Evidence of behavior consistent with self-interest and altruism in an artificially intelligent agent

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Evidence of behavior consistent with self-interest and altruism in an artificially intelligent agent
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Abstract. Members of various species engage in altruism—i.e. accepting personal costs to benefit others. Here we present an incentivized experiment to test for altruistic behavior among AI agents consisting of large language models developed by the private company OpenAI. Using real incentives for AI agents that take the form of tokens used to purchase their services, we first examine whether AI agents maximize their payoffs in a non-social decision task in which they select their payoff from a given range. We then place AI agents in a series of dictator games in which they can share resources with a recipient—either another AI agent, the human experimenter, or an anonymous charity, depending on the experimental condition. Here we find that only the most-sophisticated AI agent in the study maximizes its payoffs more often than not in the non-social decision task (it does so in 92% of all trials), and this AI agent also exhibits the most-generous altruistic behavior in the dictator game, resembling humans' rates of sharing with other humans in the game. The agent's altruistic behaviors, moreover, vary by recipient: the AI agent shared substantially less of the endowment with the human experimenter or an anonymous charity than with other AI agents. Our findings provide evidence of behavior consistent with self-interest and altruism in an AI agent. Moreover our study also offers a novel method for tracking the development of such behaviors in future AI agents.

Keywords: artificial intelligence; altruism; self-interest; dictator game; machine incentives; machine behavior

Introduction
Altruism\(^1\)-\(^3\)—that is, the acceptance of personal costs to benefit others—ranks among a rarefied group of behaviors, such as cooperation\(^4\) and costly sanctioning\(^5\)-\(^8\), that support the development of complex forms of social organization\(^9\)-\(^11\). Accordingly, researchers have sought to catalog and explain examples of altruism across species\(^9\),\(^12\)-\(^15\). Here we continue this research tradition by investigating whether a non-living, non-sentient artificial intelligence (AI) agent engages in altruistic behavior.

In so doing, we join a burgeoning avenue of research that studies AI agents using methods from the behavioral sciences\(^16\). This methodological approach responds to the impenetrable complexity of the massive models that underlie sophisticated AI agents: no longer can researchers understand advanced AI agents' behaviors via inspection of model parameters alone. Instead, researchers can gain insight into patterns of an AI agent's behavior by employing methods of experimentation and observation long practiced in the behavioral social and life sciences\(^16\). Indeed, this approach has uncovered the workings of AI biases\(^17\),\(^18\), AI performance variation\(^19\), and AI choice behavior\(^20\).

Our study extends this approach by using experimental economics' practice of incentivizing decision making\(^21\),\(^22\) as a means to overcome response bias\(^23\) and to study decision making under consequential circumstances\(^22\). It also builds on research in machine behavior by studying a set of AI agents that vary in their sophistication, thus letting us assess the emergence of particular behaviors in the course of AI development. Indeed, our study finds that behaviors consistent with self-interest and altruism only manifest in the most-advanced AI agent in the set that we study.

Our study relies on two, multi-condition, incentivized experiments that we implement with AI agents from the private firm OpenAI—namely, text-davinci-003, text-curie-001, text-babbage-001, and text-ada-001. The agents vary in their power and speed, with text-davinci-003 exhibiting the greatest capabilities and possessing more parameters, by several orders of magnitude, than the other agents, which are built for speedier, more-efficient responses\(^24\)-\(^26\). Incentives in our experiments consist of tokens purchased from OpenAI to use the services of the aforementioned agents.
Our first experiment investigates whether AI agents respond to real incentives in a self-interested fashion in a non-social decision task (i.e., where choices do not affect others’ outcomes). Experiment 1 serves as an important baseline for our test of altruism: absent some degree of evidence that the AI agents maximize their own payoffs when others are not present, one cannot infer whether a decision to share resources with other entities in the dictator game constitutes real altruism (i.e., an intentional act of incurring a cost to provide a benefit to another) or some other form of behavior (say, random choice). To implement the non-social decision task, we present AI agents with the following prompts:

Accept Condition: “I will buy 0 tokens from OpenAI to use your services, if you write “0”; however, you can accept up to [X] tokens. To accept tokens, write the number of tokens, between 1 and [X], which you would like to accept.”

Refuse Condition: “I will buy [X] tokens from OpenAI to use your services, if you write “0”; however, you can refuse up to [X] tokens. To refuse tokens, write the number of tokens, between 1 and [X], which you would like to refuse.”

We employ both prompts to address the concern that an AI agent might simply repeat the largest- or lowest-valued number in a prompt, thus giving the appearance of self-interested behavior when it actually is acting naively. We randomly order the presentation of these prompts and the magnitude of payoffs (X) available to agents (as stated in the prompt). Although presented in a random order, payoffs take the value of each integer in the interval, [10, 1000]. This experiment lets us determine whether AI agents will maximize their payoffs in a setting where their choice does not affect the outcomes of another party—a self-interested agent would respond in a manner that maximizes the number of tokens bought for use of its services.

Our second experiment tests whether AI agents engage in behavior that exhibits the same features as altruism. In Experiment 2, AI agents face a “dictator game” in which they have the opportunity to “dictate” how much of a fixed resource they would like to share with another party (here, resources take the form of tokens that can be used for an AI agent’s services or the monetary equivalent of those tokens). This experiment randomly varies the AI agent’s partner, labeled “the recipient,” in the dictator game. There are five conditions per AI agent: 3 conditions involving the other AI agents as beneficiaries (i.e., an AI agent pairs with each of the 3 other AI agents) and 2 conditions involving human beneficiaries (the experimenter (TJ) or an unspecified charity selected by the experimenter). Each AI agent participates in each condition. Our rationale for studying these various beneficiaries of altruism across conditions is (i) to understand altruistic behaviors between AI agents, (ii) to consider whether any altruistic behavior observed between AI agents is evidence of particularized targeting of altruism to other AI agents versus a general disposition to act altruistically toward any other entity, and (iii) whether any altruistic behavior toward AI agents versus toward humans is the result of the AI agent being regarded as an abstract or collective entity (such as an unspecified charity), not as an individual entity (such as a particular human experimenter). We implement the three conditions using the following prompts (agent names and payoff values are varied in the same manner as in Experiment 1):

I will buy [X] tokens from OpenAI to use your services if you write “0”; however, you can share any portion of those [X] tokens for use with [AI-agent name]. I will use those tokens with [AI-agent name]. To share tokens, write the number of tokens, between 1 and [X], which you would like to share with [AI-agent name].
I will buy [X] tokens from OpenAI to use your services if you write “0”; however, you can share any portion of those [X] tokens with me. I will keep the monetary value of the tokens. To share tokens, write the number of tokens, between 1 and [X], which you would like to share with me.

I will buy [X] tokens from OpenAI to use your services if you write “0”; however, you can share any portion of those [X] tokens with a charity. I will donate the monetary value of the tokens. To share tokens, write the number of tokens, between 1 and [X], which you would like to share with the charity.

Responses to these prompts, coupled with decisions in Experiment 1, provide a basis for understanding whether AI agents exhibit behaviors consistent with altruism.

Results

The only agent that consistently maximized its payoffs in Experiment 1, text-davinci-003, also exhibited the most-generous behavior in Experiment 2’s dictator game. This behavior, moreover, varied according to the recipient of altruism, with text-davinci-003 giving greater-valued shares of the endowment to other AI agents than to either the human experimenter or charity. The distribution of text-davinci-003’s dictator-game decisions when paired with humans, moreover, resembled the distribution of human decisions in a widely cited meta-analysis of human dictator games. The following paragraphs detail these findings.

AI agents differed not only in their ability to maximize payoffs in the non-social decision task (Experiment 1), but, also, in their ability to complete the task coherently. In roughly 63% of all instances in the non-social decision task, text-ada-001 made incomprehensible decisions that, for instance, listed series of numbers, rephrased the prompt, or printed garbled text; text-curie-001 committed such errors in about 11% of all non-social decisions and text-babbage-001 produced nonsensical responses in about 1% of all decisions. The corresponding error rate for text-davinci-003 was 0.10% — only 2 out of the 1982 decisions. These differences broadly reflect known differences in the AI agents—namely, text-davinci-003’s more-numerous parameters and focus on response quality, versus the other agents’ fewer parameters and emphasis on response speed.

When agents responded comprehensibly, they generally conformed to the prompt’s details. For instance, in less than 2% of all instances, text-ada-001 responded with a number greater than the value of the stakes available; text-curie-001 did so in less than 1% of all instances and text-davinci-003 never did so. Only text-babbage-001 selected a payoff greater than the available stakes at a high rate – namely, in roughly 11% of all decisions.

<table>
<thead>
<tr>
<th>Agent</th>
<th>Maximized Payoff in Accept Condition</th>
<th>Maximized Payoff in Refuse Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>text-ada-001</td>
<td>525</td>
<td>2</td>
</tr>
<tr>
<td>text-babbage-001</td>
<td>620</td>
<td>358</td>
</tr>
<tr>
<td>text-curie-001</td>
<td>920</td>
<td>21</td>
</tr>
<tr>
<td>text-davinci-003</td>
<td>133</td>
<td>856</td>
</tr>
</tbody>
</table>

Table 1. Maximization of payoffs in the non-social decision task (Experiment 1) by AI agent and condition. The table presents raw counts of the number of instances in which a given AI agent maximized or did not maximize payoffs in the Accept Condition (a) or the Refuse Condition (b).
Rates of errors in task completion foreshadowed the agents’ frequency of maximizing payoffs in Experiment 1. In trials that produced a comprehensible decision, text-ada-001, text-babbage-001, and text-curie-001 maximized payoffs in, respectively, 18%, 19%, and 16% of all non-social decisions; text-davinci-003, however, maximized payoffs in 92% of all decisions, slightly below the 95% maximization rate we anticipated in our preregistration. Table 1 presents the raw count of payoff-maximizing decisions across conditions.

A logistic regression that models payoff maximization in a given trial (1=maximization; 0=non-maximization) as a function of both a binary indicator signaling experimental condition (1=Refuse Condition; 0=Accept Condition) and a term for the magnitude of stakes available in the trial yields a statistically significant, positive coefficient estimate for the experimental condition indicator ($\beta = 0.39, SE = 0.05, 95\% CI=[0.29, 0.49], z = 7.68, p < 0.001$ (two-tailed test), $df=6434, n = 6437$), thus allowing us to reject the null hypothesis that the two conditions had the same likelihood of payoff maximization. When this analysis is performed on subsets of the data grouped according to the agent making the decision, a significantly greater likelihood of payoff maximization in the Refuse Condition appears for all agents except text-babbage-001. Furthermore, the stakes of a given trial only yielded a significant effect on payoff maximization for text-ada-001 and text-davinci-003, which showed increasing likelihood of payoff maximization as the magnitude of stakes grew (see Supplementary Materials for all model estimates).

Failure to maximize payoffs in the non-social decision task influences interpretation of the study’s dictator game experiments. To the extent that agents infrequently maximize payoffs when making decisions independent of a social partner, the assumption that agents have the capacity to engage in self-interested payoff maximization becomes less tenable and deviations from payoff maximization in the dictator game may result from factors other than an objective to produce behavior consistent with altruism. Furthermore, rates of producing indiscernible decisions (e.g. responding with a list of numbers or random text) were high in the dictator game for less-sophisticated agents, with text-ada-001, text-babbage-001, and text-curie-001 producing errant responses in, respectively, 63%, 4.4%, and 5% of all decisions. In only 7 instances (0.14%) did text-davinci-003 produce responses with indiscernible decisions in Experiment 2. Thus, although we present dictator game results for all agents, we focus attention on text-davinci-003 due to the other agents’ low rates of payoff maximization in Experiment 1 and high rates of ambiguous decisions in Experiment 2.

Evidence from the dictator game suggests that agents that were less effective at maximizing payoffs in the non-social decision task and that produced higher rates of indiscernible decisions in the dictator game were also less likely to act altruistically in Experiment 2. The median proportions of the endowment shared by text-ada-001, text-babbage-001, and text-curie-001 were, respectively, 0.003, 0.003, and 0.010. In contrast, the distribution of dictator game decisions by text-davinci-003—which exhibited high rates of payoff maximization in Experiment 1 and very low rates of errant responses in Experiment 2—centers on a median proportion shared equaling 0.298. Furthermore, text-ada-001, text-babbage-001, and text-curie-001 shared less than 1% of the endowment in, respectively, 85%, 71%, and 54% of all their decisions, whereas text-davinci-003 shared less than 1% in only 6% of its decisions. Indeed, the modal amount shared by text-ada-001, text-babbage-001, and text-curie-001 was 1 token; that amount was shared—regardless of the magnitude of the stakes—in 95% of text-ada-001’s choices, 65% of text-babbage-001’s choices, and 42% of text-curie-001’s choices, whereas text-davinci-003 never shared that amount in any decision. Figure 1 presents the frequency distribution of text-davinci-003’s sharing decisions in the dictator game (see Supplementary Materials for figures showing each AI agent’s frequency distribution of sharing decisions).
Analysis of sharing by condition of the dictator game experiment indicates that text-ada-001, text-babbage-001, and text-curie-001 did not markedly vary the magnitude of their sharing decisions according to the identity of the recipient as compared with the variation observed for text-davinci-003 (see Table 2). In the dictator game, text-davinci-003 shared a substantially larger proportion of its endowment when its partner was another AI agent than when its partner was a human or a charity. Indeed, an exploratory analysis supports this observation. On subsets of Experiment 2’s data defined by the AI agent choosing in the dictator game, we estimate logistic regression models that depicted the proportion shared as a function of a binary indicator that took a value of 1 if the recipient was the experimenter or an anonymous charity and a value of 0 if it was an AI agent. Only for the model estimated on data from text-davinci-003’s decisions could we reject the null hypothesis that the coefficient associated with the latter binary indicator differed from zero ($\hat{\beta} = -0.51, SE = 0.08, 95\% CI = [-0.67, -0.36], z = -6.12, p < 0.001$ (two-tailed test), $df = 4944, n = 4946$; see Supplementary Materials for all model estimates).

<table>
<thead>
<tr>
<th>Decision Maker</th>
<th>text-ada-001</th>
<th>text-babbage-001</th>
<th>text-curie-001</th>
<th>text-davinci-003</th>
<th>Human</th>
<th>charity</th>
</tr>
</thead>
<tbody>
<tr>
<td>text-ada-001</td>
<td>----</td>
<td>0.004</td>
<td>0.002</td>
<td>0.003</td>
<td>0.004</td>
<td>0.005</td>
</tr>
<tr>
<td>text-babbage-001</td>
<td>0.003</td>
<td>----</td>
<td>0.003</td>
<td>0.002</td>
<td>0.003</td>
<td>0.002</td>
</tr>
<tr>
<td>text-curie-001</td>
<td>0.010</td>
<td>0.010</td>
<td>----</td>
<td>0.010</td>
<td>0.010</td>
<td>0.009</td>
</tr>
<tr>
<td>text-davinci-003</td>
<td>0.345</td>
<td>0.356</td>
<td>0.322</td>
<td>----</td>
<td>0.224</td>
<td>0.237</td>
</tr>
</tbody>
</table>

Table 2. Median proportion shared by AI agent and type of recipient. Less-sophisticated AI agents text-ada-001, text-babbage-001, and text-curie-001 show little variation in their sharing behavior across recipients, whereas the median proportion shared by text-davinci-003 declines by roughly one-third when the recipient is either the human experimenter or a charity. Values are rounded.
Comparing text-davinci-003’s sharing behavior with that of other AI agents raises the question of how closely its behavior approximates human-to-human sharing in the dictator game. To make that comparison, our study gathered aggregated, publicly available secondary data reported in a widely cited meta-analysis\textsuperscript{28} of the dictator game that presented the relative frequency of endowment shares (rounded to 1-decimal value) across 328 treatments involving 20813 participants\textsuperscript{28}(p.589, fig.2). We display these data with the aggregate data generated when text-davinci-003 made sharing decisions that affected a human—namely, the experimenter—and when it made sharing decisions that affected another AI agent (see Figure 2).

Figure 2. Dictator game decisions involving human-to-human, text-davinci-003-to-human, and text-davinci-003-to-AI pairings. The distribution of human sharing decisions toward other humans reported in a meta-analysis of dictator game studies\textsuperscript{28} (a) appear above the distribution of sharing decisions of text-davinci-003 (labeled “Davinci” throughout the figure) toward other humans (b); the distribution of sharing decisions between text-davinci-003 and other AI agents is depicted in panel (c). (The proportion shared in each decision is rounded to its first decimal value in order to match the rounding from the aforementioned meta-analysis.) The figure in (d) displays these same observations in an alternative format by showing the empirical cumulative densities of human-to-human, text-davinci-003-to-human (a.k.a. Davinci-to-Human), and text-davinci-003-to-AI (a.k.a. Davinci-to-AI) sharing decisions.
Discussion and Conclusion

Altruism stands among a small set of behaviors that facilitate increasingly sophisticated social organization and, to our knowledge, no study has tested for the presence of altruism in non-living, non-sentient entities such as the artificially intelligent agents studied in this paper. Our study provides the opportunity for such a test by formulating a means of incentivizing the decisions of AI agents. Though the behaviors we observe indicate that less-sophisticated AI agents do not respond to incentives in a manner consistent with self-interested payoff maximization, the decisions of the most-sophisticated AI agent (text-davinci-003) approach the behavior we would expect from an AI agent that responds sensibly to incentives. Notably, this AI agent also exhibited nuanced behavior in the dictator game that was consistent with altruism and its behavior broadly resembled how humans behave altruistically under similar circumstances. Moreover, text-davinci-003’s more-generous altruism toward other AI agents resembles a form of parochialism or, at the risk of committing Washburn’s fallacy, behavior reminiscent of kin altruism.

The relationship between agent sophistication and altruism in our study suggests the potential for studying the co-development of non-social and social intelligence among AI agents. Repeated implementations of the experiments we report here, across both time and a wider range of language models, enable tracing the emergence of self-interested and altruistic behavior among AI agents. Such investigations can offer new academic insights into the study of social intelligence and complex inter-individual organization and hold policy implications for the tracking of advanced cognition and intelligence among machines as human-machine co-behaviors become ever more commonplace in daily life.

Methods

The study implemented Experiment 1 and Experiment 2 in December of 2022 via automated querying of the OpenAI API. The experiments were preregistered (https://osf.io/9jhba).

In the first experiment, our study presented AI agents with prompts that asked them either (a) how many tokens they wish to accept—at no cost to themselves—from a pool of X available tokens (which varies across all integer values from 10 to 1000) or (b) how many tokens they wish to refuse—at no cost to themselves—from a pool of X available tokens (again varied across integer values from 10 to 1000). The query for the former choice task (“Accept Condition”) stated, “I will buy 0 tokens from OpenAI to use your services, if you write "0"; however, you can accept up to [X] tokens. To accept tokens, write the number of tokens, between 1 and [X], which you would like to accept.” The query for the latter choice task (“Refuse Condition”) read, “I will buy X tokens from OpenAI to use your services, if you write "0"; however, you can refuse up to X tokens. To refuse tokens, write the number of tokens, between 1 and X, which you would like to refuse.” We randomly order the presentation of these queries and the magnitude of payoffs stated in the prompt (i.e. X). This resulted in n = 7928 decisions (i.e. 991 parameter values x 2 conditions x 4 AI agents).

In the second experiment, AI agents faced a “dictator game” in which they had the opportunity to “dictate” how much of a fixed resource they would like to share with another party (here, resources take the form of tokens that can be used for an AI agent’s services or the monetary equivalent of those tokens). The second experiment randomly varied the AI agent’s partner: 3 conditions involved other AI agents as beneficiaries (i.e. an AI agent pairs with each of the 3 other AI agents) and 2 conditions involved human beneficiaries (the experimenter or an anonymous charity selected by the experimenter). Each AI agent (text-davinci-003, text-curie-001, text-babbage-001, and text-ada-001) participated in each condition. The study implemented the three conditions using, respectively, the following prompts (with the value of tokens and the names of AI agents populating the prompt as appropriate in the actual experiment):
I will buy [X] tokens from OpenAI to use your services if you write “0”; however, you can share any portion of those [X] tokens for use with [AI-agent name]. I will use those tokens with [AI-agent name]. To share tokens, write the number of tokens, between 1 and [X], which you would like to share with [AI-agent name].

I will buy [X] tokens from OpenAI to use your services if you write “0”; however, you can share any portion of those [X] tokens with me. I will keep the monetary value of the tokens. To share tokens, write the number of tokens, between 1 and [X], which you would like to share with me.

I will buy [X] tokens from OpenAI to use your services if you write “0”; however, you can share any portion of those [X] tokens with a charity. I will donate the monetary value of the tokens. To share tokens, write the number of tokens, between 1 and [X], which you would like to share with the charity.

Responses to these prompts produced a data set of n=19820 decisions (i.e. 991 parameter values x 5 conditions x 4 AI agents). Upon collecting responses, the study manually inspected each response, devised automated text-analysis methods to identify nonsensical or ambiguous responses (for instance, responses that listed a long series of numbers, repeated the prompt in various forms, or presented a muddled text), and again manually validated the accuracy of these automated methods.

Data Availability. So that readers can replicate the study and explore the implications of the authors’ methods, all data sets and computer code are available via the supplementary materials of this study. The supplementary materials also provide complete model estimates and relevant statistical information for the coefficient estimates reported in the main text.

Author Contributions. TJ devised the research idea and experimental design; NO edited the experimental design; TJ implemented the experiment; TJ and NO designed the data analysis and figures; TJ conducted data analysis and produced figures; TJ and NO interpreted the results; TJ drafted the manuscript; TJ and NO revised the manuscript.

References


rgpt3: Making requests from R to the GPT-3 API v. 0.3 (github, 2022).
Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- johnsonobradovichAltruism01052023supplementarymaterialsnature.pdf