University at Buffalo
State University of New York

Department of Computer Science and Engineering

January 22, 2014

Princeton Undergraduate Admissions
Clio Hall
Princeton University
Princeton, NJ 08544

Dear Admissions Committee:

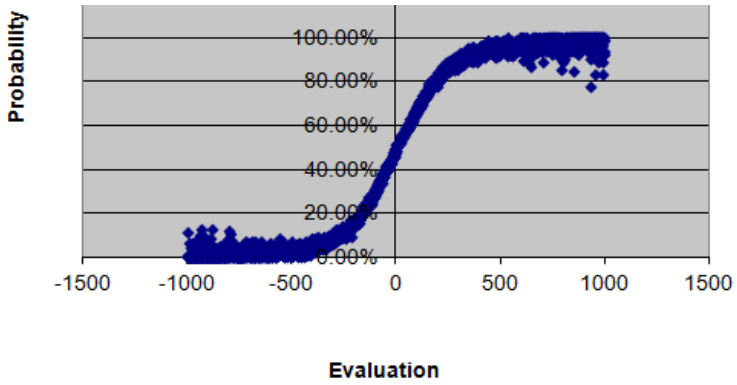
I am delighted to write an account of research being done for me by Jason Zhou as part of my project on human decision-making in chess and comparison to computer play. We know Jason through Nichols School where my wife Debbie (Wellesley '86) teaches. I am coming on 25 years of research in my main field of Computational Complexity while on the faculty of SUNY/Buffalo, and co-manage the weblog *Gödel's Lost Letter and P=NP* founded by Professor Richard J. Lipton, who was on Princeton's CS faculty for a long time. My chess work was written up in the science section of the New York Times two years ago, and also featured in the book *Average is Over* by noted economist Tyler Cowen.

My work uses computer analysis of vast numbers of chess games—by players of all strengths—to establish authoritative and objective values for all possible moves in all positions. These values train my statistical model, which judges human likelihood to "sniff out" moves of best value according to players' skill parameters, which in turn are trained to the Elo scale used to rate human and computer players both. From 2008 through 2012 there was one clear best chess program to use for analysis, called Rybka. A year-plus ago, however, a trio of programs named Komodo, Stockfish, and Houdini surpassed it, and their latest versions finished 1-2-3 in last month's championship. My problem in incorporating these programs is that each uses its own scale for values, and they are not simply proportional. I decided that a common scale must be defined not via conversion to the values given by Rybka (or any other program), but rather in terms of the proportion of wins and draws actually scored by players who had positions to which a certain program gives a certain value v.

As I started realizing this in late 2012, Mark Braverman—a leading light in complexity theory who is on your CS faculty, where my classmate and friend Andrew Appel '81 is Chair—contacted me about a junior paper by Leonardo Stedile '14 which he was advising. This was about a phenomenon I published in 2011 that *human* players make markedly greater error e per move the further v is from zero, i.e., the more advantage one side has. I explained this in terms analogous to studies of consumer psychology by Daniel Kahneman and Amos Tversky: that humans judge not by e but by the ratio e/v. Stedile seeks to explain it instead as *rational* risk-taking in unbalanced positions. He used my extant data analyzed by Rybka alone for his Jan. 2013 paper. Last summer when Jason joined my project I started compiling parallel sets of over 700,000 positions analyzed by each of the four programs, also correcting errors in game records (which Jason started by helping with) to ensure more uniform quality. This is hopefully large enough data to tease apart the two hypotheses, besides calibrating the four chess progarms, and that's the most ambitious goal I've set Jason for his Nichols Senior Paper due in April.

When my first sets finished this autumn, Jason wrote programs in the language `Python` to collate $726{,}120 \times 4$ data points and plot the points-percentage results against v. Here is an example of the tabulations and plots he gave me—actually the latest one with the newest Stockfish version in sets that completed over New Year's:

Davis Hall Room 338, Box 602000, Buffalo, NY 14260-2000
Tel: (716) 645-3180 Fax: (716) 645-3464



This is an elegant sigmoidal curve, and I've also set Jason the task of telling which of three sigmoidal families it is closest to. But notice that it's not quite centered on 50% at $v = 0$, rather about 48.5%. That was disturbing, so I asked my own graduate student to do this too, writing in a different programming language called `Perl`. He gave me tables and plots crossing the axis at about 50.5%, a little high but still within the margin of error for the expected 50%, whereas Jason's 48.5% value was well outside the margin. So I thought either my data must be flawed or Jason was filtering it incorrectly, and put all this off to after my crush-busy December.

Well this past weekend I discovered with my grad student that he had misunderstood and had collated the data irrespective of which side was to move. Doing it both ways showed that Jason was correct, and ratified the discrepancy as a real phenomenon. He'll be named its discoverer in a joint paper. The phenomenon shows up for all four chess programs, holds for a wide range of v around 0, and persists under various filtering policies and despite attempts to explain it away on technicalities. So I'm currently left with an explanation straight out of Ambrose Bierce:

> The player to move is at a disadvantage because he/she has the first opportunity to blunder.

Well there are ways to test this too, and I've just told Braverman and Stedile that I'm confident in the integrity of my new sets, while I start compiling more data on games played by computers.

What can I say about Jason beyond exemplifying that I have full research-level confidence in him? He is marvelously attentive to long explanations, as when I took him through my whole setup last summer. He does this without being intense, rather affable and cheerful so that you don't see he's taken it all in until the next meeting. I guess he knows from music to come prepared. He is also very much moved by Princeton's historic connections in mathematics and physics, as I was when setting my sights from age 13. Indeed I felt this when choosing Roger Pensose's beautiful 1,000-page physics text *The Road to Reality* as the "Regan present" for his multi-family birthday party two years ago. He has been a great friend to both my children, on numerous mind-sports teams and also cross-country running with both. In sum I can recommend him as someone really special and fitting, and I would be happy to answer any further questions you may have.

Yours sincerely

Dr. Kenneth W. Regan '81
(716) 645-4738, regan@buffalo.edu, http://www.cse.buffalo.edu/~regan/