If it's important, then I am curious: A value intervention to induce 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 topic be stimulated by evidence that the topic has potential value? In two experiments we show that increasing people's perceptions about the usefulness of a scientific topic also influences their 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 topic if they perceive it to be directly valuable to them. Given the link between curiosity and learning, these results have important implications for science communication and education more broadly.

Keywords: curiosity; intervention; education

Introduction

"Sometimes these dollars go to projects that have little or nothing to do with the public good. Things like fruit fly research. I kid you not."

– Sarah Palin, former Alaska Governor

In one of her first policy speeches, former Alaska Governor and Vice Presidential nominee Sarah Palin made the above remark to alert people to the alleged misuse of federal funds. Her comments were met with disappointment and dismay within the scientific community, and for good reason – fruit flies have been an essential part of biological research, and research on them has shed light on basic aspects of biology and prompted medical advance (Siegel, 2009).

Unfortunately, Palin's attack on fruit flies is not the first example of a politician deriding specific kinds of research (Kempner, 2008). While such statements could be motivated by various political or economic considerations, they also seem to reflect a lack of curiosity about the scientific topics in question. This highlights an important aspect of curiosity in that the *same* topic can elicit quite *different* levels of curiosity in different people. What accounts for this difference, and how might greater curiosity be induced?

Psychological accounts of curiosity posit that curiosity is piqued whenever people observe discrepancies (Berlyne, 1950, 1960), or perceive a "moderate" gap between their actual and desired knowledge state (Loewenstein, 1994). Based on these theories, many people's low curiosity for scientific topics (such as fruit flies) could be explained by a lack of (perceived) discrepancy and/or by inadequate prior knowledge, such that the information gap is too large. However, Palin's comments suggest an additional possibility: perhaps people simply fail to see any *value* in pursuing topics that seem to lack theoretical or practical implications. Indeed, a recent account of curiosity suggests that people's curiosity should be higher for information if they perceive that information to be important to them (Dubey & Griffiths, 2017). Furthermore, various studies from the education literature have shown that students' perceived utility value i.e., how valuable they think a task would be for future goals, correlates with their task enjoyment and engagement (Eccles & Wigfield, 1995; Hulleman et al., 2008). In line with these findings, education researchers have successfully used utility-value interventions to increase student's motivation and performance in various learning settings (Hulleman et al., 2010; Harackiewicz et al., 2012; Brown et al., 2015). However, this work has not investigated whether utility-value interventions can successfully induce *curiosity*.

The current work explores a novel way to stimulate curiosity – by manipulating the perceived value of a topic. More specifically, we explore whether changing the perceived value of a scientific topic can also affect people's curiosity about that topic. If such a value manipulation indeed affects curiosity, then interventions on value could not only have important implications for curiosity researchers, but also for science communicators and educators of all kinds.

The importance of perceived value

Motivation and value

A classic model of motivation is the expectancy-value theory (Atkinson, 1964; Wigfield & Eccles, 2000), which posits that motivation in educational contexts is determined by an individual's expected success (i.e., belief that one can succeed at an activity) and subjective task value. Studies based on this theory have primarily developed interventions that focus on the 'expected success' component – that is, on improving students' perceived ability to master tasks to improve their motivation and performance (Eccles & Wigfield, 1995; Wigfield & Eccles, 1994). More recently, a number of researchers have also developed interventions that focus on the 'subjective value' component. These interventions show that an increase in students' perception about the usefulness of a subject leads to enhanced motivation and improved performance in various learning settings (Hulleman et al., 2010;

Harackiewicz et al., 2012, 2014; Brown et al., 2015). Although curiosity is usually considered distinct from motivation, and possibly involves different computational and neural mechanisms, these findings provide a useful starting point for developing interventions on curiosity, and for considering why perceived value might play a role.

Curiosity and value

Although curiosity has long been recognized as an important aspect of cognition, there is no single, agreed-upon theory of curiosity (Kidd & Hayden, 2015). Instead, a number of theories have been proposed to explain curiosity (Berlyne, 1950, 1960; Schmidhuber, 1991; Loewenstein, 1994; Oudeyer et al., 2007). These theories link curiosity with various psychological factors, but none of them explicitly consider the potential role that value can play in influencing curiosity.

Dubey and Griffiths (2017) recently proposed an account that 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. According to the theory, people's curiosity is evoked whenever they perceive an opportunity to increase the value of their knowledge (i.e., topics that either increase understanding or perceived usefulness). In essence, this model can be interpreted as providing a quantitative articulation of the expectancy-value theory. If people's curiosity is indeed driven by the perceived opportunity to increase the value of their knowledge, then this suggests that curiosity can be driven towards topics that seem initially unimportant if people come to perceive them as useful or otherwise valuable.[1]

Overview of experiments

In the current paper we ask whether manipulating perceived value can influence curiosity. Answering this question provides an opportunity to empirically evaluate theoretical claims related to the link between value and curiosity while also extending the rich literature in educational psychology on motivation.

To address this question, we report two experiments in which we present scientific topics to participants and have them indicate their curiosity about those topics. We then manipulate the perceived usefulness of those topics and record participants' change in curiosity. In Experiment 1, we manipulate how 'valuable' it would be for medical research to study fruit flies and rats, and we measure how participants' curiosity and information search is affected by this manipulation. In Experiment 2, we go one step further by considering what *kind* of value most effectively drives curiosity.

Experiment 1: Does value influence curiosity?

In Experiment 1, we investigated whether people's curiosity towards a scientific topic can be influenced by manipulating the perceived value of that topic, and whether this boost in curiosity affects subsequent information search. Participants read two short articles about two different scientific topics (one article for each topic). One of the two articles was 'high-value', and the other was 'low-value'. Participants' curiosity for the two scientific topics was recorded before and after they read the articles. Subsequently, participants had the choice to read some facts about the two scientific topics.

The experiment tested the following predictions: (1) Reading a high-value article will increase curiosity, and it will do so to a greater extent than reading a low-value article, (2) Participants will be more likely to read facts corresponding to the topic of the high-value article than those corresponding to the topic of the low-value article, and (3) The effect of the value manipulation on curiosity will be mediated by perceived value.

Participants

We recruited 240 participants from Amazon Mechanical Turk. They earned \$1.00 for participating in a study that took approximately 7-8 minutes to complete.

Note that for both Experiments 1 and 2, sample sizes were determined prior to data collection; based on pilot data, we aimed to recruit at least 60 participants per condition (which required 240 in experiment 1, given two conditions with counterbalanced order).

Stimuli

The stimuli used in the experiment were two short articles describing the biology of fruit flies and two short articles describing the biology of rats. For each of the two topics (i.e., fruit fly and rat), one article was a 'high-value' article and the other was a 'low-value' article. The high-value article emphasized how research about that animal could be highly beneficial to medicine, while the low-value article raised questions about whether research concerning that animal could generate any medical benefits for humans. All four articles were otherwise matched in terms of length and, as much as possible, for general content and style (stimuli available at - `https://goo.gl/BNpHzU`).

Procedure

At the start of the experiment, participants were randomly assigned to one of two conditions. In condition 1, participants were assigned to the high-value article for fruit flies and to the low-value article for rats. In condition 2, participants were assigned to the low-value article for fruit flies and to the high-value article for rats.

Phase 1 At the beginning of the first phase, participants were presented with one of the two scientific topics, either 'biology of fruit flies' or 'biology of rats' (counter-balanced). After seeing the topic, participants were asked to respond to each of 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] Additionally, we note that although Loewenstein's theory of curiosity (Loewenstein, 1994) does not explictly consider value in its formal account, it does hypothesize that people will be more curious about topics that are important to them.

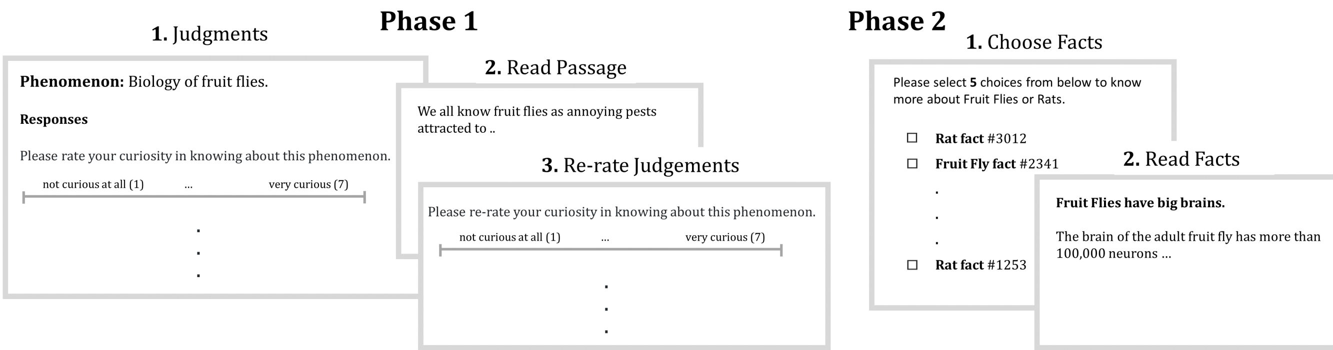

Figure 1: **Design of Experiment 1.** The experiment was divided into two phases. In Phase 1, participants were first presented with one of the two topics from our stimuli and asked to provide ratings for curiosity, understanding, and usefulness. They then read an article about that topic and once again rated curiosity, understanding, and usefulness. This procedure was then 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

2. *Understanding:* "Please rate how well you feel you understand this phenomenon."

3. *Curiosity:* "Please rate your curiosity in knowing about this phenomenon."

The first question was to ensure that our manipulation of value was successful, and the second question was to ensure that the effect of value on curiosity couldn't be reduced to understanding. The third question i.e. participants' rating of their curiosity was the key variable of interest in Phase 1. After providing the ratings, participants were presented with the assigned article for that topic and they were instructed to read it as carefully as possible. After they finished reading the article, participants were asked to re-rate their understanding, perceived usefulness, and curiosity about that topic. Following this, the above procedure was repeated for the other topic (also refer to Figure 1).

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 only needed to read 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.

Results

For all analyses that follow, we compare participants' ratings for the low-value stimuli relative to the high-value stimuli across the two conditions.

Phase 1 We first investigated the change in participants' understanding ratings after reading the low- and high- stimuli. As shown in Figure 2(a), the mean understanding rating increased by 0.63 for the low-value stimuli and by 1.16 for the high-value stimuli. A mixed ANOVA revealed a significant interaction between time (pre and post ratings) and stimulus (low-value or high-value) on understanding, $F(1,239) = 29.1, MSE = 16.8, p < 0.001$. We next confirmed that our manipulation of value successfully manipulated perceived usefulness. As shown in Figure 2(b), the mean rating of value increased by 0.40 for the low-value stimuli and by 1.16 for the high-value stimuli. A mixed ANOVA again revealed a significant interaction between time (pre and post ratings) and item (low-value or high-value) on perceived value, $F(1,239) = 47.692, MSE = 35.3, p < 0.001$, indicating that our manipulation of value was effective. Finally, we tested whether our value manipulation influenced participants' curiosity. As shown in Figure 3(a), the mean curiosity rating increased by 0.44 for low-value stimuli and by 1.04 for high-value stimuli i.e. the increase for the high-value stimuli was 0.60 points higher than the increase for the low-value stimuli. A mixed ANOVA revealed a significant interaction between time (pre and post ratings) and item (low-value or high-value) on curiosity ,$F(1,239) = 32.69, MSE = 21.6, p < 0.001$, indicating that the manipulation of value had a significant effect on curiosity. A follow-up paired-samples t-test showed that the increase of curiosity was greater for the 'high-value' stimuli compared to the 'low-value' stimuli, $t(478) = -4.71, p < 0.001$.

We next considered whether understanding or perceived value mediated the effect of our value manipulation on curiosity. We first ran a linear regression to predict curiosity based on value manipulation (i.e. 'low-value' or 'high-value'); this yielded a significant and positive coefficient of 0.60, $t = 4.7, p < 0.001$, 95% CI$[0.35, 0.85]$. We then considered a regression predicting curiosity based on perceived value; yielding a significant and positive coefficient of 0.47, $t = 12.1, p < 0.001$, 95% CI$[0.39, 0.54]$. We also considered a regression predicting curiosity based on understanding; again yielding a significant and positive coefficient of 0.37, $t = 8.7, p < 0.001$, 95% CI$[0.28, 0.45]$. We then fit a multiple regression with both value manipulation and perceived value as predictors; this yielded coefficients of 0.26 and 0.44 respectively ($t = 2.21, p < 0.05$, 95% CI$[0.03, 0.49]$ and $t = 11.2, p < 0.001$, 95% CI$[0.37, 0.52]$),

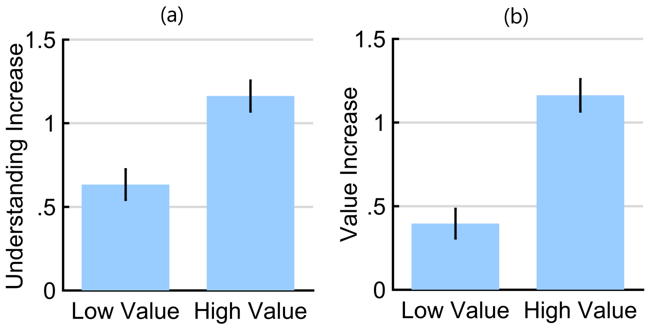

Figure 2: **Effect of value manipulation on understanding and perceived value (Experiment 1).** (a) Change in understanding ratings for participants who received the low-value and high-value stimuli before and after they read the corresponding articles. (b) Change in value ratings for participants before and after they read the corresponding articles.

suggesting partial mediation. Finally, we fit a multiple regression with both value manipulation and understanding as predictors which yielded coefficients of 0.42 and 0.34 respectively ($t = 3.46, p < 0.001, 95\%$ CI$[0.18, 0.66]$ and $t = 7.98, p < 0.001, 95\%$ CI$[0.25, 0.42]$), again suggesting partial mediation.

Phase 2 We next investigated whether participants were more likely to reveal facts about the high-value stimuli compared to the low-value stimuli. As shown in Figure 3(b), participants indeed revealed more facts about the high-value stimuli (3 vs. 2). A paired-samples t-test found that this difference was significant, $t(478) = -10.6, p < 0.001$.

Discussion

Experiment 1 tested and found support for two of our three predictions about the effects of value on curiosity. First, results from phase 1 showed that participants became more curious about stimuli after reading information that suggested the topic was of high (vs. low) value. Second, results from phase 2 demonstrated that participants were more likely to reveal additional information about a topic after reading information suggesting it was of high value. We also found that our stimuli successfully manipulated perceived value, and that perceived value partially mediated the effect of our value manipulation on curiosity. However, the effect of our value manipulation on curiosity was also partially mediated by understanding. This raises the concern that perceived value is confounded with understanding, and that changes in understanding drove the effects of our manipulation on curiosity. We address this concern in Experiment 2.

Experiment 2: What influences value most?

Experiment 2 had two aims. First, the experiment aimed to test the influence of perceived value on curiosity while controlling for understanding. Second, the experiment aimed to investigate the effect of different kinds of information on people's perceived value and subsequently on curiosity. Participants were randomly assigned to three conditions in which

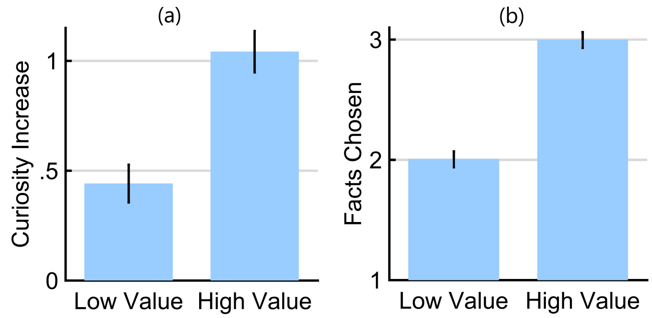

Figure 3: **Value influences curiosity (Experiment 1).** (a) Mean increase in participants' curiosity about a topic after reading a 'low-' or 'high-value' article. (b) Mean facts chosen after reading a 'low-' or 'high-value' article about that topic.

they read a short article about the 'biology of fruit flies' and provided ratings before and after they read the article. In condition 1, the article presented interesting facts about *fruit fly reproduction*. In condition 2, the article showed how fruit flies are *valuable to the environment*. In condition 3, the article provided evidence that fruit flies are *valuable to medical research*. We hypothesized that participants' increase in understanding would be similar across the three conditions, but that perceived value would not be. Moreover, the contrast between conditions 2 and 3 allows us to test the hypothesis that perceived value would be especially sensitive to value with potential personal relevance.

More specifically, the experiment tested these predictions: (1) Participants' curiosity about fruit flies will increase most strongly in condition 3 (compared to conditions 1 and 2), and (2) the effect of perceived value on curiosity will not be reducible to other factors, such as understanding or surprise.

Participants

We recruited 203 participants from Amazon Mechanical Turk ($n = 67, 72$, and 64 for condition 1, 2, and 3 respectively). They earned \$0.35 for participating in a study that took approximately 2-3 minutes to complete.

Stimuli

The stimuli used in the experiment were three short articles describing the biology of fruit flies. The three articles varied in terms of their value to humans – the first article simply presented interesting facts about the reproductive cycle of fruit flies, the second article had facts about the importance of fruit flies for the ecosystem, and the third article provided facts about the importance of fruit flies for medical research. All three articles were matched for length and as much as possible for general content and style (stimuli available at - `https://goo.gl/BNpHzU`).

Procedure

At the start of the experiment, participants were randomly assigned to one of the three conditions. The three conditions followed the same procedure and differed only with respect to

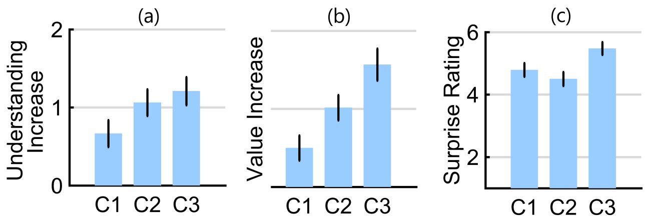

Figure 4: **Effect of value manipulation on understanding, value, and surprise (Experiment 2).** (a) Mean change in understanding ratings. (b) Mean change in value ratings. (c) Mean surprise ratings of participants in each condition.

which of the three articles the participants read. Participants were first presented with the scientific topic, 'biology of fruit flies', and were asked to rate their understanding, perceived value, and curiosity as in Experiment 1. After providing these ratings, participants were presented with the assigned article and they were instructed to read it as carefully as possible. After they finished reading the article, participants were asked to re-rate understanding, perceived usefulness, and curiosity about that topic. In addition to these ratings, after the participants read the article, they 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." This question on surprise was added as an additional control to ensure that any potential increase in curiosity was not caused simply by surprise.

Results

We first investigated how participants' understanding changed after they read the corresponding articles across the three conditions. As shown in Figure 4(a), participants' understanding ratings increased significantly after they read the article for all three conditions, $t(142) = -2.34, p < 0.05$ for condition 1, $t(126) = -3.57, p < 0.001$ for condition 2, and $t(132) = -3.88, p < 0.001$ for condition 3. Moreover, a one-way ANOVA revealed that these three groups were not significantly different from each other, $F(2,200) = 2.64, MSE = 5.5, p = 0.07$, indicating that understanding ratings increased the same across all three conditions. We next evaluated how participants' perceived value changed across the three conditions. Although participants' value ratings increased numerically for all three conditions (refer to Figure 4(b)), this increase was not significant for condition 1, $t(142) = -1.52, p = 0.13$. This suggests that simply presenting interesting facts about a topic was not enough to influence perceived value. Furthermore, a one-way ANOVA showed that the three groups differed significantly from each other, $F(2,200) = 9.25, MSE = 19.8, p < 0.001$, with condition 3 significantly higher than condition 2, $t(129) = 2.1, p < 0.05$, and condition 2 significantly higher than condition 1, $t(134) = 2.2, p < 0.05$. We next analyzed how much surprise each article evoked (refer to Figure 4(c)) and found that there was a significant difference for the surprise ratings across the three conditions, $F(2,200) = 5.12, MSE = 16.7, p < 0.01$. Specifically, condition 3 was significantly

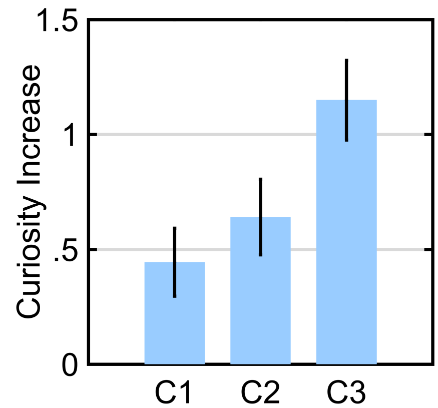

Figure 5: **People's curiosity is highest when they perceive something to be of direct value to them (Experiment 2).** Mean change in curiosity ratings for the three different conditions. Participants' curiosity increased the most in condition 3, in which they read an article that provided evidence that fruit flies are highly beneficial to medicine.

different than condition 2, $t(129) = 3.19, p < 0.05$, but condition 2 was not significantly different compared to condition 1, $t(134) = 0.92, p = 0.36$.

We next evaluated the change in participants' curiosity ratings and found that as per our hypothesis, curiosity ratings increased the most in condition 3 (by 1.15 points, also refer to Figure 5). Furthermore, similar to perceived value ratings, although participants' curiosity ratings increased for all three conditions, that increase was not significant for condition 1, $t(142) = 1.45, p = 0.15$. We also conducted a one-way ANOVA analysis and found that the three groups were significantly different from each other, $F(2,200) = 5.14, MSE = 9.1, p < 0.01$. Follow-up paired-samples t-tests showed that condition 3 was significantly different than condition 2 ,$t(129) = 2.13, p < 0.05$, but condition 2 was not significantly different compared to condition 1, $t(134) = 0.89, p = 0.38$. These results suggest that if people perceive stimuli to be less valuable to them, then they are less likely to become curious about them.

As in Experiment 1, we tested whether the effect of our value manipulation on curiosity was mediated by perceived value. First, a linear regression predicting curiosity from value manipulation (i.e. condition 1, condition 2, or condition 3) revealed a significant positive coefficient of 0.35,

Source	Effect Size	t	p-value	95% CI
condition 1	−0.30	−1.38	0.17	[−0.73, 0.13]
condition 2	−0.22	−1.01	0.31	[−0.65, 0.21]
understanding*	0.13	2.12	< 0.05	[0.01, 0.25]
value*	0.21	3.35	< 0.001	[0.09, 0.34]
surprise*	0.15	3.10	< 0.01	[0.06, 0.25]

Table 1: **Regression results (Experiment 2).** Regression results of the increase of curiosity ratings with condition 1, condition 2, understanding ratings increase, value ratings increase, and surprise; significant differences are starred.

$t = 3.1, p < 0.005, 95\%$ CI$[0.13, 0.57]$. A similar regression with perceived value as the predictor produced a coefficient of 0.33, $t = 5.64, p < 0.001, 95\%$ CI$[0.21, 0.45]$. Next, a multiple regression with both value manipulation and perceived value resulted in a non-significant coefficient of 0.19 for value manipulation, $t = 1.72, p = 0.09, 95\%$ CI$[-0.03, 0.41]$, while perceived value remained significant at 0.3, $t = 4.91, p < 0.001, 95\%$ CI$[0.18, 0.42]$. This suggests that the effect of value manipulation on curiosity was fully mediated by perceived value. Finally, to confirm that the effect of perceived value on curiosity is not reducible to condition, understanding, or surprise, we conducted a linear regression to predict the increase of curiosity ratings with condition 1, condition 2, increase of understanding ratings, increase of value ratings, and surprise. We found a significant regression equation, $F(5, 197) = 10.61, p < 0.001$, with an R^2 of 0.192 and a significant effect of value on curiosity, greater than any of the other factors (refer to Table 1).

Discussion

The findings from Experiment 2 support both of our predictions. First, we found that not all kinds of value are equal: participants were more likely to become curious about a scientific topic if they learned of its direct value to them (condition 3 vs. 2). Second, we succeeded in identifying an effect of value that could not be explained by differences in understanding or surprise. Our results suggest that simply presenting interesting facts that have no direct value is not enough to induce curiosity (condition 1), even if those facts boost understanding and induce surprise.

General Discussion

The primary purpose of this research was to test whether curiosity can be influenced by manipulating people's perceptions of value. Across two experiments, we find that manipulating the perceived value of a topic influenced curiosity (Experiment 1 and 2), and this also influenced subsequent information search (Experiment 1). Results from Experiment 2 further demonstrated that the effects of our manipulation on curiosity were fully mediated by perceived value and cannot be reduced to understanding or surprise, which are both known to influence curiosity.

Our results have considerable theoretical implications as they demonstrate a link between value and curiosity. In doing so, our findings lend support to Dubey and Griffiths's (2017) theory of curiosity. They also challenge previous accounts of curiosity, such as the incongruity theory (Berlyne, 1960) and the information-gap theory (Loewenstein, 1994), insofar as those theories fail to incorporate an *explicit* role for value.

Despite the promise of our results, the significance of our study is limited by the nature of our stimuli, task, and our focus on short-term consequences of value on curiosity. Furthermore, several key theoretical questions about curiosity remain. For example, previous studies have shown that people become curious about completely irrelevant and sometimes even potentially harmful stimuli (Hsee & Ruan, 2016). Conversely, people are sometimes averse to information, even when that information is potentially useful to them (Sweeny et al., 2010). Understanding how curiosity interacts with value in these contexts is an important research question for future work.

Another limitation of our experimental manipulation is that the importance of the information is clearly spelled out to the participants especially in the high-value articles. Therefore, it is possible that the participants rate that information to be important even though they may not necessarily believe that to be the case (perhaps due to a social desirability bias). Future work will consist of conducting further experiments to rule out this possibility.

We also note that some theories stipulate that curiosity is an intrinsic drive and is not instrumental, thereby making our results seem counter-intuitive. On the other hand, even if the experience of curiosity is a drive for knowledge for its own sake, it is still possible that curiosity can be modulated by instrumental factors. Prior work has similarly pointed to the challenge of delineating extrinsic and intrinsic factors in various cases (Kidd & Hayden, 2015). For instance, what is intrinsic for one individual could be extrinsic for another.

Regardless of this debate, our work shows that self-reported curiosity (and information-seeking behavior) can be influenced by value and it sheds light on effective strategies to do so. The results from Experiment 2 suggest that simply presenting information that seems interesting is not effective in influencing value or curiosity (condition 1). Instead, a more effective way to stimulate curiosity is to present information in a way that allows people to directly see its value and relevance (condition 3). Perhaps fruit flies will never be welcome in our homes, but maybe people will become more curious about them – and more welcoming of basic research on them – once they find out how valuable they are to us.

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