After all, our machines have long since surpassed us in strength, speed, and stamina. And yet we still find a special triumph in spectacles such as the Olympics—because there we can still see human beings striving to be the best they can be. ■ **M. MITCHELL WALDROP**

New Life for Small Science

London

The British government has backed away from its controversial proposal to abolish almost half the physics and chemistry departments in U.K. universities. Two reports published last October called for small departments—those with fewer than 20 faculty members or 200 undergraduates—to close or amalgamate. But the Universities Funding Council (UFC), which provides general support for British universities, said last week that it will not cut off funding for smaller units to force them out of existence. Instead, it will allow individual universities to decide how to allocate funds to different departments.

Denis Noble, a cardiac physiologist at Oxford University and founder of the Save British Science campaign, said, "at last some wisdom has prevailed. The quality of the argument—that many of the small departments are damned good—has got through."

Sir Peter Swinnerton-Dyer, chief executive of the UFC, offered a different explanation: The smaller departments may be needed to accommodate an expected increase in student numbers in the 1990s. "Given this expectation," he said, "the right policy must be to retain most of the small chemistry and physics departments, even though in the short run they may be smaller than one would wish."

The cost of restructuring is also believed to be a factor in the UFC's change of heart. A spokesman for the committee said that the recent rationalization of departments of earth sciences, which had been the focus of an earlier UFC review, had proved more expensive than anticipated. Considerable new funds were required to reequip departments that were merged or expanded.

The two reports that recommended shutting smaller physics and chemistry departments were commissioned by the Universities Grants Committee, the predecessor of the UFC, as part of a fundamental review of university teaching and research. Both argued that small departments were not viable. While the reports did not name names, subsequent estimates said that 17 of the 49 existing chemistry departments and 20 of the 47 physics departments did not meet one or the other of the two criteria of minimum faculty size or student numbers.

Now the UFC says that while it still thinks that small departments may not be viable, it will not insist that they meet any strict criteria to survive. Universities will be allowed to make their own funding allocations, but the UFC will continue to push toward larger departments. It says "evidence of compliance" with the recommendations of the review groups will be a factor when it comes to giving money to departments in future years.

As for the hoped-for increase in student numbers, the British government has simply indicated that it would like to see a far greater proportion of people going on from high school to college education, and it has suggested that private industry should fund this expansion. The UFC intends universities to make competitive bids for additional students. The universities would receive a fixed amount of support for each student, and although the formula linking support to student numbers has not yet been finalized, it will inevitably favor low-cost departments. Universities could then decide for themselves whether to subsidize small, expensive departments with money attracted by other departments rather than have these decisions thrust upon them by their paymasters.

Oxford's Noble, in an address last week to science graduates of Kingston Polytechnic in the south of London, welcomed the plan to increase student enrollments. But he warned that the government's desire for industry to commit more funds will be thwarted unless the government also comes up with an increase. "There is no way to get Californian levels of participation without Californian levels of public funding," Noble said.

But prospects for significant funding increases for science are dim. The Thatcher government's own analysis of government-funded research, published last week, reveals that real support for civilian research and development will fall over the next 3 years.

Last year's spending on R&D was £4616 million, down £200 million from the previous year. In 2 years, the figure will be £4282 million, in constant currency. The nonmilitary part of the total will fall to £2145 million over the 3-year period, accounting for most of the overall decline. ■ **JEREMY CHERFAS**