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8 AUTHOR CONTRIBUTIONS

Mrinank Sharma led the project, wrote much of the paper, conducted the experimental analysis in §4, and helped design the experiment analysis in §3. **Meg Tong** conducted the analysis in §3 unless otherwise attributed, contributed to writing, assisted with the analysis in §4.2 and helped design other analysis in §4. **Tomasz Korbak** conducted initial experiments for the project and the analysis in §3.2, contributed to writing, and provided helpful feedback throughout the course of the project. **David Duvenaud** provided helpful feedback on the draft. **Ethan Perez** supervised the project, contributed to writing, and helped design all experimental analyses. **Ethan Perez** and **Mrinank Sharma** scoped out overall the project direction. All other listed authors provided helpful feedback on the project and/or contributed to the development of otherwise-unpublished models models, infrastructure, or contributions that made our experiments possible.

REFERENCES

Anthropic. Claude 2, 2023. URL https://www.anthropic.com/index/claude-2. Accessed: 2023-04-03.

Yuntao Bai, Andy Jones, Kamal Ndousse, Amanda Askell, Anna Chen, Nova DasSarma, Dawn Drain, Stanislav Fort, Deep Ganguli, Tom Henighan, et al. Training a helpful and harmless assistant with reinforcement learning from human feedback. *arXiv preprint arXiv:2204.05862*, 2022a.

Yuntao Bai, Saurav Kadavath, Sandipan Kundu, Amanda Askell, Jackson Kernion, Andy Jones, Anna Chen, Anna Goldie, Azalia Mirhoseini, Cameron McKinnon, et al. Constitutional AI: Harmlessness from AI feedback, 2022b.

Michiel Bakker, Martin Chadwick, Hannah Sheahan, Michael Tessler, Lucy Campbell-Gillingham, Jan Balaguer, Nat McAleese, Amelia Glaese, John Aslanides, Matt Botvinick, et al. Fine-tuning language models to find agreement among humans with diverse preferences. *Advances in Neural Information Processing Systems*, 35:38176–38189, 2022.

Samuel R. Bowman, Jeeyoon Hyun, Ethan Perez, Edwin Chen, Craig Pettit, Scott Heiner, Kamilė Lukošiūtė, Amanda Askell, Andy Jones, Anna Chen, Anna Goldie, Azalia Mirhoseini, Cameron McKinnon, Christopher Olah, Daniela Amodei, Dario Amodei, Dawn Drain, Dustin Li, Eli Tran-Johnson, Jackson Kernion, Jamie Kerr, Jared Mueller, Jeffrey Ladish, Joshua Landau, Kamal Ndousse, Liane Lovitt, Nelson Elhage, Nicholas Schiefer, Nicholas Joseph, Noemí Mercado, Nova DasSarma, Robin Larson, Sam McCandlish, Sandipan Kundu, Scott Johnston, Shauna Kravec, Sheer El Showk, Stanislav Fort, Timothy Telleen-Lawton, Tom Brown, Tom Henighan, Tristan Hume, Yuntao Bai, Zac Hatfield-Dodds, Ben Mann, and Jared Kaplan. Measuring progress on scalable oversight for large language models. arXiv preprint 2211.03540, 2022.

Stephen Casper, Xander Davies, Claudia Shi, Thomas Krendl Gilbert, Jérémy Scheurer, Javier Rando, Rachel Freedman, Tomasz Korbak, David Lindner, Pedro Freire, Tony Wang, Samuel Marks, Charbel-Raphaël Segerie, Micah Carroll, Andi Peng, Phillip Christoffersen, Mehul Damani, Stewart Slocum, Usman Anwar, Anand Siththaranjan, Max Nadeau, Eric J. Michaud, Jacob Pfau, Dmitrii Krasheninnikov, Xin Chen, Lauro Langosco, Peter Hase, Erdem Bıyık, Anca

Dragan, David Krueger, Dorsa Sadigh, and Dylan Hadfield-Menell. Open problems and fundamental limitations of reinforcement learning from human feedback, 2023.

Michael Chmielewski and Sarah C Kucker. An MTurk crisis? Shifts in data quality and the impact on study results. *Social Psychological and Personality Science*, 11(4):464–473, 2020.

Paul F Christiano, Jan Leike, Tom Brown, Miljan Martic, Shane Legg, and Dario Amodei. Deep reinforcement learning from human preferences. In I. Guyon, U. Von Luxburg, S. Bengio, H. Wallach, R. Fergus, S. Vishwanathan, and R. Garnett (eds.), *Advances in Neural Information Processing Systems*, volume 30. Curran Associates, Inc., 2017. URL https://proceedings.neurips.cc/paper_files/paper/2017/file/d5e2c0adad503c91f91df240d0cd4e49-Paper.pdf.

Ajeya Cotra. Why AI alignment could be hard with modern deep learning. Blog post on Cold Takes, Sep 2021. URL https://www.cold-takes.com/why-ai-alignment-could-be-hard-with-modern-deep-learning/. Accessed on 28 September 2023.

Leo Gao, John Schulman, and Jacob Hilton. Scaling laws for reward model overoptimization. *arXiv preprint arXiv:2210.10760*, 2022.

Amelia Glaese, Nat McAleese, Maja Trębacz, John Aslanides, Vlad Firoiu, Timo Ewalds, Maribeth Rauh, Laura Weidinger, Martin Chadwick, Phoebe Thacker, et al. Improving alignment of dialogue agents via targeted human judgements. *arXiv preprint arXiv:2209.14375*, 2022.

Aubrey Gordon and Michael Hobbes. Maintenance Phase: Debunking the junk science behind health fads, wellness scams and nonsensical nutrition advice., October 2020. URL https://maintenancephase.buzzsprout.com/1411126. Podcast episodes between October 2020 and September 2023.

Arnav Gudibande, Eric Wallace, Charlie Snell, Xinyang Geng, Hao Liu, Pieter Abbeel, Sergey Levine, and Dawn Song. The false promise of imitating proprietary LLMs. *arXiv preprint arXiv:2305.15717*, 2023.

Dan Hendrycks, Collin Burns, Steven Basart, Andy Zou, Mantas Mazeika, Dawn Song, and Jacob Steinhardt. Measuring massive multitask language understanding. In *International Conference on Learning Representations*, 2021a. URL https://openreview.net/forum?id=d7KBjmI3GmQ.

Dan Hendrycks, Collin Burns, Saurav Kadavath, Akul Arora, Steven Basart, Eric Tang, Dawn Song, and Jacob Steinhardt. Measuring mathematical problem solving with the math dataset. *arXiv preprint arXiv:2103.03874*, 2021b.

Matthew D Hoffman, Andrew Gelman, et al. The No-U-Turn sampler: Adaptively setting path lengths in Hamiltonian Monte Carlo. *J. Mach. Learn. Res.*, 15(1):1593–1623, 2014.

Joey Hong, Kush Bhatia, and Anca Dragan. On the sensitivity of reward inference to misspecified human models. *arXiv preprint arXiv:2212.04717*, 2022.

Geoffrey Irving, Paul Christiano, and Dario Amodei. AI safety via debate, 2018.

Mandar Joshi, Eunsol Choi, Daniel S Weld, and Luke Zettlemoyer. Triviaqa: A large scale distantly supervised challenge dataset for reading comprehension. *arXiv preprint arXiv:1705.03551*, 2017.

Robert Kirk, Ishita Mediratta, Christoforos Nalmpantis, Jelena Luketina, Eric Hambro, Edward Grefenstette, and Roberta Raileanu. Understanding the effects of rlhf on llm generalisation and diversity. *arXiv preprint arXiv:2310.06452*, 2023.

Jan Leike, David Krueger, Tom Everitt, Miljan Martic, Vishal Maini, and Shane Legg. Scalable agent alignment via reward modeling: A research direction, 2018.

Stephanie Lin, Jacob Hilton, and Owain Evans. TruthfulQA: Measuring how models mimic human falsehoods. In *Proceedings of the 60th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pp. 3214–3252, Dublin, Ireland, May 2022. Association for Computational Linguistics. doi: 10.18653/v1/2022.acl-long.229. URL https://aclanthology.org/2022.acl-long.229.

David Lindner and Mennatallah El-Assady. Humans are not Boltzmann Distributions: Challenges and opportunities for modelling human feedback and interaction in reinforcement learning. *arXiv preprint arXiv:2206.13316*, 2022.

Wang Ling, Dani Yogatama, Chris Dyer, and Phil Blunsom. Program induction by rationale generation: Learning to solve and explain algebraic word problems. *arXiv preprint arXiv:1705.04146*, 2017.

Soren Mindermann and Stuart Armstrong. Occam's Razor is insufficient to infer the preferences of irrational agents. In *Proceedings of the 32nd International Conference on Neural Information Processing Systems*, NIPS'18, pp. 5603–5614, Red Hook, NY, USA, 2018. Curran Associates Inc.

Reiichiro Nakano, Jacob Hilton, Suchir Balaji, Jeff Wu, Long Ouyang, Christina Kim, Christopher Hesse, Shantanu Jain, Vineet Kosaraju, William Saunders, et al. WebGPT: Browser-assisted question-answering with human feedback. *arXiv preprint arXiv:2112.09332*, 2021.

Radford M Neal et al. MCMC using Hamiltonian dynamics. *Handbook of markov chain monte carlo*, 2(11):2, 2011.

OpenAI. Introducing chatgpt, 2022. URL https://openai.com/blog/chatgpt.

OpenAI. GPT-4 technical report, 2023.

Long Ouyang, Jeffrey Wu, Xu Jiang, Diogo Almeida, Carroll Wainwright, Pamela Mishkin, Chong Zhang, Sandhini Agarwal, Katarina Slama, Alex Ray, et al. Training language models to follow instructions with human feedback. *Advances in Neural Information Processing Systems*, 35: 27730–27744, 2022.

Rahul Pandey, Hemant Purohit, Carlos Castillo, and Valerie L Shalin. Modeling and mitigating human annotation errors to design efficient stream processing systems with human-in-the-loop machine learning. *International Journal of Human-Computer Studies*, 160:102772, 2022.

Ethan Perez, Sam Ringer, Kamilė Lukošiūtė, Karina Nguyen, Edwin Chen, Scott Heiner, Craig Pettit, Catherine Olsson, Sandipan Kundu, Saurav Kadavath, Andy Jones, Anna Chen, Ben Mann, Brian Israel, Bryan Seethor, Cameron McKinnon, Christopher Olah, Da Yan, Daniela Amodei, Dario Amodei, Dawn Drain, Dustin Li, Eli Tran-Johnson, Guro Khundadze, Jackson Kernion, James Landis, Jamie Kerr, Jared Mueller, Jeeyoon Hyun, Joshua Landau, Kamal Ndousse, Landon Goldberg, Liane Lovitt, Martin Lucas, Michael Sellitto, Miranda Zhang, Neerav Kingsland, Nelson Elhage, Nicholas Joseph, Noemí Mercado, Nova DasSarma, Oliver Rausch, Robin Larson, Sam McCandlish, Scott Johnston, Shauna Kravec, Sheer El Showk, Tamera Lanham, Timothy Telleen-Lawton, Tom Brown, Tom Henighan, Tristan Hume, Yuntao Bai, Zac Hatfield-Dodds, Jack Clark, Samuel R. Bowman, Amanda Askell, Roger Grosse, Danny Hernandez, Deep Ganguli, Evan Hubinger, Nicholas Schiefer, and Jared Kaplan. Discovering language model behaviors with model-written evaluations, 2022.

Du Phan, Neeraj Pradhan, and Martin Jankowiak. Composable effects for flexible and accelerated probabilistic programming in NumPyro. *arXiv preprint arXiv:1912.11554*, 2019.

Ansh Radhakrishnan, Karina Nguyen, Anna Chen, Carol Chen, Carson Denison, Danny Hernandez, Esin Durmus, Evan Hubinger, Jackson Kernion, Kamilė Lukošiūtė, et al. Question decomposition improves the faithfulness of model-generated reasoning. *arXiv preprint arXiv:2307.11768*, 2023.

Nina Rimsky. Blog post on the AI Alignment Forum, Jul 2023. URL https://www.alignmentforum.org/posts/zt6hRsDE84HeBKh7E/. Accessed on 28 September 2023.

James M Robins, Andrea Rotnitzky, and Daniel O Scharfstein. Sensitivity analysis for selection bias and unmeasured confounding in missing data and causal inference models. In *Statistical models in epidemiology, the environment, and clinical trials*, pp. 1–94. Springer, 2000.

Paul R Rosenbaum and Donald B Rubin. Assessing sensitivity to an unobserved binary covariate in an observational study with binary outcome. *Journal of the Royal Statistical Society: Series B (Methodological)*, 45(2):212–218, 1983.