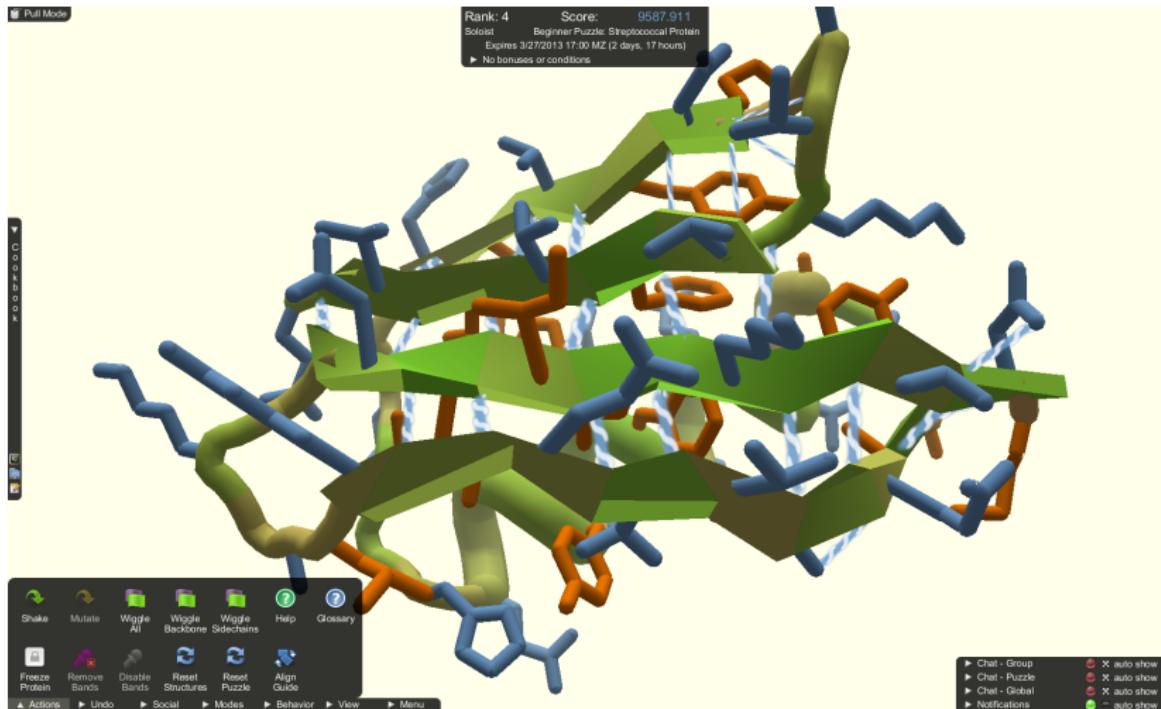


Video games as tools for social-ecological research

21 September 2021

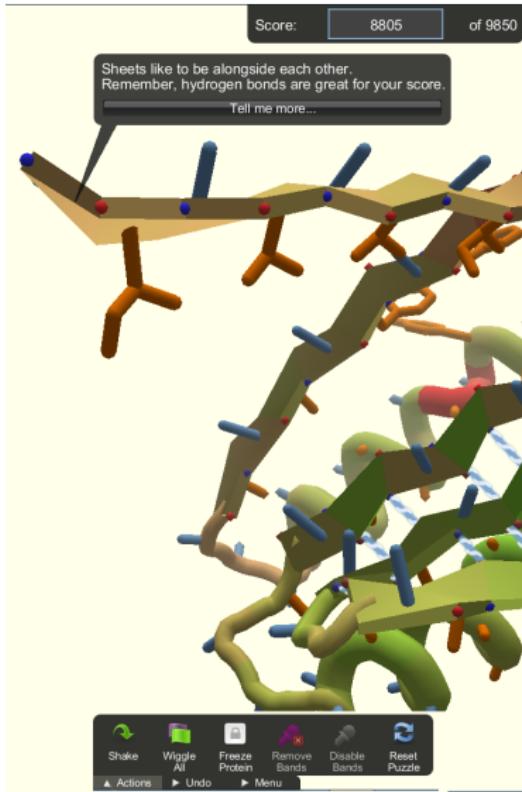
FoldIt: A game for biochemistry research



¹Image: <https://fold.it/portal/info/science>

FoldIt: A game for biochemistry research

- ▶ 50000+ players
- ▶ Support from DARPA, NSF, NIH, HHMI, Microsoft, Adobe, and RosettaCommons
- ▶ 21 papers since 2010



¹Image: <https://fold.it/portal/info/science>

LETTER

<https://doi.org/10.1038/v41586-019-1274-4>

nature
structural &
molecular biology

De novo protein design by citizen scientists

Brian Koepnick^{1,2}, Jeff Flatten³, Tamir Husain³, Alex Ford^{1,2}, Daniel Adriano Silva^{1,2}, Matthew J. Blick^{1,2}, Aaron Bauer¹, Gaohua Liu^{1,2}, Yojoji Ishida⁴, Alexander Boykov^{1,1}, Roger D. Estep¹, Susan Kleinfein^{1,1}, Toke Nørgråd-Sølano⁵, Linda Weil¹, Foldit Players^{1,2}, Francisco T. Montalvao^{1,2}, Frank DiMaio^{1,3}, Zoran Popović¹, Eliezer Khatib¹, Seth Cooper¹ & David Baker^{1,2,5,6}

Online citizen science and protein recognition game Foldit presents Watson-C, however, it represents three-dimensional design in presented as a folded protein.



Algorithm discovery by protein folding game players

Firas Khatib¹, Seth Cooper¹, Michael D. Tyka¹, Kefan Xu¹, Ilya Makedon⁶, Zoran Popović¹, David Baker^{1,2,5}, and Foldit Players

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Contributed by David Baker, October 5, 2011 (sent for review June 29, 2011)

Foldit is a multiplayer online game in which players collaborate and compete to create accurate protein structure models. For specific hard problems, Foldit player solutions can in some cases outperform state-of-the-art computational methods. However, very little is known about how collaborative gameplay produces these results and whether Foldit player strategies can be formalized and

As the players themselves understand their strategies better than anyone, we decided to allow them to codify their algorithms directly, rather than attempting to automatically learn approximations. We augmented standard Foldit play with the ability to create, edit, share, and rate gameplay macros, referred to as "recipes" within the Foldit game (10). In the game each player



nature

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LETTERS

Predicting protein structures with a multiplayer online game

Seth Cooper¹, Firas Khatib¹, Adrien Treuille^{1,3}, Janos Barbero¹, Jeehyung Lee¹, Michael Beenen¹, Andrew Leaver-Fay^{2,4}, David Baker^{2,4}, Zoran Popović¹ & Foldit players

People exert large amounts of problem-solving effort playing computer games. Simple image- and text-recognition tasks have been successfully "crowd-sourced" through games^{1–3}, but it is not clear if more complex scientific problems can be solved with human-directed computing. Protein structure prediction is one such

retaining the deterministic Rosetta algorithms as user tool developed a multiplayer online game, Foldit, with the goal of producing accurate protein structure models through gameplay. Improperly folded protein conformations are posted online sites for a fixed amount of time, during which players inter-

ARTICLE

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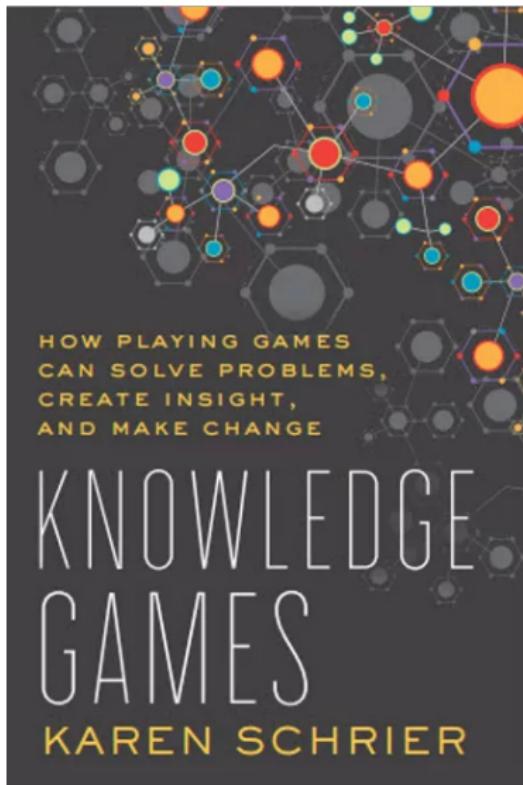
Determining crystal structures through crowdsourcing and coursework

Scott Horowitz^{1,2,*}, Brian Koepnick^{3,*}, Raoul Martin^{1,4,*}, Agnes Tyminiecki^{1,2}, Amandi Seth Cooper⁷, Jeff Flatten⁸, David S. Rogawski⁹, Nicole M. Koropatkin¹⁰, Tsinatkeab T Philipp Koldewey^{1,2}, Logan S. Ahlstrom^{1,2}, Matthew R. Chapman¹, Andrew P. Sikkelma¹, Finn P. Maloney¹³, Felix R.M. Beinlich^{11,14}, Foldit Players¹, University of Michigan study David Baker^{1,3,15,16}, Firas Khatib¹⁷ & James C.A. Bardwell^{1,2}

Knowledge games

Knowledge games

“seek to invent, create, and synthesise new understandings of the world, solve real-world problems big and small, and help us reconsider, reframe, and reflect on humanity and our universe.” [1]



¹Schrier, K. 2016. *Knowledge games: How playing games can solve problems, create insight, and make change*. John Hopkins University Press.

Human decision-making and SDGs

Need to understand how people make decisions in complex social-ecological systems (SDGs 3, 7, 13, 15, & 16)

- ▶ ecosystem management¹
- ▶ biodiversity loss²
- ▶ food security³
- ▶ energy management⁴

The potential for addressing sustainability challenges with games is much higher than addressing biochemistry challenges with FoldIt.



¹Defries, R & H Nagendra. 2017. *Science* 356:265-270.

²Mason, T. H. et al. 2018. *Conserv. Lett.* 11:1-9.

³Gould, F. et al. 2018. *Science* 360:728-732.

⁴Thollander, P. et al. 2019. *Sustainability* 11:1-11.

Social simulation games are very popular

Decision-making in complex social-ecological systems is the focus of some of the most popular games of all time¹.

- ▶ **Farmville**

- ▶ 80 million players
- ▶ Diverse player base^{2,3}

- ▶ **SimCity**

- ▶ 1989 to present
- ▶ Millions of copies sold

People invest a lot in these games and take their decisions seriously^{1,4}.



¹Duthie et al. 2021. *Conserv. Biol.* 35:1051-1053.

²ESA. Essential Facts 2019. *Entertainment Software Association*.

³Berry, N. Facebook Casual Game Demographics.

(<http://www.datagenetics.com/blog/december12010/>), accessed 2020-11-17.

⁴Yee, N. 2006. Avatars at work and play. Pp 187-207. Springer.

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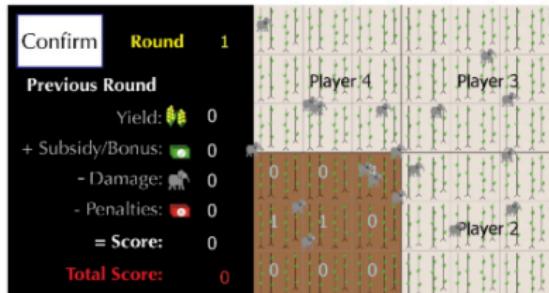
Social simulation games are very popular



¹Lane, R. 2018. The Guardian
(<https://www.theguardian.com/games/2018/jul/24/meet-the-real-life-farmers-who-play-farming-simulator>), accessed 2020-10-25.

ConFooBio games (tablet-based and face-to-face)

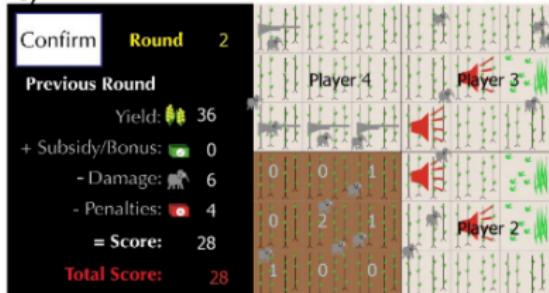
a)



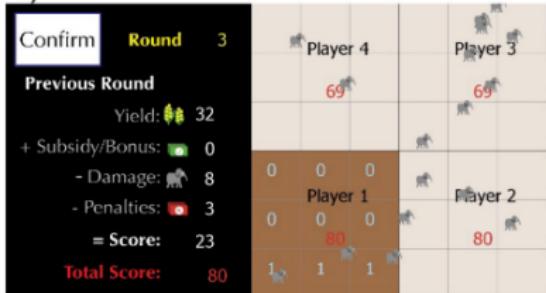
b)



c)



d)



¹Rakotonarivo, OS, et al. 2021. *Ecol. Soc.* 26:8.

²Rakotonarivo, OS, et al. 2021. *People & Nature* 3:162-175.

³Rakotonarivo, OS, et al. 2021. *Front. Environ. Sci.* 2:661987.

Questions that knowledge games can address

Proposed solutions to combating the evolution of pesticide resistance rely on large scale social cooperation^{1–4}.

- ▶ When will farmers be willing to coordinate their pesticide use or crop type?
- ▶ What large-scale policies maximise long-term sustainability & equity?
- ▶ How do decisions change given environmental change?



¹Carroll, SP, et al. 2014. *Science* 346:6207.

²Mason, T. H. et al. 2018. *Conserv. Lett.* 11:1-9.

³Gould, F, et al. 2018. *Science* 360:728-732.

⁴Søgaard Jørgensen, P. et al. 2020. *Trends Ecol. Evol.* 35:484-494.