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If it's important, then I'm curious: Increasing perceived usefulness stimulates curiosity

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ABSTRACT

Curiosity is considered essential for learning and sustained engagement, yet stimulating curiosity in educational contexts remains a challenge. Can people's curiosity about a scientific topic be stimulated by providing evidence that knowledge about the topic has potential value to society? Here, we show that increasing perceptions of 'social usefulness' regarding a scientific topic also increases curiosity and subsequent information search. Our results also show that simply presenting interesting facts is not enough to influence curiosity, and that people are more likely to be curious about a scientific topic if they perceive it to be useful personally and socially. Given the link between curiosity and learning, these results have important implications for science communication and education more broadly.

1. Introduction

Consider the following scenario. A new species of fruit fly has been discovered in Malaysia – remarkably, the fruit flies can jump up to 5 feet high in the air. Biologists believe that these fruit flies can improve our understanding of insect locomotion. Now imagine another scenario. Another species of fruit fly has been discovered in Indonesia – remarkably, the fruit flies share 95% of their DNA with humans. Biologists believe that these fruit flies could help us understanding the origins of cancer in humans. Which species of fruit fly are you more curious to learn about?

Curiosity has long been recognized as an important impetus to scientific discovery and to everyday information-seeking (Berlyne, 1950; Simon, 2001; Kidd & Hayden, 2015). A dominant viewpoint is that curiosity is *non-instrumental*. Correspondingly, most prior work has focused on perceived uncertainty and/or novelty as drivers of curiosity, where curiosity is pursued for its own sake (Schmidhuber, 1991; Berlyne, 1960; Oudeyer et al., 2007; Kobayashi et al., 2019). Yet the introductory example suggests that expected practical usefulness, a canonically *instrumental* consideration, may also direct our curiosity towards some stimuli over others.[1]

The role of instrumental factors, such as perceived usefulness, has been recognized in recent theoretical work on curiosity (Dubey and Griffiths, 2020; Golman, Loewenstein, Molnar, & Saccardo, 2020; Liquin and Lombrozo, 2020b).[2] For instance, one theoretical account (Dubey & Griffiths, 2020) links curiosity to 'value of knowledge', which is a function of people's current understanding of a topic and the perceived usefulness of that topic, and posits that curiosity is piqued whenever one perceives an opportunity to increase the value of one's knowledge (i.e., topics that either increase understanding or perceived usefulness or both). While prior research has explored ways to stimulate curiosity by motivating reduction of uncertainty (Gentry et al., 2002; Law et al., 2016; Clark et al., 2019), this account additionally suggests that it should also be possible to direct curiosity towards scientific topics – topics that may seem initially unimportant – if people come to appreciate their practical usefulness.

Prompted by this potential link between curiosity and usefulness, in this work, we consider stimulating curiosity by changing the perceived

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[1] In the introductory example, both of the newly discovered species of fruit flies are similar in terms of novelty as well as their potential to reduce uncertainty, but the second species of fruit flies would presumably stimulate greater curiosity, and we suggest this is at least in part due to its greater usefulness.

[2] We additionally note that although Loewenstein's influential theory of curiosity does not explicitly consider usefulness in its formal account, it does hypothesize that people will be more curious about topics that are important to them (Loewenstein, 1994). Recent formulations of the theory have formally studied how curiosity is driven by information that people perceive as being important to them (Golman & Loewenstein, 2018; Golman et al., 2020).

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usefulness of a scientific topic. Given that scientific topics often include basic research with highly indirect effects for any given individual, a focus on immediate practical usefulness might have limited applicability. Instead, we here focus on *social* usefulness – that is, on how knowledge of a scientific topic might benefit others and society more broadly. This has the advantage of targeting a wider range of science, and additionally allows us to explore a relatively understudied aspect of curiosity: its social role (Sinha et al., 2017; Dubey et al., 2021). Given the importance of curiosity for fostering learning (Kang et al., 2009; Gruber et al., 2014; Marvin & Shohamy, 2016; Gruber & Ranganath, 2019; Wade & Kidd, 2019; Gross et al., 2020) and potentially even reducing political polarization (Kahan et al., 2017; Erceg et al., 2020), successfully stimulating curiosity could have tremendous theoretical and practical value. Theoretically, finding a causal connection between perceived usefulness and curiosity would lend support to accounts of curiosity that feature usefulness, and go beyond prior demonstrations of a correlation between the two. Practically, it would offer a method for educators and science communicators to motivate learning about science.

2. Experiment 1: confirming the correlation between curiosity and usefulness

In Experiment 1, we aimed to confirm the existence of a correlation between curiosity and perceived social usefulness for a broad range of scientific questions. Prior to collecting the data, we pre-registered the data collection protocol, stimuli, and analysis plan (https://osf.io/3pnkv).

2.1. Participants

We recruited 300 participants from Prolific. They earned $1.15 for participating in a study that took approximately 5-6 minutes to complete. We removed participants who failed a simple attention check. Four participants were thus excluded, but their inclusion does not affect the significance of our findings.

2.2. Stimuli

The stimuli used in the experiment were 100 diverse scientific questions sampled from Reddit's *Explain Like I'm Five* subreddit. Out of these 100 questions, 50 questions were the highest-rated questions of all time (i.e., the questions that were the most popular and received the highest amount of engagement; number of up-votes was greater than 1000 for these questions). The other 50 questions were moderately popular questions, as reflected in up-votes between 200 and 600, and were taken directly from a prior study on curiosity (Dubey et al., 2021). We chose this diverse set of questions in order to elicit a wide range of curiosity in our participants. Note that we did not include questions that received fewer than 200 up-votes, as many of these questions contained grammatical errors or were poorly written.

2.3. Procedure

At the start of the experiment, each participant was assigned 10 questions randomly sampled from our 100-question database. For each question, participants were asked to rate their *curiosity* ('How curious are you to know the answer to this question?') on a scale from 1 ('not at all curious') to 7 ('very curious'). This was the key variable of interest. Further, we asked participants to provide their ratings for two dimensions of usefulness: *personal usefulness* ('To what extent would knowing the answer to this question benefit you personally?') and *social usefulness* ('To what extent would knowing the answer to this question benefit others and society in general?'). Both were measured on a scale from 1 ('not beneficial at all') to 7 ('very beneficial').

Lastly, we asked participants to rate their *confidence* in knowing the answer to the question, on a scale of 1–7 ('How confident are you that you know the correct answer to this question?'). We added this question to ensure that any effect of personal or social usefulness on curiosity is not reducible to confidence. After participants provided the ratings for their assigned 10 questions, the experiment was finished and they were debriefed and paid for their participation.

2.4. Results

To test the effect of confidence, personal usefulness, and social usefulness of curiosity, we ran a mixed-effects linear model with confidence, personal usefulness, and social usefulness as fixed effects, and question ID and subject ID as random effects. As shown in Table 1, both personal and social usefulness were positive and significant predictors of curiosity, even controlling for confidence.

2.5. Discussion

Experiment 1 confirmed the existence of a correlational link between perceived usefulness and curiosity on a broad range of everyday scientific questions. We also found that both personal and social usefulness were significant predictors of curiosity.

These results are consistent with accounts of curiosity that incorporate a role for instrumental value. However, they go beyond most prior work in identifying a role for *social* usefulness that appears to be distinct from *personal* usefulness. Why might social usefulness be associated with curiosity? One possibility is that socially useful information is valued in its own right, and so prompts curiosity for this reason. Another possibility, however, is that our question about social usefulness captured indirect forms of personal usefulness – for instance, the expectation that something might be of personal use in the future (because it is of use to others more broadly), or that one might gain social capital by knowing information that is useful to others. Rather than disentangling these possibilities here, our subsequent studies probe the power of social usefulness: can perceptions of social usefulness be leveraged to promote curiosity about science?

3. Experiment 2: does usefulness influence curiosity?

Having established a correlation between usefulness and curiosity, we next investigated whether curiosity about a scientific topic can be influenced by manipulating its perceived social usefulness, and whether this affects subsequent information search.

3.1. Participants

We recruited 240 participants from Amazon Mechanical Turk (AMT). They earned $1.00 for participating in a study that took approximately 7-8 minutes to complete. For both Experiments 2 and 3,

Table 1
Experiment 1: results from the mixed linear effect model.

	Coef.	Std. Error	z	P> |z|	[0.025	0.975]
Intercept	2.37	0.13	18.08	0.00	2.11	2.63
Confidence	0.11	0.02	5.54	0.00	0.07	0.14
Personal usefulness	0.16	0.02	7.98	0.00	0.12	0.19
Social usefulness	0.16	0.02	8.20	0.00	0.12	0.19
Question ID	0.13	0.02				
Subject ID	1.29	0.09				

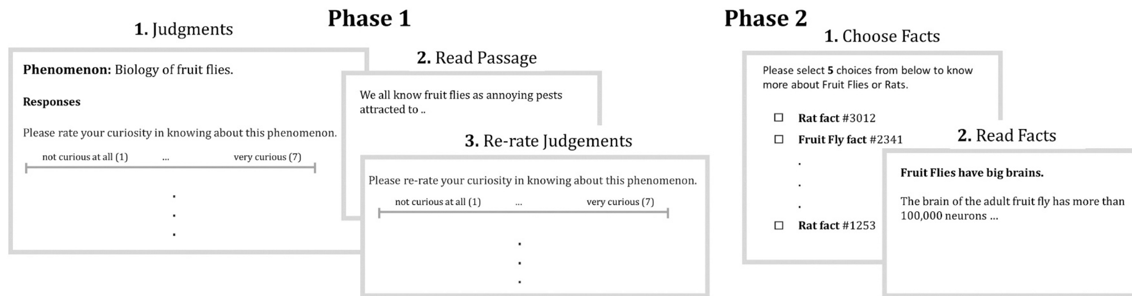

Fig. 1. Design of Experiment 2. The experiment was divided into two phases. In Phase 1, participants were presented with one of the two topics (fruit flies or rats) and asked to provide ratings for curiosity, understanding, and usefulness. They then read an article about that topic and once again rated curiosity, understanding, and usefulness. This procedure was repeated for the second topic. In Phase 2, participants had the choice to reveal five out of eight facts presented to them (four facts from each topic). The chosen facts were then presented one by one. Note that instructions were provided before each phase.

sample sizes were determined prior to data collection.[3]

3.2. Stimuli

Two short articles describing the biology of fruit flies and two short articles describing the biology of rats were used. For each of the two topics (i.e., fruit fly and rat), one article was 'high-use' and the other was 'low-use'. The high-use article emphasized how research about that animal could be highly beneficial to medicine, while the low-use article raised questions about whether research concerning that animal could generate any medical benefits. Thus, compared to the low-use article, the high-use article was designed to primarily increase perceptions of social usefulness (although it might also indirectly increase perceptions of personal usefulness). For both Experiment 2 and 3, all articles were matched in terms of length and, as much as possible, for general content and style. (See Supplementary Materials for complete stimuli.)

3.3. Procedure

3.3.1. Phase 1

At the beginning of Phase 1, participants were presented with one of the two scientific topics, either 'biology of fruit flies' or 'biology of rats' (counter-balanced). Participants then responded to the following on a scale from 1-7:

1. *Usefulness:* "To what extent would knowing about this phenomenon be useful to you in the future?" 1 (Not useful at all) to 7 (Very useful)
2. *Understanding:* "Please rate how well you feel you understand this phenomenon." 1 (Very vaguely) to 7 (Very thoroughly)
3. *Curiosity:* "Please rate your curiosity in knowing about this phenomenon." 1 (Not curious at all) to 7 (Very curious)

The first question was included to verify the successful manipulation of usefulness, and the second to ensure that the effect of usefulness on curiosity couldn't be reduced to perceived understanding. Curiosity rating was the key variable of interest in Phase 1. After providing their ratings, participants were presented with the assigned article for that topic and were instructed to read it as carefully as possible. The article advocated for either high or low-use (counter-balanced). After reading the article, participants were asked to re-rate usefulness, understanding, and curiosity about the initial topic. This procedure was then repeated for the other topic, which was always paired with the other level of use (for example, someone who received the high use article for rats would then receive the low use article for fruit flies; also refer to Fig. 1).

[3] Based on pilot data, we aimed to recruit at least 60 participants per condition, which required 240 participants in Experiment 2, given two conditions with counterbalanced order.

3.3.2. Phase 2

In the second phase, participants were instructed that they would be presented with some facts about the two topics (four for each topic, eight in total), but that they could only select five of those facts. The eight fact choices were then presented (e.g., "Rat Fact #3201"), and participants indicated their five choices. The corresponding facts were shown to participants after they indicated their choices.

3.4. Results

3.4.1. Phase 1

We evaluated each of our dependent variables in a mixed ANOVA with time point (2: pre vs. post ratings) as a within-subjects factor, article usefulness (2: low vs. high) as a within-subjects factor, and high use topic (2: rat, fruit fly) as a between-subjects factor.

We first confirmed that our manipulation of usefulness successfully affected perceived usefulness ratings. Indeed, there was an expected interaction between time and usefulness, $F(1, 239) = 47.69$, $MSE = 35.3$, $p < 0.001$, such that the high-use article led to an increase in usefulness ratings of 1.16 from pre to post, whereas the low-use article led to an increase of 0.40 (Fig. 2a). We next investigated the change in understanding ratings and found that there was an interaction between time and understanding, $F(1239) = 29.1$, $MSE = 16.8$, $p < 0.001$, such that the mean understanding rating increased by 0.63 for the low-use stimuli and by 1.16 for the high-use stimuli (Fig. 2b).

Finally, we considered our primary measure of interest, curiosity, and found that there was an expected interaction between time and usefulness, $F(1239) = 32.69$, $MSE = 21.6$, $p < 0.001$, with the increase in curiosity being greater for the high-use stimuli (1.04) compared to the low-use stimuli (0.44), $t(478) = -4.71$, $p < 0.001$ (Fig. 3a). Note that no other effects were significant for any of the above ANOVAs.

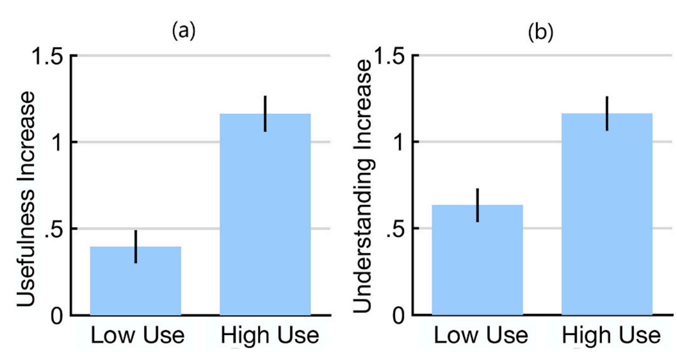

Fig. 2. Effect of usefulness manipulation on perceived usefulness and understanding (Experiment 2). (a) Change in usefulness ratings for participants who received the low-use and high-use stimuli before and after they read the corresponding articles. (b) Change in understanding ratings for participants before and after they read the corresponding articles.

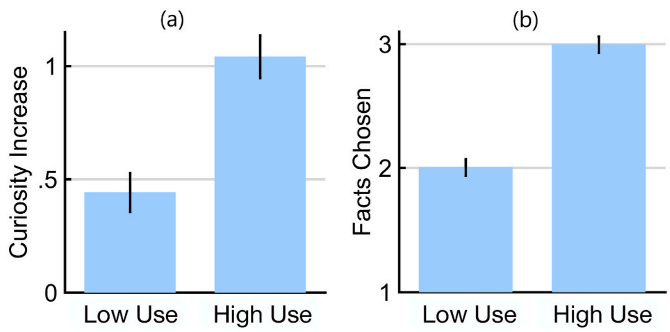

Fig. 3. Usefulness influences curiosity (Experiment 2). (a) Mean increase in participants' curiosity about a topic after reading a 'low-' or 'high-use' article. (b) Mean number of facts chosen after reading a 'low-' or 'high-use' article about that topic.

We next considered whether understanding or perceived usefulness mediated the effect of our usefulness manipulation on curiosity. We found partial mediation for both; however, the effect of perceived usefulness in predicting curiosity survived the inclusion of understanding as a predictor (refer to Supplemental Materials for analyses).

3.4.2. Phase 2

We next investigated whether participants were more likely to reveal facts about the high-use stimuli compared to the low-use stimuli. Participants indeed revealed more facts about the high-use stimuli (3 vs. 2, Fig. 3b). A one-sample t-tests revealed that the mean number of facts revealed about the high-use stimulus was significantly higher than the chance value of 2.5 whether the high-use topic was fruit flies, $t(244) = 4.06$, $p < 0.001$, or rats, $t(232) = 6.79$, $p < 0.001$.

3.5. Discussion

Experiment 2 found that participants became more curious about stimuli after reading information that suggested the topic was of high (vs. low) use (Phase 1), and that they were more likely to reveal additional information about the high-use topic (Phase 2). This suggests that manipulating perceived usefulness, in this case the social usefulness of biological information via medical applications, led to an increase in curiosity about the corresponding scientific topic. However, Experiment 2 also has some potential concerns. For one, we found that the effect of our manipulation on curiosity was partially mediated by understanding. Thus, it could be that changes in understanding (and not perceived usefulness) partially drove the effects of our manipulation on curiosity. Another concern is that even though our goal was to lower the perceived usefulness for the low-use stimuli, it could be that our manipulation instead lowered their perceived *informativeness* (the low-use stimuli contained the line: "some of these pet projects, they really don't make a whole lot of sense and sometimes these dollars go to projects that have little or nothing to do with the public good" and people could have inferred there is nothing to be learned by doing research on these topics). We address these concerns in Experiment 3.

4. Experiment 3: what are the more effective usefulness cues?

Experiment 3 had three aims. First, we aimed to test the influence of perceived usefulness on curiosity while controlling for understanding. Second, we aimed to study the influence of usefulness on curiosity while controlling for informativeness. Last, we aimed to isolate effects of personal and/or social usefulness from more generic claims of importance.

4.1. Participants

We recruited 203 participants from AMT ($n = 67$, 72, and 64 for INTEREST, ECOLOGY, and MEDICAL respectively). They earned $0.35 for participating in a study that took approximately 2-3 minutes to complete.

4.2. Stimuli

Three short articles describing the biology of fruit flies were used. In the INTEREST condition, the article presented interesting facts about *fruit fly reproduction*. In the ECOLOGY condition, the article illustrated how fruit flies are *useful to the environment*. In the MEDICAL condition, the article provided evidence that fruit flies are *useful to medical research*. (See Supplementary Materials for complete stimuli.)

4.3. Procedure

Participants were randomly assigned to read a short article about the 'biology of fruit flies' (INTEREST, ECOLOGY, or MEDICAL) and provided ratings before and after they read the article. Participants were first presented with the scientific topic and were asked to rate their understanding, perceived usefulness, and curiosity as in Experiment 2. After providing these ratings, participants were presented with the assigned article and then asked to re-rate understanding, perceived usefulness, and curiosity about that topic. Participants were also asked to respond to the following on a scale of 1–7: "Please rate how surprising you found the previously shown information on fruit flies to be", from 1 (Not surprising at all) to 7 (Very surprising). This was added as a control to ensure that any potential increase in curiosity was not caused simply by surprise.

We hypothesized that participants' increase in understanding would be similar across the three conditions, but that perceived usefulness would not be. Further, we also hypothesized that the INTEREST condition, despite providing interesting information, would not be deemed as useful and would also result in a smaller increase in curiosity (which would address the second potential confound from Exp 2). The contrast between the ECOLOGY and MEDICAL conditions also allows us to test whether curiosity is especially sensitive to evidence for potential social (or even personal) usefulness: while ECOLOGY emphasized importance and value to other species, only MEDICAL emphasized potential usefulness for individual humans and society.

4.4. Results

We first investigated how participants' understanding changed after they read the corresponding articles across the three conditions. Participants' understanding ratings increased significantly after they read the article for all three conditions, $t(142) = -2.34$, $p < 0.05$, for INTEREST, $t(126) = -3.57$, $p < 0.001$, for ECOLOGY, and $t(132) = -3.88$, $p < 0.001$, for MEDICAL (Fig. 4a). A one-way ANOVA revealed that these three groups were not significantly different from each other, $F(2200) = 2.64$, $MSE = 5.5$, $p = 0.07$, indicating that the increase in understanding was similar across all conditions, which successfully eliminates the potential confounds from Experiment 2.

We next evaluated how perceived usefulness changed across conditions. Although participants' usefulness ratings increased numerically for all three conditions (Fig. 4b), this increase was not significant for INTEREST, $t(142) = -1.52$, $p = 0.13$, although it was for both ECOLOGY, $t(126) = 3.31$, $p < 0.01$, and MEDICAL, $t(132) = 5.01$, $p < 0.01$. This suggests that simply presenting interesting facts about a topic was not enough to influence perceived usefulness. Further, a one-way ANOVA revealed a significant effect of condition, $F(2200) = 9.25$,

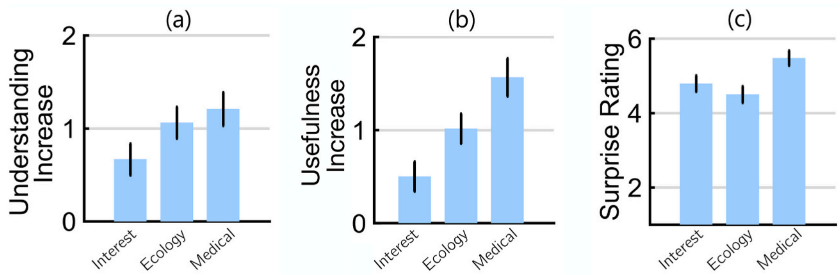

Fig. 4. Effect of usefulness manipulation on understanding, usefulness, and surprise (Experiment 3). (a) Mean change in understanding ratings. (b) Mean change in usefulness ratings. (c) Mean surprise ratings of participants in each condition.

$MSE = 19.8$, $p < 0.001$, with MEDICAL significantly higher than ECOLOGY, $t(129) = 2.1$, $p < 0.05$, and ECOLOGY significantly higher than INTEREST, $t(134) = 2.2$, $p < 0.05$.

We next analyzed how much surprise each article evoked (Fig. 4c) and found that there was a significant difference for the surprise ratings across the three conditions, $F(2200) = 5.12$, $MSE = 16.7$, $p < 0.01$. Specifically, MEDICAL was significantly more surprising than ECOLOGY, $t(129) = 3.19$, $p < 0.01$, and was significantly more surprising than INTEREST, $t(137) = 2.24$, $p < 0.05$, but ECOLOGY and INTEREST did not differ, $t(134) = 0.92$, $p = 0.36$.

We next evaluated the change in participants' curiosity ratings. Although participants' curiosity ratings increased for all three conditions, that increase was not significant for INTEREST, $t(142) = 1.45$, $p = 0.15$, but it was significant for ECOLOGY, $t(126) = 2.13$, $p < 0.05$, and for MEDICAL, $t(132) = 3.68$, $p < 0.01$. A one-way ANOVA confirmed a significant effect of condition, $F(2200) = 5.14$, $MSE = 9.1$, $p < 0.01$. Follow-up t-tests showed that MEDICAL was significantly different from ECOLOGY, $t(129) = 2.13$, $p < 0.05$, but ECOLOGY was not significantly different from INTEREST, $t(134) = 0.89$, $p = 0.38$. These results suggest that if people perceive stimuli to be less useful, then they are less likely to become curious about them.

As in Experiment 2, we tested whether the effect of our usefulness manipulation on curiosity was mediated by perceived usefulness and found that the effect of the usefulness manipulation on curiosity was fully mediated by perceived usefulness, whereas understanding and surprise only partially mediated this effect (refer to Supplemental Materials)Fig. 5.

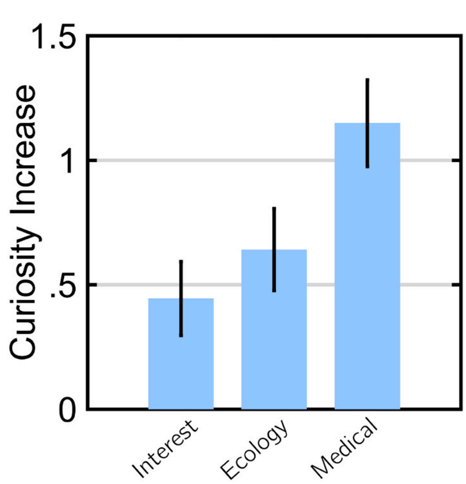

Fig. 5. People's curiosity is higher when they perceive something to be more useful (Experiment 3). Mean change in curiosity ratings for the three different conditions. Participants' curiosity increased the most in MEDICAL, in which they read an article that provided evidence that fruit flies are highly beneficial to medicine.

4.5. Discussion

The findings from Experiment 3 reveal that not all cues to value are equal: participants were more likely to become curious about a scientific topic if they learned it might be more useful for humans and society versus the environment and other species (MEDICAL vs. ECOLOGY). Further, Experiment 3 succeeded in identifying an effect of usefulness that could not be explained by differences in understanding or surprise. Our results suggest that simply presenting interesting facts that do not offer evidence of usefulness is not enough to induce curiosity (INTEREST), even if those facts boost understanding and induce surprise.

5. General discussion

Across three studies, we show that the perceived usefulness of information predicts (Exp 1) and influences (Exp 2-3) both self-reported curiosity (Exp 1-3) and subsequent information search (Experiment 2). Moreover, the effects of perceived usefulness on curiosity cannot be reduced to perceived understanding or surprise (Exp 3).

5.1. Implications

The idea that curiosity is influenced by both instrumental and non-instrumental considerations is not new (Rossing & Long, 1981). Researchers have long recognized a role for both of these factors in influencing curiosity, but many have deliberately focused on the latter, in part because information search can be driven by factors other than curiosity, making non-instrumental information search an especially diagnostic marker of curiosity (Eliaz & Schotter, 2007; Kidd & Hayden, 2015). However, in recent years, the field has largely come to adopt the assumption that curiosity is, by definition, the urge to acquire *non-instrumental* information (Cervera, Wang, & Hayden, 2020; FitzGibbon, Lau, & Murayama, 2020; Gottlieb & Oudeyer, 2018; Hsee & Ruan, 2016; Kobayashi et al., 2019; Oudeyer, Baranes, & Kaplan, 2013).[4] By demonstrating a link between usefulness and curiosity, our work challenges this prevalent assumption and also provides support to recent accounts that explicitly link curiosity to utility (Abir et al., 2022; Dubey and Griffiths, 2020; Golman et al., 2020; Liquin and Lombrozo, 2020b). That said, our findings are consistent with the idea that curiosity is typically *experienced* as an intrinsic and non-instrumental drive (see also Liquin & Lombrozo, 2020a; Gottlieb et al., 2020; Sharot & Sunstein, 2020).

We also make a contribution in revealing a particularly powerful instrumental consideration: the perceived usefulness of scientific information. Our studies suggest that perceived usefulness has both personal and social dimensions (Exp 1), and that it goes beyond generic claims of value or importance (Exp 3). Further, the connection between curiosity and information-seeking (demonstrated in Exp 2) makes interventions

[4] Although not all such work makes this assumption (e.g. Loewenstein, 1994; van Lieshout et al., 2018, 2020)

on curiosity especially relevant for educational contexts. Indeed, the importance of perceived utility (a construct closely related to usefulness) has been documented within the education literature, with studies showing that students' perceived 'utility value' i.e., how valuable they think a task would be, influences motivation as well as the allocation of study time (Atkinson, 1964; Wigfield & Eccles, 2000; Eccles & Wigfield, 1995; Hulleman et al., 2008, 2010; Harackiewicz et al., 2012; Brown et al., 2015; Dunlosky & Ariel, 2011; Ariel et al., 2009). While curiosity and motivation are typically considered distinct, and potentially involve different computational and neural mechanisms, our findings contribute to a body of work that suggests both are influenced by instrumental considerations, raising new questions about how curiosity might shape motivation. Finally, our focus on social usefulness opens up new questions about when and why different forms of usefulness might matter. When it comes to motivating interest in basic research, history, or distant parts of the world, the case for immediate personal usefulness may be hard to make, but focusing on social usefulness may nonetheless be an effective route to manipulating perceived usefulness.

5.2. Limitations

Our work has several limitations, which also present opportunities for future work. For one, the usefulness cues provided in our experimental stimuli were relatively explicit and strong. This could limit the generalizability of our findings to more naturalistic contexts where usefulness is not always so clearly identified, but rather must be inferred from social and contextual cues (see also Dubey et al., 2021). Relatedly, the different articles in Experiment 3 were quite different from each other (despite being similar in length and writing style); future work would benefit from using a broader range of stimuli, including materials with more direct relevance to formal and informal educational settings. Another limitation of our work is that we did not explicitly differentiate personal and social usefulness in our interventions (Experiments 2 and 3), and so we do not know which kind of usefulness is most effective in stimulating curiosity. For example, is students' curiosity for scientific topics more likely to be increased by demonstrating that a scientific topic could provide personal benefit (e.g., knowing algebra might help them get better jobs), or by demonstrating that knowing more about a scientific topic could help solve societal issues? Notably, our interventions in Experiments 2-3 involved information of personal and social value in the sense that it had personal and social implications, but the information was not actually actionable for individual participants; it may be that actionable information has even larger effects on curiosity.

Another limitation of our work is that we do not differentiate between curiosity and information-search beyond including measures of both. While we find corresponding effects of usefulness on both measures in Experiment 2, it is possible for someone to be curious but still avoid obtaining information, or to seek information despite lacking curiosity. Despite this limitation, we make some progress in improving our understanding of curiosity by showing that like information-seeking, which has been shown to be influenced by both instrumental and non-instrumental cues (Sharot & Sunstein, 2020; Kelly et al., 2021), curiosity can also be driven by instrumental considerations. That said, several key theoretical questions about curiosity and usefulness remain. Studies have shown that people can become curious about irrelevant and sometimes even potentially harmful stimuli (Hsee & Ruan, 2016; Cabrero et al., 2019; FitzGibbon et al., 2019; Lau et al., 2020), and that people are sometimes averse to information, even when that information is potentially useful to them (Sweeny et al., 2010; Golman et al., 2017; Charpentier et al., 2018). Understanding how curiosity interacts with usefulness in these contexts is an important future direction.

5.3. Concluding remarks

Despite the above open questions, our work shows that self-reported curiosity and information-seeking behavior can be influenced by perceived usefulness, and it points to effective strategies for stimulating curiosity about science. The results from Experiment 3 suggest that simply presenting information that is interesting or surprising is insufficient to drive curiosity. Instead, a more effective way to stimulate curiosity is to present information in a way that allows people to more clearly appreciate its personal and social usefulness. These results will be of importance to education researchers and science communicators concerned with piquing curiosity for public health or general understanding of science. Perhaps fruit flies will never be welcome in our homes, but by learning about their usefulness, *information* about them could be more welcome in our minds.

Appendix A. Supplementary data

Supplementary data to this article can be found online at 10.1016/j.cognition.2022.105193.

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