The Invisible Hand as an Intuitive Sociological Explanation

Izabelė Jonušaitė[1] and Tomer D. Ullman (tullman@fas.harvard.edu)[2,*]

[1]Department of Brain & Cognitive Sciences, Massachusetts Institute of Technology, Cambridge MA 02139

[2]Department of Psychology, Harvard University, Cambridge MA 02138,

[*]Corresponding Author

Abstract

An invisible-hand explanation explains a situation as the outcome of individual actions, without individuals intending the situation. Invisible-hand explanations have been used for decades to account for all kinds of phenomena, from segregation to traffic norms. But, they have not been studied cognitively and empirically as an intuitive explanation type. We propose and show that US-based adults intuitively prefer invisible-hand over intentional-design explanations. We first validate pairs of explanations as equally likely to cause a social phenomenon (Exp 1). We then show that given that social phenomenon, participants prefer an invisible-hand to an intentional-design explanation, and that the preference for invisible-hand explanations is also negatively linked to conspiratorial beliefs. (Exp 2). We find that when participants are asked to come up with explanations themselves, they are equally fast to come up with invisible-hand or intentional-design explanations (Exp 3), but that both they and other participants prefer the participant-generated invisible hand explanations (Exp 3 and 4). We conclude that US-based adults likely have a prior preference for invisible-hand explanations for social phenomena.

Keywords: invisible hand, intuitive sociology, domain theories, explanation, hierarchical reasoning

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Introduction

Why don't clouds fall down? Why did the girl refuse to do her homework? Why did the protest break out? Without knowing more specific details, it's hard to give a specific answer to such questions. And yet, even without more specific details, the questions themselves suggest a *kind* of explanation. To say that clouds don't fall down 'because they have flobinium in them' makes more sense than 'because they are held up by pixies', even though both pixies and flobiunium don't exist. The cloud question is a physical question, and a likely answer would likely appeal to physical forces and properties. The homework question is a psychological question, and so an answer should appeal to desires, beliefs, and intentions. This is all pretty well known: People intuitively understand from a young age that physical phenomena require physical explanations, and psychological phenomena require psychological explanations (Carey, 2000; Schulz, Bonawitz, & Griffiths, 2007; Springer & Keil, 1991). But the third question does not fall neatly into this divide: Why *did* the protest break out? And while we're at it, why did the fad fizzle out? Why does the new train line not stop at that neighborhood? We suggest that such questions fall into a distinct domain, that of intuitive sociology. We propose that for intuitive sociology questions, people prefer a distinct type of causal explanation: an invisible-hand explanation.

An invisible-hand explanation accounts for a phenomenon by showing that it is the collective result of people pursuing their local interests, without the individuals holding the given phenomena as their intended goal. The end result is then the outcome of human action, but not human intention. The 'invisible hand' metaphor is familiar in many disciplines as a formal explanation type, particularly in economics. But, to our knowledge, it has not been examined cognitively as an intuitive yet distinct kind of explanation.

The Invisible Hand and its Relation to Other Explanation Types, Briefly

The invisible-hand metaphor was first introduced by Adam Smith (Smith, 1950), and has since been read as explaining how general patterns of commerce – such as the creation of national wealth or division of labor – emerge as global patterns from the actions of individuals trying to succeed in their own local circumstances (although see Harrison, 2011; Kennedy, 2009, for the debate surrounding the historical use and misuse of this metaphor). The invisible hand was later proposed as a more general type of explanation for social phenomena (Nozick, 1974; Ullmann-Margalit, 1978), and became an important basis for subsequent thought on how macro-social phenomena might emerge. The principles of the invisible hand, and the theory of spontaneous order which the invisible hand is a part of (Aydinonat, 2008), have been applied to diverse phenomena, such as emergence of money as a medium of exchange (Von Mises, 2013), residential segregation (Schelling, 1969, 1971), traffic rules (Young, 1996), and various social structures and group behaviors (Epstein & Axtell, 1996). The emergence of norms from local behavior has also been studied formally and computationally (e.g. Hawkins, Goodman, & Goldstone, 2019). But these are academic pursuits, experts giving an expert explanation for social phenomena, to other experts. Here, we are interested in whether everyday people intuitively prefer or reject the invisible hand as an explanation type in social situations. We note, however, that our experiments were all run with US-based adults, and all statements of generality should be seen as applying to that population. While we believe our findings may hold outside this population, such a belief will need to be backed up with further studies, as discussed in the Discussion.

We already know that people have preferences for types of explanations, reflecting domain-level intuitive theories (Gerstenberg & Tenenbaum, 2017; Lombrozo, 2012) of different areas, such as intuitive physics, intuitive biology, and intuitive psychology. Such mental divides are early-emerging, and continue into adulthood (Carey, 2000; Lake, Ullman, Tenenbaum, & Gershman, 2017; Schulz et al., 2007; Wellman & Gelman, 1992).

On top of this, a great deal of research has examined people's intuitive understanding of groups and relations in the social domain (e.g. Banaji & Gelman, 2013; Kaufmann & Clément, 2014; Thomas, Woo, Nettle, Spelke, & Saxe, 2022; Vasilyeva, Gopnik, & Lombrozo, 2018), but to our knowledge this work has not focused on the invisible hand as an overall explanation type within the social domain.

The invisible hand is part of a more general class of explanations that are concerned with emergent phenomena, connecting local patterns to global outcomes. Such explanations apply beyond the social domain. For example, emergent explanations connect the local motion patterns of atoms to the global diffusion of temperature. Previous research has documented people's difficulty with formal causal explanations for emergent phenomenon (e.g. Chi, Roscoe, Slotta, Roy, & Chase, 2012; Tümay, 2016). But these studies were carried out mostly in formal educational settings, and examined physical, chemical, or biological phenomena (diffusion, acidity, giraffe necks) rather than our aim here: everyday explanations for social phenomena (protests, fashion, fake news).

The main alternative to an invisible-hand explanation is an intentional-design explanation (Chi et al., 2012; Nozick, 1974; Ullmann-Margalit, 1978). An intentional-design explanation accounts for a phenomenon as having come about due to being the goal of someone's plan, the implementation of a person or group's intentions and desires. Why is the city segregated? Because someone wanted it to be segregated, and acted to segregate it. Both invisible-hand and intentional-design explanations deal with effects driven by human action, but we suggest that they fit different intuitive domains: Intentional design for the psychological domain, and invisible hand for the social domain. The first part has already been studied in the literature. Here, we investigate the second part, and specifically hypothesize that people will generally expect social phenomena to be accounted for by invisible-hand explanations, as opposed to intentional-design explanations.

Framework

Our overall framework is that of hierarchical Bayesian Reasoning (Griffiths, Chater, Kemp, Perfors, & Tenenbaum, 2010; Lombrozo, 2006; Tenenbaum, Kemp, Griffiths, & Goodman, 2011; Ullman & Tenenbaum, 2020). This framework sees inductive biases as priors, operating over multiple levels of abstractions. Many cognitive operations can then be seen approximating posterior inference, such that given space of possible hypotheses H, and some data D, the posterior probability over possible hypotheses becomes $P(H|D) \propto P(D|H) \cdot P(H)$. For example, within the space of intuitive psychology (Baker, Jara-Ettinger, Saxe, & Tenenbaum, 2017; Baker, Saxe, & Tenenbaum, 2009; Jara-Ettinger, Gweon, Schulz, & Tenenbaum, 2016), seeing a person take a particular action A is the data, and the explanation is a combination of mental factors such as beliefs (B) and goals (G), which maximize $P(B, G|A) \propto P(A|B, G) \cdot P(B, G)$. But intuitive psychology is one framework. We could also explain an action through physical variables such as forces, weight, and friction. The preference for a given hypothesis or explanation is driven both by how well it explains the data, and priors at increasingly abstract levels.

Before continuing, we note here an important issue of terminology: Previous work over the past decades modeling people's reasoning over the mental states of others has at times referred to these as models of 'intuitive psychology' (e.g Lake et al., 2017; Shu et al., 2021, and the work mentioned above). For the most part these models consider the mental states of single agents, or possibly multi-planning agents with clearly separated agendas. Such reasoning has been distinguished from *social* reasoning about groups and relations, which has been argued to constitute a separate area of core reasoning (Spelke, 2022; Spelke & Kinzler, 2007). Such terms are useful but also unfortunately can be confusing, in that psychology as an academic pursuit can include social reasoning (including social psychology), and also given that there are ongoing, decades-long discussions of the basic approaches to account for multi-agent and group behaviors. We clarify that our use in this paper of 'intuitive psychology' is meant in line with the previous use of referring to the intuitive reasoning over the goals and beliefs of separate agents (possibly in a multi-agent paradigm), and as opposed to a proposed domain of intuitive social reasoning over group behavior, social structure, and relationships.

Here, we consider different social events E, and two competing hypotheses for how that event came about: an invisible-hand cause H_{IH}, and an intentional-design cause H_{ID}. We are interested in people's relative priors over these causes, independent of the event E.

That is, we are interested in the *prior odds* $P(H_{IH})/P(H_{ID})$, and our hypothesis is that this factor is >1. We cannot assess this factor directly, but we can ask people to perform a comparison. That is, given an event E (e.g. a protest turned into violent clashes with the police), was the event more probably the result of an invisible-hand cause H_{IH} (e.g. multiple protesters individually felt boxed-in and shoved the people nearest to them), or an intentional-design cause H_{ID} (e.g. the police commissioner wanted the protest to turn violent, and took steps to make sure that happened). This reasoning can be captured as a hypothesis test (cf. Griffiths, Kemp, and Tenenbaum, 2008):

$$\frac{P(E|H_{IH})}{P(E|H_{ID})} \cdot \frac{P(H_{IH})}{P(H_{ID})} = \frac{P(H_{IH}|E)}{P(H_{ID}|E)} \qquad (1)$$

Our interest is in the middle factor, the *prior odds*, but we cannot assess it directly. We can assess the other factors, triangulating the factor of interest. The right-most term in Eq. 1 is the *posterior odds*, which we assessed by gauging people's preferences for one explanation over another given a variety of fictional social vignettes and causes. This by itself is insufficient, however. It is possible that the explanations and causes we chose just so happen to line up such that the invisible-hand causes were more likely to cause a given event. This is the left-most term in Eq. 1, the *likelihood ratio*. We assessed this term by independently asking people to suppose a given cause was true (e.g. suppose that the Police Commissioner wanted a protest to turn violent), and then having them estimate the likelihood that a given effect would come about. If we fix the likelihood ratio to 1, then any deviation from in the posterior odds should in principle be attributed to the prior odds. By assessing the posterior odds and the likelihood ratio, we can estimate the prior odds. We first chose vignettes and explanations such that both invisible-hand and intentional-design causes were seen as equally likely to bring about a given outcome, when holding each one true independently (a likelihood ratio of 1, Experiment 1). We then found in a separate, direct comparison that invisible-hand explanations are preferred to intentional-design explanations for a given event (the posterior odds are > 1, Experiment 2). The triangulation then leads to the conclusion that the prior odds are > 1.

We note that while our motivating framework is that of hierarchical Bayesian reasoning in line with previous studies on explanation types (e.g. Lombrozo, 2016; Schulz et al., 2007), adopting such a framework is not strictly necessary for a reader to agree (or disagree) with our work (and we thank a reviewer for this point). One can think of Experiment 1 as simply ensuring the potential causal power of the paired explanations is similar, and so that Experiment 2 is assessing commitment to types of explanations, without recourse to Bayesian reasoning about likelihoods, priors, and posteriors.

While we show people have an overall preference for invisible-hand explanations in social domains, we also expected individual variation in this preference. Some people may tend more to see a 'hidden hand' in things. An overall preference for explaining things as the intended design of a person or small group of people easily slides into conspiratorial thinking (Ullmann-Margalit, 1978). Given this, we expected that there will be a negative correlation between a preference for invisible-hand explanations, and conspiratorial beliefs. We found a small-but-significant such correlation in Experiment 2, indicating a link between acceptance of an invisible hand and less conspiratorial thinking.

The first two experiments together find evidence in favor of a preference for invisible-hand explanations, but they use experimenter-generated explanations, rather than participant-generated ones. This leaves open the possibility that we are operating in a very small and specific space which does not capture everyday intuition. In our next set of studies we asked people to come up with both invisible-hand and intentional-design explanations (Experiment 3), and to evaluate these explanations in a paired comparison (Experiment 3 and 4). We note that these experiments are based on participant generated data and depart from the likelihood test grounding of Experiment 1. Given the existing philosophical and cognitive literature, we initially hypothesized that invisible-hand explanations will be more difficult to come up with, but found that in fact they were as easy to generate as intentional-design ones (as measured by the time it took participants). We also found that for participant-generated explanation pairs, people overall preferred invisible-hand explanations.

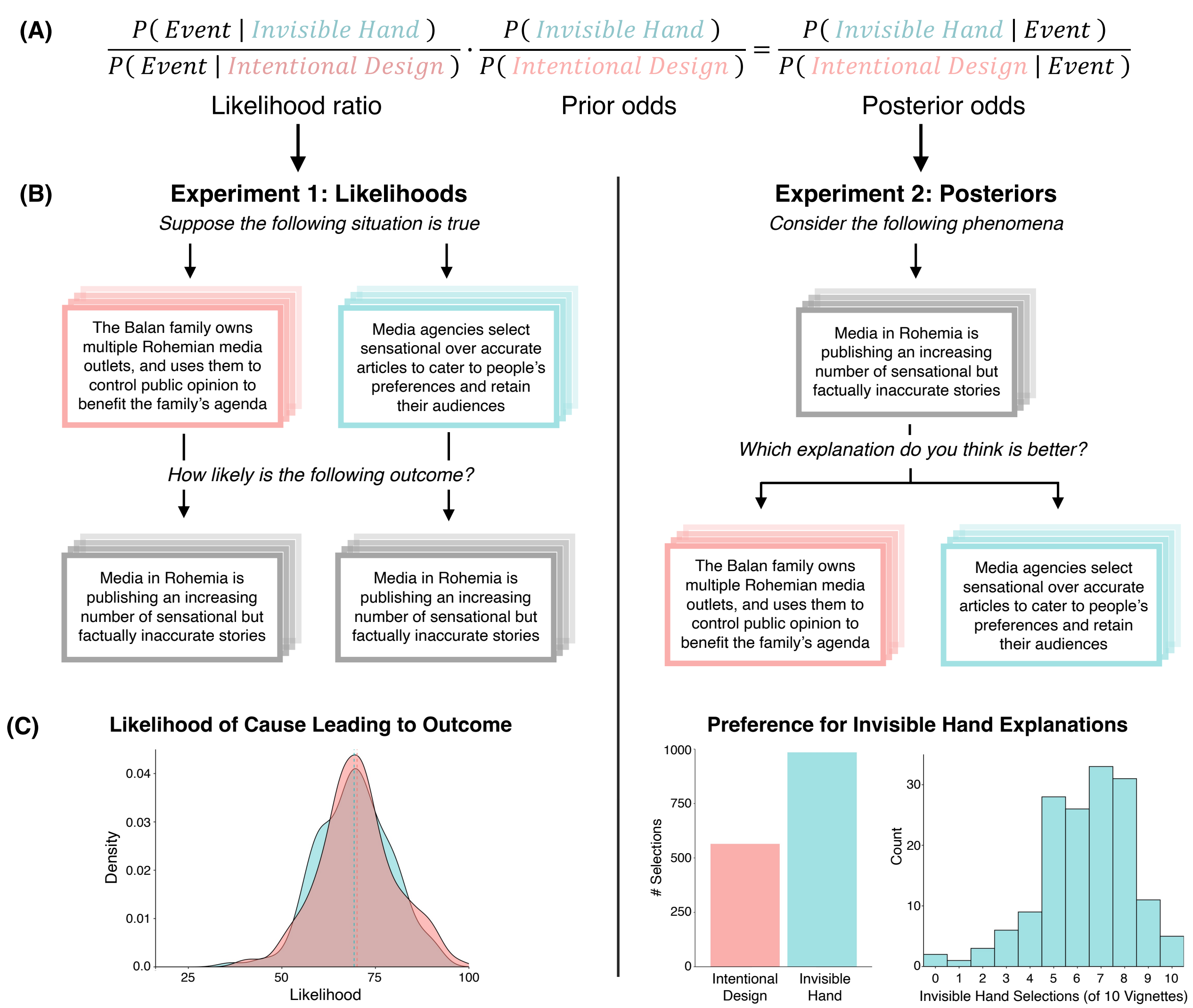

Figure 1 (A) Framework, (B) Experiment flow for Experiments 1 and 2, and (C) Main results of Experiments 1 and 2. *To establish whether the prior odds for invisible hand vs. intentional design is >1, we assessed the Likelihood ratio (Experiment 1) and Posterior odds (Experiment 2). In Experiment 1, participants were asked to suppose various causes are true, and estimate the likelihood of a fictional event. Both explanation types were equally likely overall. In Experiment 2, participants were given the fictional events and asked to choose which explanation is better. Overall, participants showed a preference for invisible-hand explanations.*

Experiment 1: Likelihoods

Our hypothesis was that people's prior odds for invisible-hand vs. intentional-design explanations was greater than 1, but we could not estimate that directly. Instead, we estimated people's likelihood ratio, followed by the posterior odds. In this study, we validated that our experimenter-generated invisible-hand and intentional-design explanations are equally likely *on their own* to cause a given outcome. Participants were asked to suppose different causes were true, then assessed the likelihood a given social event will occur given that cause (see experiment flow in Figure 1B, left).

Methods

All experiments were approved under an existing IRB (IRB19-1861 Commonsense Reasoning in Physics and Psychology). All participants provided informed consent. All experiments, procedures, analyses, and hypotheses were preregistered on Open Science Framework or asPredicted. The data for all experiments is available at https://osf.io/234bq/?view_only=feb6722ff18143529efde4c8cc7b6192. The pre-registration for Experiment 1 specifically can be found at https://osf.io/k94bg.

Sample Size

We hypothesized a null result in Experiment 1, and determined the sample size for this experiment by simulating data with a meaningful difference (10%) between the invisible-hand and intentional-design explanation likelihood judgments (0-100%), and testing sample size needed to detect this difference. A bootstrap power analysis using simulation data showed that a sample size of N=18 would suffice to detect a 10% difference with >95% power ($\alpha = 0.05$). Given that this is a new research direction, it was difficult to estimate an exact effect size. We erred on the side of caution, and aimed for a sample size of N=150, far above that suggested by the bootstrapped power analysis. In retrospect, it is possible that a 10-point difference was too high as the upper bar for a null effect (and we thank a reviewer for this point). However, as we find below, the actual point difference was -0.5

Participants

In all experiments, participants were recruited online (Peer, Brandimarte, Samat, & Acquisti, 2017) via the online participant recruitment service Prolific (https://www.prolific.co). Participants were compensated at the rate of 10 USD per hour. The inclusion criteria were as follows: participants had to be 18 years old or older, residing in the United States, with a Prolific approval rate at or above 90%. Participants who took part in relevant pilot studies or other studies in this series of experiments could not participate in a given study. The mean age of participants was 37, and 111 identified as female.

Data Exclusion

Our exclusion criteria were to exclude participants who failed two attention check questions, aborted the experiment, or finished an experiment in less than 180 seconds. None of the participants failed the two attention check questions. Of the remaining participants, 13 aborted the study and were excluded. None of the participants who completed the study did so in under 180 seconds.

During data collection, we observed that some participants spent a negligible amount of time on a number of vignettes. This was not reflected in the total time taken to complete the survey, as those participants would take a disproportionate amount of (idle) time on a random part of the survey. While this was not a part of the pre-registered exclusion criteria, we used an additional criterion to exclude this data in the following way: participants who answered too quickly (<5 seconds per vignette) to be reading at least half the vignettes were discounted. This resulted in an additional 14 participants being excluded from Experiment 1. This decision was made prior to any data analysis. Participants who were excluded were replaced, leaving a total sample size of N=154 for analysis.

Materials

To investigate people's intuitive expectations about social situations, we presented participants with fictional vignettes, which included social outcomes, invisible-hand causes, and intentional-design causes. The scenarios were fictional, and created specifically for this study. This was a design choice, so that participant responses will not be driven by specific experience. Instead, participants presumably relied on more abstract knowledge, over-hypotheses, and intuitive domain theories.

We designed 10 text-based vignettes describing macro-social scenarios, and two possible explanations or causes for each scenario. Vignettes were modified to measure explanation likelihoods (Experiment 1) and preferences (Experiment 2). See the Supplementary Material for a detailed description of the vignettes.

Participants were first presented a cause with the prompt "Suppose the following situation is true". Then, participants were presented with the prompt "Consider this possible outcome", followed by a fictional social scenario. Participants were then asked "How likely is the situation to lead to the outcome?" Participants indicated their estimated likelihood on a 0-100% slider.

Prior to the experiments, the vignettes were iteratively designed and checked for readability. We used Flesch readability in particular (Flesch, 1979), a common ease-of-reading measure that takes into account the total words, sentences, and syllables used (estimated with the *textstat* Python package). The average score of Flesch readability for all vignettes was 43. For invisible-hand explanations, the score was 42, and for intentional-design it was 45 (This difference was not significantly different by a paired T-test, $t(9) = 0.752$, $p = 0.47$). In addition, we designed the vignettes to describe both positive and negative social outcomes, with an even split between positive and negative.

In both Experiments 1 and 2, we administered the Generic Conspiratorial Belief (GCB) scale (Brotherton, French, & Pickering, 2013). The GCB consists of 12 items. Each item states a generic conspiratorial belief, and the participant is asked to indicate the extent to which they think that statement is likely to be true (using a 5 point Likert scale, from “Definitely not true” to “Definitely true”).

Procedure

All experiments were presented to the participants online, on the Qualtrics platform. Participants were informed that the studies were designed to investigate commonsense reasoning about social situations, and provided with a consent form. If a participant did not provide consent, the survey terminated before starting the study.

Following consent, participants were given an outline of the contents of the study, and an estimated completion time.

In Experiment 1, participants were informed of the vignette structure (“For each vignette, you will read about a particular situation, and a particular outcome that may or may not result from that situation”), their task (“For each vignette, we’d like you to estimate: how likely is the situation to cause the outcome?”), and the response scale (“You will use a scale ranging from 0% (this situation is extremely unlikely to cause this outcome) to 100% (this situation is extremely likely to cause this outcome)”). Participants then saw one vignette at a time in randomized order, for a total of 20 vignettes.

In the second part of the experiment, we administered the Generic Conspiratorial Belief scale. Participants were presented with 12 generic conspiratorial statements and were asked to rate each statement on a 5-point Likert scale, indicating the extent to which they believe the statement to be true. All 12 items and rating options were presented at the same time, in the form of a matrix.

Participants were asked two attention check questions. A captcha test was also included, to exclude potential bots. At the end of each experiment, participants were given an optional demographic survey. Following the demographic survey, participants were thanked, and given a text slot for providing feedback. On average, people took 19 minutes 31 seconds to complete Experiment 1.

Results

As can be seen in Figure 1C, we found that the type of cause (invisible hand and intentional design) had no significant effect on the likelihood of a given effect. That is, there was no significant within-subject difference in invisible-hand vs. intentional-design explanations on a paired t-test, $t(153) = 1.39$, $p = 0.23$). Given this, we take the likelihood ratio for our experimenter-generated vignettes and explanations to be roughly 1. The findings on their own are expected, but do not yet shed light on invisible-hand explanations. This experiment mainly serves to validate the vignettes and explanations, as the basis for Experiment 2.

We also note two additional post-hoc analyses examined the likelihoods in more detail, which we expand on in the Supplementary Materials. Briefly summarized here: we examined the likelihood differences by vignette, as the lack of overall difference may mask individual likelihood differences. However, we found no significant difference between the likelihoods of the paired explanations either. In addition, we examined the possible relationship between individual Generic Conspiratorial Belief (GCB) scores, and likelihood ratings, finding no correlation.

Experiment 2: Posteriors

Given that our explanations were seen to have the same likelihood of causing the outcome, we next assessed people's posterior odds over the different explanations. In Experiment 2 a new group of participants was given the fictional vignettes, and paired possible explanations (that were validated by Experiment 1). Participants then selected the cause they thought led to the given effect (see experiment flow in Figure 1B, right).

Methods

The pre-registration for Experiment 2 can be found at https://osf.io/7xm5n.

Sample Size

A bootstrap power analysis using pilot data showed that a sample size of N=37 would suffice to show our main effect with 95% power (α = 0.05). For the correlation effect, a power analysis showed that a sample size of N=33 would show the effect with power of 95%, and a sample of N=70 would show the effect with >99% power. Using the same reasoning as Experiment 1, we went far above the sample size suggested by the bootstrapped power analysis, and aimed for a sample size of 150 participants.

Participants

As in Experiment 1, participants were recruited online (Peer et al., 2017) via the online participant recruitment service Prolific (https://www.prolific.co). Participants were compensated at the rate of 10 USD per hour. The mean age of participants was 34, and 121 identified as female.

Data Exclusion

We used the same exclusion criteria as in Experiment 1. Once again, none of the participants failed the two attention check questions, and none completed the study in under 180 seconds. Of the remaining participants, 11 aborted the study and were excluded. We applied again the same logic of Experiment 1 in noticing that some participants answered some vignettes too quickly (<5 seconds per vignette, for at least half the vignettes), and used this to exclude 5 additional participants. Once again, this decision was made prior to data analysis. Participants who were excluded were replaced, resulting in 155 participants in the final analysis.

Materials

We used the same vignettes as in Experiment 1. Participants were presented a fictional social scenario, and asked a contextualized question on the cause of the scenario. Then, two possible explanations were presented (an invisible-hand explanation, and an intentional-design explanation). Participants were asked "Which explanation do you think is better?" and used numbered buttons to indicate their preference.

Procedure

Following consent, participants were informed of the study and vignette structure ("The first part consists of 10 descriptions of situations and 2 possible explanations for each situation"), and their task ("Read the description and choose the explanation that is better and more likely"). Then, participants saw one vignette at a time in randomized order, for a total of 10 vignettes. The order of invisible-hand and intentional-design explanations within each vignette was pseudo-randomized. That is, the order was based on a random string, but that random ordering was then used for all participants. This was followed by the Generic Conspiratorial Belief scale, as in Experiment 1. On average, people took 15 minutes 24 seconds to complete Experiment 2.

Results

As can be seen in Figure 1C, right, we found that people had a marked preference for invisible-hand explanations. Approximately 2 out of every 3 participants chose a majority of invisible-hand explanations across the vignettes. Only about 1 in 6 participants chose a majority of intentional-design explanations. A Wilcoxon Signed-Rank test confirmed that the invisible-hand explanation selection frequency (*Median* = 7) was statistically significantly different from an unbiased selection, $p < 0.01$). Given this, we take the posterior odds to be > 1. Taken together with the unbiased likelihood ratio, the results suggest people have a prior preference for invisible-hand explanations.

While the mass of the probability of selecting explanations was towards the invisible hand, there was individual variation in this preference. Some people much preferred it, but a small minority (~15%) selected a majority of intentional-design explanations. We hypothesized that this variance will correlate with conspiratorial beliefs. In the second part of Experiment 2, after the main study, participants also filled out the Generic Conspiratorial Belief (GCB) questionnaire (Brotherton et al., 2013). We indeed found a medium correlation between intentional-design selections and GCB scores ($r(153) = 0.23$, $p < 0.01$).

Our main interest was in the aggregate effect, but given that the vignettes were idiosyncratic, there was variation between the vignettes. While not part of our original pre-registered analysis plan, several useful and important additional analyses examining the individual vignettes came up during review. We detail these more in the Supplementary Materials, but briefly summarize them here as well. First, we considered the main effect (a preference for invisible hand explanations) by each vignette. We used a z-test of proportions to examine participant proportions against a point of indifference (0.5), and corrected for multiple comparisons with the Holm-Bonferroni method. Of our 10 vignettes, 6 were significantly above the point of indifference in the direction of the Invisible Hand explanation, 3 are not distinguishable from indifference and only one is significantly in the direction of an Intentional Design explanation.

We also considered the vignettes by the valence of their outcome. As a reminder, we designed the vignettes to be equally split between 5 vignettes with a negative outcome, and 5 vignettes with a neutral-or-positive outcome. This too was a post-hoc, non-pre-registered analysis that came up in review, but there are several grounds for thinking a-priori that the valence of the outcome will affect people's preferences. For example, perhaps intentional-design explanations for negative outcomes are seen as particularly conspiratorial and nefarious, and people prefer to not think of themselves as conspiratorial. Conversely, negative outcomes may lend themselves particularly well for agent-based explanations. The results in this case were mixed: Both the negative and non-negative vignettes show the preference for invisible-hand explanations. That is, the overall proportion of selections of the invisible-hand explanation was 67.6% for the negative vignettes, and 59.4% for the non-negative vignettes, both of which are significantly above 50% by a z-test of proportions against 0.5 ($p < 10^{-24}$ and $p < 10^{-7}$). But, both proportions are also different from one another by a z-test of proportion ($p < 0.001$).

We can further examine the possible effect of individual vignettes by considering the individual differences per vignette in the posterior preference for IH explanations against the individual differences per vignette in the likelihood of paired explanations (Experiment 1). While the main studies concluded an aggregate null effect for likelihood differences, this may mask effects of individual vignettes. We found however that there was no correlation between the preference for IH explanations and the likelihood differences.

Beyond additional analyses, two important further concerns led us to conduct follow-up studies to Experiment 2, detailed in the Supplementary Materials. First, our interpretations so far have rested on questions of probability, but in the presentation of the paired stimuli in Experiment 2 we asked participants to select the "better" explanation. This is problematic, as participants may be selecting explanations as "better" because they are more elegant, shorter, nicer, or other factors that are unrelated to probability. To address this, we recruited a new group of participants (Experiment S1 in the Supplementary, N = 200, US-based sample, mean age 37 years, 108 identified as female), and conducted the relevant portion of Experiment 2 again, but asking participants to select the explanation that is "more likely/probable". We found a high correlation between the proportion of participants who selected the IH explanation in Experiment 2 and this new Study S1 (Pearson's $r = 0.91$, $p < 0.001$), which we take to suggest that participants treated the terms similarly in our experiments.

An additional important concern was that the Invisible Hand explanations may be more vague than the Intentional Design explanations, and that vaguer explanations are preferred as specific ones can be more easily refuted. To address this concer, we recruited a new group of participants (Experiment S2 in the supplementary, US-based sample, mean age 41 years, 120 identified as female). The materials were nearly identical to Experiments 2 and S1, except that participants were asked to select the explanation that was "more vague". While on the whole IH explanations were selected as more (57% of all explanations), there was no relationship between vagueness and how good (or likely) an explanation was. If anything, the trend was in the negative direction, such that IH explanations had to overcome a bias *against* vagueness to still be preferred.

Experiment 3: Generating Explanations

Our experiments so far give us reason to think that overall people have a prior in favor of invisible-hand explanations. However, the previous experiments used paired explanations that were constructed and validated by the experimenters, controlling for their likelihood, readability, valence, and so on. Such validation and control can lend strength to the conclusion, *but* it can also be cause for concern. If we are after people's intuitive understanding, the rough-and-ready world of everyday explanations may not readily distinguish the types we are interested in, or may even have a reverse preference.

Put differently, by using carefully constructed explanations we may be operating in a limited mental space, with equally limited conclusions. It is possible that people consider *both* paired explanations as quite unlikely. While our use of paired explanations was in line with previous studies on explanation types (Lombrozo, Bonawitz, & Scalise, 2018; Schulz et al., 2007), what we further need are everyday explanations that people come up with on the fly.

Moreover, even if people do have a prior in favor of invisible-hand explanations (as opposed to intentional-design explanations), this does not mean that invisible hand explanations come more readily to mind. There is a distinction between the process of coming up with a theory or hypothesis, and the process of evaluating it (see e.g. Carroll & Kemp, 2015; Dasgupta, Schulz, & Gershman, 2017). In the philosophical literature, some have argued that an invisible-hand explanation 'typically replaces an easily forthcoming and initially plausible' intentional design explanation (Ullmann-Margalit, 1978). This claim has not been directly tested empirically, though we note it is in line with other multi-step models of attribution or explanation, in which an initial, automatic attribution is followed by a more effortful correction for situational factors (see for example Gilbert, Pelham, & Krull, 1988, and also the discussion of intentionality and teleological reasoning in the Discussion).

Given this, in the next pair of studies (Experiments 3 and 4) we moved to participant-generated explanations. Our design was to have participants generate paired intentional-design and invisible-hand explanations (Experiment 3), and to have those participant generated-explanations evaluated both by themselves, and by a different group of participants (Experiment 4). Our initial expectation was that invisible-hand explanations will be more difficult to come up with (resulting in longer reaction times for different parts of Experiment 3), but that other people will prefer the invisible-hand explanations. We anticipated that independent group of people will show the invisible-hand prior for the new explanations, rather than the people who came up with them originally. This was based on the weak sense that, like other kinds of off-spring, people love their explanations equally.

To not bury the lede, we found that in fact people took the same amount of time to come up with the different explanation types, that people preferred invisible-hand explanations even when they generated them, and (as shown in the next study) that this preference was also present in independent evaluators.

Methods

The pre-registration for Experiment 3 can be found at https://aspredicted.org/HPR_WKZ.

Sample Size

As this is a new research direction, we did not have a good basis for anticipated effect sizes when considering the time it takes to generate different types of explanations. Based on rough simulation analyses and erring on the side of caution, we recruited 300 participants, which were then divided into 3 conditions as described below.

Participants

As in other studies, participants were recruited online via the online participant recruitment service Prolific (https://www.prolific.co). Participants were compensated at the rate of 12 USD per hour. The mean age of participants was 40, and 140 identified as female.

Data Exclusion

We excluded from analyses participants who failed the final attention check (asking participants to describe in their own words what they were asked to do in the study). The decision of what constituted a 'low effort' answer was made prior to data analysis, and resulted in 39 participants being excluded.

In addition, we excluded from analysis participants who took more than 5 minutes to generate a given explanation. This decision was made before data-collection and was enacted prior to data-analysis. It resulted in an additional 31 participants being excluded. Overall 230 participants remaining in the analysis.

Materials

We randomly selected 3 of the fictional vignettes used in Experiments 1 and 2, with the caveat that at least one must be negative in outcome, and at least one must be non-negative in outcome. Specifically, we used vignette 3 ('Protesters Clash with the Police in Altorid, Valtany'), vignette 4 ('Social Movements Grow Influence in Gredland') , and Vignette 8 ('Fashion trends accelerate in Jirev').

Participants were presented with one of the fictional social scenarios, and asked to come up with both an invisible-hand explanation, and an intentional-design explanation to explain that situation.

Procedure

Following consent, participants were informed of the study and structure and their task ("you will be asked read one short fictional vignette describing different situations, and then asked to come up with 2 different types of explanation for that situation."). Then, participants read a briefing detailing the difference between an invisible-hand and an intentional-design explanation. This part involved both definitions for the different types, and examples using held-out vignettes (see Supplementary Materials for detailed information regarding the briefing). Participants were then asked to indicate their confidence level in understanding the task on a scale of 1-7. The median confidence was 6, and approximately 93% of people reported a confidence level of 5 or higher.

Following the briefing, participants were randomly assigned to read one of the 3 fictional vignettes, and then asked to come up with an invisible-hand explanation, and an intentional-design explanation for it (the ordering of which explanation to come up with first was randomized), using a free-form text entry box. People were then asked to indicate which of the two explanations they themselves preferred. Participants were then thanked for their time, asked to explain the task in their own words, and were given the chance to offer feedback. The median time to complete the entire task was 10 minutes and 39 seconds.

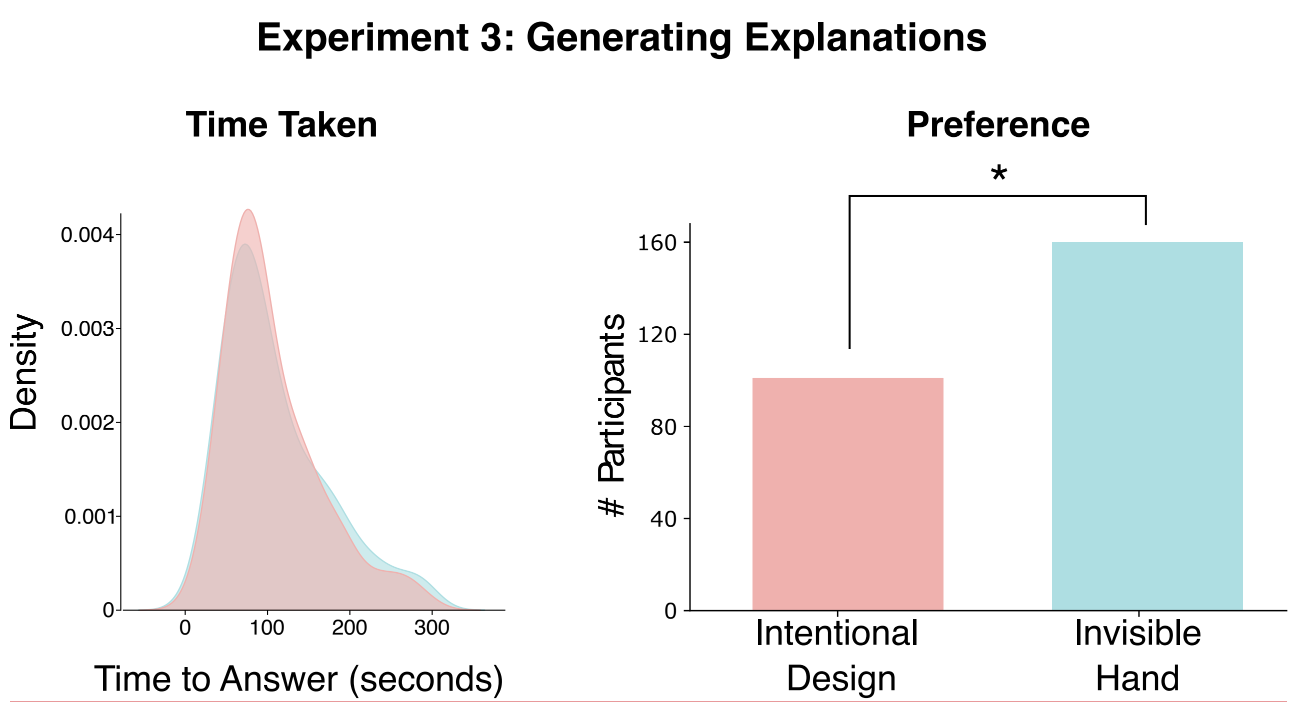

Figure 2 Main results for Experiment 3. *Left: Time taken to generate different types of explanations. Right: Overall preference of intentional-design and invisible-hand explanations.*

As can be seen in Figure 2 (left), there was no difference in the amount of time it took people to generate invisible-hand explanations compared to intentional. The average time participants spent on the page asking them to generate an invisible-hand explanation was 109 seconds, and for the intentional-design it was 105 seconds. Using a bootstrap analysis with 10,000 samples, the 95% confidence interval on this difference contains 0 (95% CI: [-3.10 – 11.05]). A related-samples, one-sided t-test also shows this difference to be not statistically significant ($t(239) = 0.91$, $p = 0.18$). Examining the difference by vignette also showed no statistically significant difference ($\Delta t_{v3} = 3.8$, 95% CI: [-9.37 –

17.44], Δt_{v4} = 9.61 , 95%CI: [-1.73 – 21.26], Δt_{v8} = -0.82 , 95% CI: [-12.87 – 10.87]). The lack of statistical difference held when considering other timing measures, such as 'from the first click to submission'. Such a finding was in contrast to our initial hypothesis which was based on the existing philosophical and cognitive literature, but seems to indicate that it takes the same amount of effort to generate an invisible-hand explanation as an intentional-design one.

When it comes to preference, however, we found that people preferred their own self-generated invisible-hand explanations over the intentional-design ones (Figure 2, right). The overall proportion of selecting invisible-hand explanations was 61% with a 95% CI of [0.56 – 0.66] using a bootstrap analysis with 10,000 samples. This is also significant by a one-sided z-test of proportions ($p < 0.0001$). When breaking this preference down by individual vignettes, all vignettes showed >50% preference for the invisible hand, but only vignette V3 was statistically significant. We emphasize that we did not expect to find *any* preference in people for their own explanations, and the real test for an existence of a prior is in the preferences of others, which we turn to next.

Experiment 4: Evaluating Participant-generated Explanations

We were mildly surprised to find that participants on average had a preference for the invisible-hand explanation over an intentional-design one when they themselves came up with the explanation, as we expected various biases to cloud this judgement based on the fact that both explanations are 'theirs'.

When designing both Experiment 3 and 4 in tandem, we anticipated that a better test of the invisible-hand prior would be to have an independent group of people evaluate the explanations of participants. Such a test would also help to examine 'explanations in the wild', as opposed to relying on experimenter-generated explanations.

Methods

The pre-registration for Experiment 4 can be found at https://aspredicted.org/4M3_3B9

Sample Size

Based on the overall proportion of participants who selected the invisible-hand explanation in Experiment 2, we anticipated that roughly 100 participants would be sufficient to demonstrate this prior for each of the 3 vignettes used in Experiment 3. Given this, we recruited 300 participants, which were then split into 3 conditions, as detailed below.

Participants

As in other studies, participants were recruited online via the online participant recruitment service Prolific. Participants were compensated at the rate of 12 USD per hour. The mean age of participants was 38 years, and 138 identified as female.

Data Exclusion

We excluded from analyses participants who failed the final attention check (asking participants to describe in their own words what they were asked to do in the study). The decision of what constituted a 'low effort' answer was made prior to data analysis, and resulted in 18 participants being excluded. As examples, answers deemed too low effort in response to 'what was your task' included "to choose a similar word" (no), "it feels like something that we talk about" (not really), and "choose the answer that seemed most correct" (good try).

Materials

We used the same three fictional vignettes as in Experiment 3, which were in turn inherited from Experiments 1 and 2, in addition to a random sub-sampling of 180 explanation-pairs generated by Participants in Experiment 3 (60 explanation-pairs for each vignette). The sub-sampling was done to prevent cognitive load. Participants were presented with one of the fictional social scenarios, followed by explanation-pairs, and asked to choose the explanation they preferred.

Procedure

Following consent, participants were informed of the study and structure and their task ("you will be asked read a short fictional vignette describing a situation, and then evaluate 60 pairs of explanations for that vignette."). Participants were told there were no right or wrong answers, and to simply select the explanation they think is better and more likely within a pair.

The main study consisted of reading one of the three fictional vignettes, and then being shown 60 explanation pairs. The order of the pairs across the study was randomized, as was the presentation order of the invisible-hand vs. the intentional-design explanation. Participants use radio buttons to select the explanation they preferred for explaining the vignette. The vignette remained visible during this process. Following the main study, participants were thanked for their time, asked to explain the task in their own words, and were given the chance to offer feedback. The median time to complete the entire task was 22 minutes and 52 seconds.

Results

As can be seen in Figure 3 (left), participants had an overall preference for the invisible-hand explanation in a given pair generated by other participants. The overall proportion of invisible-hand selections was 60.4% (95% CI: CI: [60% – 61%], using 10,000 bootstrap samples). This proportion is also significant by a z-test of proportions against the 50% point of indifference ($p < 10^{-168}$).

The preference for invisible-hand explanations also held by individual vignette with the proportions of selecting the invisible hand (and 95% CI) being M_{V3} = 69.7% (95% CI: [68.5% – 70.8%]), M_{V4} = 58.8% (95% CI: [57.8% – 59.9%]), M_{V8} = 55.3% (95% CI: [54.3% – 56.3%]). These proportions are also significant by a z-test of proportions against the 50% point of indifference ($p < 10^{-183}$, $p < 10^{-43}$, $p < 10^{-17}$). There was also individual variance within participants. Of the 282 participants, 206 selected more than 30 invisible hand explanations out of the 60 they say. Put differently, if we consider an 'invisible-hand leaning' person to be something who picks a majority of invisible-hand explanations out of the set of pairs, then about 3 of every 4 participants is invisible-hand leaning in this sense.

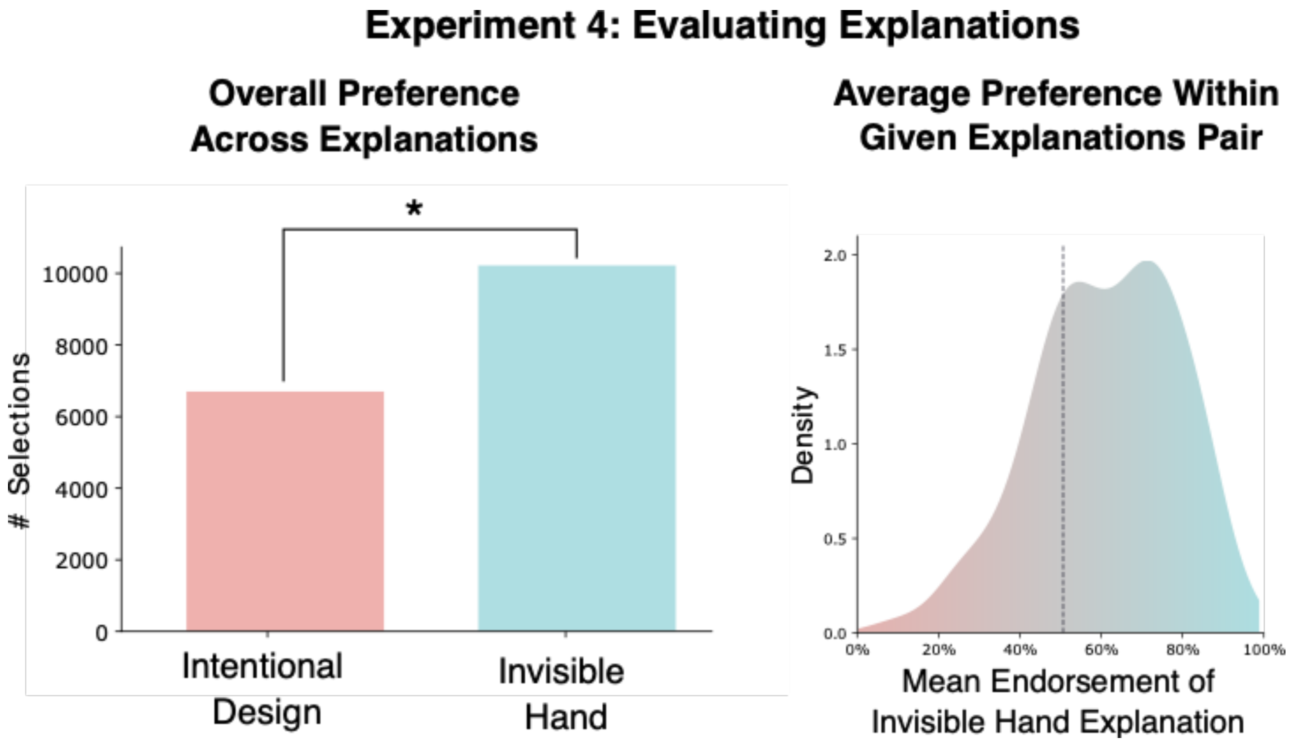

Figure 3 Main results for Experiment 4. *Left: The selections of intentional-design and invisible-hand explanations over all participants and vignettes. Right: The distribution of the average endorsement of the invisible-hand explanation above intentional design, for a given explanation pair generated by a participant. Most of the mass is towards the invisible hand.*

We also examined the preference by explanation pair. As a reminder, we had 180 explanation pairs (60 explanation pairs for 3 vignettes), with each pair being generated by a different participant. Here too there was individual variation, with some pairs involving a more strongly invisible hand explanation and some involving a more strongly preferred intentional design explanation. Out of 180 pairs, for 132 (73.3%) the majority of participants selected the invisible-hand explanation (meaning the average endorsement of the invisible-hand explanation was above 50%). Figure 3 (right) shows in more detail the distribution of the average endorsement of the invisible-hand explanation within a given pair. As can be seen, most of the density-mass is to the right of the 50% mark.

General Discussion

Mechanistic questions favor mechanistic explanations. Psychological questions favor psychological explanations. That is known. Here, we showed that social questions favor invisible-hand explanations. The invisible hand as an explanation type has been discussed in the social, philosophical, and economics literature for decades (Epstein & Axtell, 1996; Nozick, 1974; Smith, 1950; Ullmann-Margalit, 1978). This work is a significant addition to that literature, by examining the invisible hand empirically in lay explanations.

Our fictional vignettes and their associated explanations were first validated by showing that both our crafted invisible-hand and intentional-design explanations were seen as equally likely to bring about a given outcome (equal odds ratio). The crucial follow-up (Experiment 2) then showed that over a series of vignettes, 2 out of 3 participants chose a majority of invisible-hand explanations to account for the social outcome (posterior odds favors invisible hand). This lends support to the notion that people have a prior preference, independent of data, for invisible-hand explanations (prior odds favors invisible hand).

While the skew of the preference is clear, participants were not monolithic in its magnitude or direction. Such individual variation is likely linked to other individual traits, beliefs, and outlooks. In particular, it seemed a-priori reasonable to think that a preference for intentional-design explanations is linked to conspiratorial beliefs (Ullmann-Margalit, 1978). This reasonable thought turned out to be empirically true. We found a medium significant correlation between the overall preference for intentional-design explanations and generic conspiratorial beliefs.

For each fictional vignette, we attempted to match the invisible-hand and intentional-design explanations as much as we could, in features such as length, readability, outcome, and likelihood (the last one being judged by participants). This methodical burnishing may have nevertheless missed some spots. It remains possible that a different feature, not related to the invisible hand or intentional design, distinguishes these explanations. As just one example (helpfully pointed out by a reviewer), consider that 'bigger' events such as the President dying in an assassination attempt call for bigger explanations (a conspiracy) than smaller events, such as the President surviving an attempt (Leman & Cinnirella, 2007). It is in principle possible that while we did not design them this way, that some vignettes are 'bigger' in outcome than others. We did not find evidence for this, but it is a post-hoc analysis based on intuition. The point more broadly is that further work is needed to examine the context of specific vignettes, but also that above and beyond such concerns, it is possible that by the very act of polishing and burnishing, that we ended up with objects far removed from daily experience. Our concern here is with people's everyday intuition, and by using items crafted by experimenters we may have limited the generality of the conclusions. To address this worry, we asked participants to come up with different types of explanations themselves.

We initially thought that it would take people longer to come up with invisible-hand explanations. Coming up with an idea is separate from evaluating it. We can easily recognize a correct solution to a puzzle, even if we ourselves could not have come up with that solution (and see Dasgupta et al., 2017, for a more technical discussion). Similarly, even if people have an overall bias or prior in favor of invisible-hand explanations for social situations, this may manifest only in the evaluation process, not the search process. However, we found that the amount of time it took people to come up with both kinds of explanation was roughly the same. Such a finding seems to speak against the idea voiced in the philosophical literature that invisible-hand causes often replace earlier and more easily forthcoming intentional design causes (Ullmann-Margalit, 1978). But, the philosophical analysis was aimed at formal explanations in formal sciences, areas such as economics, sociology, and history, rather than daily life. It is possible that in formal settings it is indeed harder to come up with a satisfactory invisible-hand explanation. It is also possible that the philosophical conjecture was wrong.

The timing and difficulty question is of interest, but of greater relevance for our question here was people's preference, specifically evaluation by independent raters. We were less interested in how much people preferred their own explanations, reasoning that there were all kinds of biases that could lead to people liking their mental products equally (despite this lessened focus, we found that overall people did show a preference for invisible-hand explanations in their own explanations). Using an independent group of raters, we found that for participant-generated explanations, other people on average preferred the invisible hand explanation. This was true overall, this was true by vignette, this was true by participant, and this was true by explanation pair.

Broader Questions and Implications

We now turn from the specific findings of the current work to more general thoughts and considerations. To start, we note that the prior preference for invisible-hand explanations is persistent, but not over-whelming. Across our studies, depending on how one wishes to assess the strength of this preference, it is roughly somewhere around 0.6 or 0.7, on a 0 to 1 scale (we are being crass with units here). Such a prior could certainly be context-dependent, and vary by individual, setting, or culturally relevant information.

Conspiracies, Hidden Agents, and Invisible Hands

It is worthwhile to consider the overlap between the invisible hand, intentional design, and conspiracy theories, in light of our findings and analysis. This overlap is not a perfect covering. As mentioned, we found a moderate link between conspiratorial beliefs and a preference for intentional design explanations. And yet, intentional design explanations are not the same as conspiratorial explanations. A single person, acting in the open, towards a cause that most people agree with, would be classified as an intentional design explanation, but not as a conspiracy (except by those who might see a conspiracy *behind* these actions). While some of the explanations associated with our negative vignettes could be considered conspiracies (e.g. a powerful media magnate works behind the scenes to spread fake news), we designed half of the vignettes and associated explanations to be benign or neutral. The benign-or-neutral vignettes still elicited an invisible-hand preference in Experiment 2, though interestingly this preference was less than that for the negative vignettes. This pattern was replicated in Experiment 4, in which the positive/neutral vignette (V8) elicited a preference in favor of the invisible hand explanations, but one weaker than in the negative vignettes (V3, V4).

We note that a *higher* preference for the invisible hand when the intentional-design explanation overlaps with a conspiracy that has nefarious ingredients suggests that the preference is either driven by a desire not to seem conspiratorial to others, or by associating a lower probability with conspiracies in and of themselves. This issue also relates to the definition of what counts as a conspiracy theory, on which there is no universal agreement (see e.g. Dentith, 2016; Keeley, 1999; Mandik, 2007). While there is general agreement that a small group and secrecy are core ingredients of a conspiracy, the centrality of their nefariousness or their a-priori epistemic standing are still under debate, and there may also be a split between common views of conspiracies as separate from definitions used in philosophy. While we caution against drawing conclusions on the basis of individual vignettes, as it was not part of our original analysis plan, we note that it is interesting and potentially important that only one of the non-neutral vignettes was very strongly in the direction of the Invisible-Hand preference. Further studies could examine individual vignettes in more detail to separate the effect of nefarious and non-nefarious outcomes in this reasoning.

Continuing the line of conspiratorial thinking, our results do not yet resolve the causal direction between the preference for design-based explanations and conspiratorial thinking. Are some people more conspiratorial because they tend to prefer design-based explanations, or do they prefer design-based explanations because they are more conspiratorial? Or is a third component perhaps driving the two? The link is far from deterministic, and needs to be studied further.

Why a Preference at All?

Are people right or wrong to have an invisible-hand prior? Certainly in sciences such as biology, chemistry, and physics, the move from an intentional or agent-based explanation to mechanistic or physical models has been useful, and the commitment to the latter is almost taken for granted. However, we do not think that invisible hand explanations are *necessarily* true. Agent-based explanations have their place as useful and reasonable explanations in the human sphere, and they are particularly useful and reasonable when accounting for the behavior of specific persons. It makes sense to say that Susie did not do her homework because she was tired, or because she was angry with her father for trying to make her do it, and was asserting her independence. Appealing to an invisible-hand explanation in such a scenario would be difficult to concoct and not illuminating even if it could be somehow constructed. Moreover, even in the social sphere in which it is more appropriate, an invisible hand explanation does not *necessarily* hold true as opposed to a design-based one. This is true in abstraction (see the discussion of the Doge and the banking system in Ullmann-Margalit 1978), and also empirically. For example, the segregation of some cities could certainly be driven by the intentional racism of individuals rather than being solely the outcome of a Schelling preference model (Schelling, 1969).

While invisible-hand explanations are not *necessarily* true in social settings, the existence of such a prior can still be questioned in terms of validity. Is it more reasonable to have a prior in this direction than in the opposite direction? Our tentative stance is that it is, as many social phenomena of the sort we considered likely *are* driven by invisible-hand explanations. Such a question is best directed at sociologists who specialize in the true validity and relative frequency of formal explanations of this type. As psychologists, we can instead flip this question on its head and ask: given the existence of the prior, what does it tell us about the prevalence of invisible-hand explanations and causes in the wild? Here our tentative answer is that the very existence of this prior gives credence to the thought that invisible-hand explanations are more often right than not. Consider that if this bias is learned, it should be learned from some experience, and if it is innate, it should be useful in some sense. Just as the shape of an animal's eyes can point to the existence of a specific predator in its environment, the shape of our prior can point to the tell-tale existence of the invisible hand itself. Still, there are many biases that are only roundabout approximations of a bigger truth, and so our answers here are temporary and tenuous.

Supposing that the invisible-hand prior for social phenomena is true and reflects either an innate or learned bias, this seems to conflict with several established lines of work. In particular, past work has found that if anything, people tend to attribute agency (beliefs, goals, and desires) to things that want nothing to do with them, and that this in part accounts for pre-scientific accounts of natural forces (see e.g. Guthrie, 1995; Saxe, Tenenbaum, & Carey, 2005). Given some complicated natural phenomenon, people will either conjure up a hidden agent to account for it, or attribute intentions directly to that phenomenon. This needs to be squared with people being driven towards an invisible hand. First, the over extension of intuitive psychology has often been about the mis-application of intuitive psychology to physical phenomena, rather than social phenomena. So, it is possible that the contest between physical and psychological explanations is not as acute when considering instead psychological and invisible hand hypothesis comparisons. Second, despite the existence of over-extensions of intuitive physics, as mentioned studies have shown that even young children and certainly adults can, and do expect that of two possible explanations for a phenomenon, the right 'type' is the one that makes more sense (Schulz et al., 2007). We are arguing for a similar notion. Third, it is still possible that the prior does not manifest itself in the search process, but only in evaluation process. While we found no evidence that participants had greater difficulty coming up with invisible hand explanations (Experiment 3), they were asked to explicitly generate them, and the preference studies involve a direct comparison. So, the search process itself may still be biased towards intentional design. We note, however, that recent work on conspiratorial thinking (Frenken & Imhoff, 2022) has modeled reasoning over the existence of secretive intent over time using drift-diffusion modeling, and found that conspiratorial thinking can mostly be accounting for as a different 'starting point' in the search process, rather than a difference in the evidence accumulation process. This would be more in line with the notion of individual differences in a starting prior over invisible-hand explanations vs. intentional design.

Continuing the discussion of Experiments 3 and 4, one might worry that participants were generating a-priori better Invisible-Hand explanations in E3, rather than generating equally likely ones that were then judged according to an IH prior by participants in E4. We note that there is a chicken-and-egg issue here, but not necessarily a problematic one. Going back to our framework of seeing explanations as living in a hierarchical space that associates different explanations with probabilities, suppose people 'sample' from this space in proportion to how likely/probable an explanation is (such as sampling hypothesis has been useful in other cognitive domains, see e.g. Gershman, Horvitz, & Tenenbaum, 2015; Icard, 2016; Lieder & Griffiths, 2020; Vul, Goodman, Griffiths, & Tenenbaum, 2014). If a preference for explanations of type T exists, it will exist as a stronger prior over such explanations, making them more likely to be sampled – but also more likely to be convincing for others, since they use a similar space to evaluate explanations. Put differently, suppose someone was asked to explain why blueberries cause cancer (they don't). People will likely come up with biological, physical, or chemical explanations such as "it's the anti-oxidants somehow' or 'I guess they're laced with some chemical typically used to manage pests'. It's unlikely people will spontaneously generate explanations like "the ghosts of dead blueberries haunt people in the form of cancer", or "blueberries are very blue, which causes the blues, which leads to cancer", and even if tasked to come up with them such explanations they will be judged poorly. So, such explanations are a-priori less likely (and so less likely to be sampled), and also bad once they are considered, but those two things are linked. It makes sense that people would spontaneously generate better invisible-hand explanations *if* such a prior exists in the first place, and it would be odd if they did not. Experiments 3 and 4 were meant to move away from the potentially constricting logic of Experiments 1 and 2 in which we did the equivalent of generating equally-likely explanations of different types, as it may not be a psychologically plausible process more akin to forcing someone to evaluate non-physical explanations for the blueberry-cancer link that they would not come up with themselves.

Before turning to the next section, we take a step back to consider the reasonable, and broader 'why?' question, and also to consider whether the detected preference for Invisible-Hand explanations reflects a preference *for* those preferences or *against* intentional design, given that these were measured in opposition. While clearly a lot more work is needed here, we would point back to the logic of previous work on explanation types in other domains (e.g. Schulz et al., 2007), in particular that which contrasts intuitive psychological and intuitive physical explanations (we used 'intuitive psychology' here in the limited sense in which it was used previously, to describe reasoning about an agent's mental states from their observed actions). Consider the following:

Observation O: The clouds don't fall down.
Explanation A: The clouds are being held up by goblins.
Explanation B: The clouds are full of goblinium.

Adults, and children from a certain age, prefer physical explanations like B for physical phenomena like O, and conversely psychological explanations for psychological phenomena (even if they know both explanations specifically are false). This is taken to reflect a higher-order commitment, a prior within a hierarchically structured space of possible explanations. One could ask *why* such a prior or commitment exists, to which an answer is that it is either innate or learned from evidence, and if learned from evidence likely reflects higher-order learning of true relations in the world or pedagogical influences. While the developmental evidence points to a learned preference in the case of physics and psychology, we do not have evidence in our case to arbitrate it, and more developmental and cross-cultural data is needed (see also 'Future Directions' below). One could also ask whether the preference for e.g. Explanation B is driven by a liking for physical explanations for physical explanations or a disliking for agent-based explanations. Certainly it seems that as scientists we can reject an agent-based explanation like A even without a corresponding non-agent-based explanation like B, due to higher-order commitments in the sciences to non-agent explanations. But, we would suggest that when formalizing this, such a dis-preference is always measured relative to something. We have a dis-preference for agent-based explanations *relative* to something. Simply saying that it is '0.2' doesn't mean much unless we specify an alternative. Since the explanation types (physical or agent-based) are defined as a binary variable, evidence for one is evidence in disfavor of another. We find ourselves in a similar situation here. This is not to suggest that further studies can't shed more light on the topic, and certainly more are needed.

Teleology, Intentionality, and Emergence

The invisible hand explanation type is only one type among many. Previous work has considered other kinds of explanations, including mechanical, psychological, biological, physical, and teleological (with some overlap between them). How does the invisible hand prior fit in this crowded family portrait? As mentioned previously, even young children can distinguish between physical and psychological explanations, and prefer psychological explanations for psychological phenomenon (Carey, 2000; Schulz et al., 2007; Springer & Keil, 1991). But other work shows that young children display a *teleological* bias, expecting things to have a reason (Kelemen, 2004). Adults under speeded conditions also seem to favor *intentional* interpretations for causally ambiguous statements such as 'she broke the vase' (Rosset, 2008). The teleological bias seems to continue even into adulthood (Kelemen & Rosset, 2009), where people under pressure of timing will judge teleological statements such as 'the sun makes light so that plants can photosynthesize' as scientifically accurate. Even professional physicists display such an effect (Kelemen, Rottman, & Seston, 2013). While more recent work has challenged whether such teleological reasoning is unscientific or answering a different sort of question (Joo, Yousif, & Keil, 2022), here we would consider the question of invisible-hand vs. intentional design as potentially orthogonal to teleological questions, but deserving of further investigation either way. The experiments examining teleology and intentionality have focused on biological, physical, chemical, or psychological phenomena, and less on areas such as sociology and economics. Further, the early-acting teleological or intentional bias has been mostly shown for speeded judgements. This leaves open several intriguing possibilities: Previous work suggests that people have an initial bias towards teleological or intentional explanations which is over-ruled by further processing. If so, it would be in line with our results which were not under speeded conditions, that people mostly favor explanations in which a phenomenon arose without the explicit design of an specific agent. But, our speeded judgements suggest that people were no different in generating IH vs. ID explanations. It is also possible that when explaining the origins of a situation or event involving multiple persons (which was not the focus of previous studies), that people will favor an invisible-hand explanation no matter what. We also note that our situations examine emergence in a way that is not *accidental* in the sense used in some of the past work mentioned. The person in a demonstration who feels boxed in and pushes a police officer to get some air did not *intend* the eventual riot caused by the joint action of many people, but they are also not in the same causal situation of a person who knocks over a vase by accident, in which case there is a clear and direct causal link and a preference.

Continuing the theme of where to fit the invisible hand explanation among other types of explanation, there is the question of where to place the borders. The extremes seem relatively obvious: The aggregate behavior of many agents is best accounted for formally by sociology, and intuitively by the invisible hand. The behavior of a single agent or a few agents is best seen as purview of both formal psychology and intuitive psychology. Both frameworks also naturally benefit from cross-talk, connecting social behavior to the individual, and the behavior of the individual to social considerations, and such work has been ongoing for decades. But what about liminal cases? For example, how does one account for the dislike between the Smith family and the Jones family[1]? Rather than saying that such a situation necessarily should be modeling using either intuitive sociology or intuitive psychology, we would suggest that there is no barbed wire separating intuitive domains of explanations. When it comes time to make an inference or model the situation a decision needs to be made, much as legal situations may call on us to answer on which side of the border someone is, but in truth the actual decision could fall either way. The problem of demarcation exists for other types of explanation domains as well. Consider the domains of intuitive physics and intuitive psychology: When explaining why Susie is lashing out, it easier, simpler, and better to explain it with model of intuitive psychology. And when explaining the behavior of a billiard ball, it is simpler and better to call up intuitive physics. But what about a single-celled creature? Or a virus? Or a protein? Or a dot of light moving on a screen? We sometimes say "the electron doesn't want to go this way" or "the white cells hunt for germs" even though electrons don't want anything, and white cells don't have goals or beliefs (Ullman & Tenenbaum, 2020). Such flip-flopping on both ends of the demarcation border exists for both formal sciences, and for intuitive domains of explanation. So, rather than say 'the border goes here', we propose that even if the invisible hand is the right type of explanation for social situations, we would expect challenges of demarcation just like any other explanation type.

Future Directions

Just as people's overall domain preferences in intuitive psychology, biology, physics, and other domains have been fertile ground for different studies, we expect there can be many additional studies on the invisible hand as an intuitive explanation type. Of these, we highlight three research directions in particular. First, while we examined the invisible hand in the social domain, the invisible hand belongs to a broader class of explanations

[1] We thank a reviewer for this point and example.

concerned with *emergence*. Emergence is not limited to the social or psychological field (Aydinonat, 2008). Yet, people seem to have difficulty with emergent phenomena and causes in formal settings when studying non-social scientific fields (Banaji & Gelman, 2013; Vasilyeva et al., 2018). More work can examine this dissonance. Second, our studies were confined to US-based participants, and our results should be proportionally circumscribed. More work on both individual variance, as well as cross-cultural effects can help establish whether invisible-hand preferences are culture-specific. Third, whether or not the preference we found turns out to generalize cross-culturally, it is an open empirical question how and when it is learned. Our studies were all with adults, but the research on domain-based and domain-general explanations has shown that such studies can be usefully adapted to work with children (e.g. Lombrozo et al., 2018; Schulz et al., 2007).

Why *did* the protest break out, then? Without more details, one cannot put their finger on the exact answer. But, we find that even before hearing the details, people encountering everyday social situations are more inclined to accept an explanation that follows the template of an invisible hand. This doesn't mean the invisible hand is necessarily the right explanation, only that people are more inclined to see it, even if it isn't there.

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