

Mind the Gap: Self-Perpetuating Perceptions and the Energy Efficiency Gap

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Abstract

Perceptions are guided by expectations. Four experiments examine how expectations about the objective performance of eco-products affect perceptual experiences of those products, and subsequent preferences. Holding objective performance constant, we find that pre-existing expectations cause biased perceptions of eco-product performance, which reinforce biased expectations (and preferences). Expecting CFL bulbs to generate unpleasant lighting causes people to perceive unpleasant lighting; expecting toilet tissue from recycled paper to be coarse causes perceived coarseness. This research helps explain suboptimal take-up of energy efficient products (referred to as the “efficiency gap”), and persistent beliefs that eco-products underperform standard products, when many objectively do not.

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1 Introduction

The energy efficiency gap describes the widely studied theory that consumers and firms do not utilize the optimal level of energy efficient products. Many hypotheses for why we observe underinvestment in energy efficiency have been proposed and explored, but none can fully explain the energy efficiency gap that remains. In this study, we propose a new hypothesis for why we see slower than expected diffusion of energy efficient technologies. Drawing from a long history in psychology, we look to the dependence of perception on both expectations and motivated reasoning to draw new insights into the energy paradox. Our findings not only provide insight to the energy paradox, but they also contribute to the broader economic and psychological literature. We show that when perceptual experience is biased by expectations, consumers are unable to obtain full information about objective product quality even after they test the product first hand.

To illustrate how expectations and perceptions may play a role in the persistent energy efficiency gap, we will start with a brief anecdote before introducing the main hypotheses and the structure of the paper.

Suppose that an individual receives a free energy efficient compact fluorescent light (CFL) bulb at a county fair from a government agency working to promote energy efficiency. She takes the light bulb home and installs it in her bathroom light fixture. She has no prior experience with CFL bulbs and no prior expectations of how the CFL will perform. But when she flips the switch, she is struck by the lurid blue tint to the light. She looks in the mirror and sees that it makes her skin tone look sickly and garish. So she takes the light bulb out of the bathroom fixture and relegates it to a basement light socket. From her experience with this poorly performing bulb, she forms very negative expectations of the quality of CFL light bulbs. Clearly she is very unlikely to purchase another CFL, despite what it would save on her energy bills because her expectations have shaped her preferences.

A year later, after the quality of CFLs has improved significantly, her husband comes across a promotional sale on CFL bulbs at the local hardware store. He has never used a CFL, but he can't pass up a bargain, so he buys a pack and brings

it home. When his wife sees him installing a spiral CFL bulb in the living room, she recalls her previous negative experience with the energy efficient bulbs and expects the light to be garish and unpleasant. He flips on the switch. He perceives the quality of the light to be perfectly satisfactory. She perceives the light to be very unpleasant. Despite a lifetime of matrimonial harmony and similar tastes, they look at the exact same light and they experience the light very differently. Her perception has been biased by her negative expectations. His perception has not been similarly biased. Fortunately, the couple's relationship is strong enough to survive such disparate points of view. However, the purpose of this story is that illustrate that these subjective points of view are indeed very different. Each has been colored by different experiences and expectations and those expectations actually change the color and quality of light they perceive from the same light bulb.

This anecdote illustrates our first hypothesis. We hypothesize that when people expect an energy efficient product to perform less well than a standard version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

Our second hypothesis stems from a related line of psychological research. We hypothesize that if individuals are motivated to believe that eco-friendly products perform at least as well as regular products, they will perceive higher performance for eco-friendly products. Both hypotheses state that people will subjectively perceive energy efficient products as performing differently than standard versions of the products on objectively identical attributes.

Our third hypothesis posits a causal relationship between experience biased perception and product choice. We suggest that prior expectations bias the perceptual experience of product quality. The biased perception prevents consumers from obtaining full information of the objective product quality. This information bias goes on to influence product choice. We argue that prior expectations affect product choice by biasing perceptual experience.

We summarize our hypotheses as follows:

H1: When people expect an eco-product to perform less well than a standard

version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

H2: When people are motivated for an eco-product to perform less well than a standard version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

H3: Prior performance expectations of eco-products influence post-testing product choice solely through the mechanism of biased perception.

In an online survey experiment and three artefactual field experiments, we study how individuals' prior expectations and motivation for eco-products to perform well influence their perceived experiences of eco-products.¹ By randomizing the labels on identical products, we control for actual product performance and isolate the effects of participants believing that a given product is an eco-product. We test our hypotheses for two different products: energy efficient compact fluorescent light bulbs and toilet paper made from recycled paper. We find that expectations about the performance of eco-products strongly influence subjective experience of objective product performance, and subsequent product preferences. We find mixed results for the influence of one's motivation for eco-products to perform well on the perception of product quality, but we find that motivation strongly influences product preference.

In the next section, we lay out a brief description of the energy efficiency gap. In Section 3, we discuss the concepts of expectations, motivations, and perception in the context of the psychology literature. In Section 4, we propose a modification to an existing model of energy efficient capital investment decisions that incorporates the theoretical impact of expectations and motivations on perceptions and subsequent preferences. In Sections 5 through 8, we describe four experimental tests of our hypotheses and analyze the results. And in Section 9, we conclude with a brief discussion of the implications of this theory for the energy and environmental economics and policy.

¹Artefactual field experiments, a term adopted by Harrison and List [10], are similar to laboratory experiments but take place outside of the laboratory in order to recruit a non-traditional participant pool.

2 Energy Efficiency Gap

Energy efficient lights and appliances often have higher up front costs than their less efficient counterparts, but for many products, the energy savings from the more efficient product quickly makes up the initial difference in price. Yet, many consumers appear to ignore medium to long term savings and instead buy the less efficient product. Economists have been working for decades to understand what leads people to make such choices that appear to be irrational from the standpoint of utility or profit maximizing behavior.

A long literature builds a case for what is known as the energy efficiency gap. The energy efficiency gap is the disparity between the observed level of investment in energy efficient capital and the level of investment in that would generate an optimal tradeoff between upfront costs and future savings using a discount rate that individuals and businesses apply to other types of investment decisions. For example, if a business is willing to accept an internal rate of return of 10% on a capital investment in new production equipment, then if they are profit-maximizing, they would also invest in an energy efficient product with an internal rate of return of 10%. However, there is significant evidence that businesses and households routinely pass on energy efficiency investments that appear to be cost-effective.

In a seminal paper, Hausman finds that individuals use very high implied discount rates to trade-off upfront capital costs and future operating costs of energy consuming durables [11]. From Hausman's work and many others that followed, it appears that firms and individuals are failing to adopt new energy efficient technologies at a rate that would be expected given the magnitude of the potential savings. To describe the unexpectedly slow diffusion of energy efficient technologies, Jaffe and Stavins coined the term, "energy paradox" [15]. For the past three decades, economists have sought to understand why so many consumers fail to adopt energy efficient technology that appears to be cost-effective [13] [21] [14] [9] [12] [6] [2]. Economists have categorized a number of market failures that prevent optimal adoption of energy efficiency technologies.

One major source of market failure is imperfect information. Information is sus-

ceptible to market failure occur because information is a public good and tends to be under-provided by market forces. Numerous government programs have been put into place to address this market failure. Policymakers have developed energy-labeling standards that require retailers to display various products' energy consumption statistics to potential buyers. Information about a wide range of energy efficiency products and energy efficiency measures is available on the internet and through public information campaigns. While these efforts have reduced the information hurdle, consumers and businesses remain inattentive to the future energy savings afforded by energy efficient capital investments.

Thirty years after Hausman identified the issue of a surprisingly high implicit discount rate for energy efficiency investments, a widely publicized McKinsey report claimed that by adopting cost-effective energy efficiency measures, the United States could reduce projected energy demand by 23% [1]. While the magnitude of the cost-effective savings remains controversial [2], it is clear that our current models of economic behavior do not explain the failure of consumers and businesses to adopt energy efficiency measures that would pay for themselves in energy savings over a relatively short time horizon.

Part of the energy efficiency gap may not be a paradox at all, but may simply be the result of incomplete analysis of the utility maximization problem. Additional costs may exist that are unobservable from the viewpoint of an engineering estimate of cost-effectiveness. For example, transaction costs and search costs are difficult to measure, thus are often excluded from economic analysis. Transaction costs and search costs could play in many major energy efficiency investments, which often require the inconvenience of multiple energy audits and construction on one's home or place of business. Yet, these costs do not explain underinvestment in simple energy efficiency products like compact fluorescent light bulbs.

Another potential reason for the slow adoption of energy efficient products could be that the energy-efficient version of a product may not perform as well as the standard version [21]. On the other hand, the product may perform equally well, but individuals may expect the performance to be inferior. Expectations of product performance are a standard part of the economic analysis of consumer decisions.

If expectations of product quality differ from actual product quality, then the problem is simply one of incomplete information.

However, the energy efficiency literature has not addressed the potential interplay between expectations and perceptual experience. New experiences with products should be incorporated into future expectations according to the theory of Bayesian updating. But a long body of research in psychology suggests that objective information is perceived subjectively. Perception is influenced by expectations of the situation and motivations for belief. If perceptual experience is strongly influenced by expectations and motivations, then objective information is biased before it is incorporated into one's beliefs. As a result, expectations and preferences may continue to be biased even after experiencing first-hand perceptual information that may objectively contradict one's expectations. If individuals in the population carry with them heuristic biases against the performance of energy efficient products, then this psychological phenomena could provide a new explanation for persistence of the energy efficiency gap.

3 The Roles of Expectation and Motivation in Perception

It is natural to think that we see the world as it is. But numerous studies in psychology have shown that our perception is actually rather unstable. In the following section, we will give a very brief overview from the psychological literature of how the concepts of expectations and motivation relate to perceptual experience.

3.1 Expectations and Perception

People's perceptions of the world are guided by their expectations. Expectations about another person's abilities guide evaluations of his or her ability [16] [7]. People find cartoons more amusing when they are told beforehand that they are funny [22]. Expectations about the quality of a vacation or a movie impact the post-evaluation of the experiences [19]. Knowing of a distasteful 'secret ingredient' in a beer before tasting it leads bar patrons to give the beer lower ratings compared

to when they taste it ‘blind’ [20]. In this study, we examine how the self-fulfilling nature of expectations about product performance may be one reason why eco-friendly products have had slower adoption rates than might otherwise have been expected.

Eco-products have the desirable quality of being eco-friendly, which compensates for the relatively poor performance that is common for early versions of such products. Over time, and as technologies improve, eco-product performance improves. But if perception of product performance is biased by previously formed expectations, then perceptions of performance will lag behind the objective improvements in the performance of eco-products.

While it is almost tautological that expectations of performance affect preferences for products, we focus on what precedes preference formation. Consumers rely on their perceptual experience of product performance to inform their preferences. However, if subjective experience of objective performance is biased by expectations, then the preferences that are informed by these experiences will be biased. This would diminish the potential for people’s experience with improved eco-products to update their expectations and preferences.

3.2 Motivated Reasoning and Perception

Perception is influenced by expectations, as we have discussed above, but it can also be influenced by one’s motivations. Motivations, in this sense, are defined as internal states, such as one’s desires or preferences [3]. Motivations can be thought of as preferences over different states of the world. For example, a person may prefer a world where eco-products perform just as well as or better than their regular counterparts. If her motivational state influences her perception, then she would actually perceive eco-friendly products as performing better than she would if she did not have that motivation.

Visual perception involves the evaluation of a great deal of visual information. Not every piece of visual information receives equal attention or scrutiny. When it is possible to interpret a visual stimulus in more than one way, a top-down cognition

can make certain interpretations more available than others [3]. If an interpretation of an ambiguous visual stimulus is treated like a hypothesis, then the individual evaluating the stimulus seeks out information that confirms the hypothesis and gives less attention to information that would disconfirm it [3]. Similarly, studies that examine motivated reasoning find that information that would confirm a favored hypothesis is not subjected to as much scrutiny as information that would confirm the favored hypothesis [8].

Due to improved methodologies for studying motivated reasoning, there has been a recent surge in attention given to the topic in the field of psychology. In one recent experiment, Balci and Dunning explore whether motivated reasoning creates a filter for perception and actually changes the way an individual sees the world [3]. This extends earlier studies that find motivated reasoning affects higher order processes like conscious deliberation and judgment calls. In a separate study, Balci and Dunning find that internal goal states impact the perception of one's distance from a desired object [5]. A third study explores the impact of cognitive dissonance as a motivational state that drives perception. They find that in order to minimize cognitive dissonance, individuals modulate their visual perception of their environment [4]. All of these findings support the hypothesis that an individual's motivations actually change the way they perceive the world around them. We seek to extend these concepts to examine perceptions of product quality and tie the psychological theory into a utility maximizing framework.

4 A Model of Expectations Bias

While psychology has had a long history of examining the influence of expectations and motivations on perception, these concepts have had little application in the field of economics. Behavioral economics has begun to incorporate a number of biases and heuristics into economic theory through the concepts such as bounded rationality [17].

However, the impacts of biased perception of product quality have yet to be incorporated into economic analysis. In the context of experienced utility and its role

in utility maximization, Daniel Kahneman discusses how choices will be biased if the memories of past experiences are biased [18]. We take this concept one step further to examine how expectations, which are based in part on memories of past experiences, bias the perceptual experience of product quality. In this sense, biased perception would affect both hedonic forecasts of utility and experienced utility. Current economic theory would predict that the bias of hedonic forecasts of utility affect product choice. With this paper, our new contribution to economic theory is the proposition that biased perceptual experience disrupts the ability to obtain full objective information about product quality, even after testing the product first hand. The biased perceptual experience then goes on to bias product choice.

While there are many potential applications of biased perception in economic models, in this section, we will suggest one approach that incorporates a heuristic bias for energy efficient products into a utility or profit maximizing investment decision. Using Allcott and Greenstone's energy efficiency investment model as a starting point, we model the effect of a heuristic bias on the decision to invest in an energy-consuming durable product [2]. Later in the paper, we will provide experimental evidence that these additional parameters make a significant impact on both perceptions and their impact on relative preferences for products in an energy-consuming capital investment decision.

Allcott and Greenstone conceptualize the energy efficiency gap as a problem largely caused by inattention to future energy costs, thus they weight the future energy costs with the parameter, γ . They assert that this inattention parameter essentially captures mechanism driving the energy efficiency gap.

We argue that the energy efficiency gap has another source that is separate from inattentiveness to future energy costs. In addition to inattentiveness to future energy costs, we assert that some consumers have a biased perception of the objective performance of energy efficient products. First, individuals who have negative expectations of energy efficient products will perceive those products to be less effective compared to those with neutral or positive expectations. Second, individuals who are motivated for energy efficient products to perform poorly will perceive those products to be less effective compared to those with neutral or

positive expectations.

The perception bias leads to a self-perpetuating cycle through the mechanism of expectations. If an individual expects poor performance from an energy efficient product, they will perceive a lower level of performance compared to the perception of performance from an objective perspective. The biased experience of performance will be incorporated in future expectations of the product. Those expectations will once again bias the perception of the product performance in the future.

The bias in the perception of product performance goes on to inform the individual's future preferences. As a result, this bias will affect the rate of diffusion of the product. Even if the product improves, perception of the quality will lag and so too will preference for the product.

Allcott and Greenstone's model describes how a profit-maximizing firm or a utility-maximizing individual chooses whether to purchase an eco-product or a regular product. In period 1, the agent purchases the product and in period 2, the agent uses the product. The regular product is denoted as 0 and the eco-product as 1.

The authors focus on energy consuming durables and denote the energy intensities of each version of the product as e_0 and e_1 , where $e_0 > e_1$.² The upfront capital cost of the product is denoted as c , the private cost of energy is represented as p , the discount rate is r , and the intensity of product utilization is denoted as m . To account for unobserved utility costs or benefits or incremental opportunity costs, they introduce a parameter, ξ . The attention-weighted future energy costs minus the unobserved costs or benefits of using the eco-product are compared to the upfront capital cost, c . The agent will chose to purchase the eco-product if and only if:

$$\frac{\gamma p m_i (e_0 - e_1)}{(1 + r)} - \xi > c \quad (1)$$

Allcott and Greenstone discuss various ways in which the unobserved utility costs

²To extend this model to a product that is not an energy consuming product, such as toilet paper, let $e_0 = e_1 = 0$.

or benefits, ξ , could affect the utility maximizing decision. For example, they note that weatherizing a home often makes it less drafty and more comfortable. They also note that an energy efficient light bulb might produce a different quality of light. We extend this discussion by suggesting that the existence of a perception bias based on expectations and motivations would shape this parameter in predictable ways. If there is a bias in the experienced utility of an eco-product based on prior expectations of performance, then the parameter ξ will be heterogeneous across individuals and will depend upon both their prior expectations of the product's performance and their motivation for the product to perform well.

We decompose the utility parameter, ξ , into three parts: the expectations bias, θ , the motivation bias, λ , and the additional unobserved utility cost or benefit of product use, σ_i . The expectations bias is a function of product performance expectations, α_i . The motivation bias is a function of one's motivation for the energy efficient product to perform well, δ_i .

$$\xi(\theta, \lambda, \delta_i, \alpha_i, \sigma_i) = \theta(\alpha_i) + \lambda(\delta_i) + \epsilon_i \quad (2)$$

When expectations of the eco-product performance are neutral, $\alpha = 0$ and $\theta(0) = 0$. In other words, neutral expectations correspond to no bias in the experienced utility of the product. When an individual has no motivation for a product to perform well or to perform poorly, $\delta_i = 0$, and $\lambda(0) = 0$. If both $\theta(0) = 0$ and $\lambda(0) = 0$, then ξ , is unbiased compared to an objective measure of product quality.

If expectations of the eco-product performance are positive, $\alpha_i > 0$ and $\theta(\alpha) > 0$ or if there is a positive motivation for eco-products to perform well, $\delta_i > 0$ and $\lambda > 0$. Thus, if they have higher expectations of eco-product performance or are motivated to believe that eco-products perform well, individuals perceive better performance from a product when they believe that it is eco-friendly compared to when the same objective performance is associated with a product that is not eco-friendly. The converse holds for individuals with negative expectations of performance of eco-products or who are motivated to believe that eco-products perform poorly.

In the next section of this paper, we will use experimental data to test whether θ

and λ have non-zero values, which would indicate a bias in the experienced utility of eco-products.

5 Study 1 - Online Study: Perception of Energy Efficient Lighting

In an online experiment, Study 1 examines ratings of light quality in photographs. Each photograph was evaluated by participants randomly assigned to one of two treatment groups. The treatment groups differed only in what type of light bulb participants were told was used in each photo. Participants in one treatment group were told that the photo was taken using an incandescent light bulb while participants in the other treatment group were told that the identical photo was taken using an energy efficient compact fluorescent light (CFL) bulb.

Before evaluating the lights in the photos, participants were asked about their prior expectations and motivations with regards to the two different types of light bulbs. We predicted that the individual's perception of light labeled as CFL would depend on one's expectations of the relative performance of CFL and incandescent lights.

Moreover, we also predicted that individuals would have different levels of motivation to see the energy efficient CFL perform well. To illustrate this concept, we will introduce two different hypothetical consumers: Alice and Betty. Alice is unconcerned with energy efficiency. Her landlord pays her electricity bills. She never really thinks about the connection between electricity consumption and air pollution or climate change. She has very little desire for energy efficient products to perform well because energy efficiency is not part of her utility function. Thus, she has low motivation to perceive energy efficient products as high performing.

Betty is a consumer who prioritizes energy efficiency. She pays close attention to her monthly electricity bills. She is also very concerned about how her energy consumption contributes to air pollution and climate change. Betty is always looking for ways to reduce her energy consumption. She uses energy efficient

products whether they are high performing or not. Even so, she would be very happy if the energy efficient products that she uses also perform well. Betty is highly motivated to perceive energy efficient products as high performing. If energy efficient products perform well, she gains positive utility from reducing her energy consumption and positive utility from having a product that performs well. As such, the two sources of utility are positively correlated. Thus, it is in her interest to believe that the energy efficient product performs well. She could pay less attention to negative aspects of product quality and more attention to positive aspects of product quality. Regardless of the psychological pathways that may be employed, she can increase her overall utility with a perception bias. The strength of the motivation for energy efficient products to perform well leads to a stronger perception bias.

Essentially, the motivation parameter captures preferences over different possible states of the world. If an individual has a strong motivation to use energy efficient products, then she would prefer a state of the world where energy efficient products perform well. This preference for a state of the world where energy efficient products perform well motivates her to perceive better performance for energy efficient products.

In Study 1, we test the following two hypotheses:

H1: When people expect an eco-product to perform less well than a standard version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

H2: When people are motivated for an eco-product to perform less well than a standard version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

5.1 Study 1: Methods

Participants

Participants were recruited online through Amazon MTurk and paid \$1 to complete the 10-minute survey. Of the 228 eligible participants who began the survey, 208 completed most of the survey and were included in the analysis (91.2% completion rate).³ Of the 208 participants included in the analysis, 187 went on to answer questions about their demographics, political beliefs, and environmental beliefs. We asked participants to place themselves on a 7-point labeled scale of political ideology and 19% of the sample identified as somewhat conservative, conservative, or very conservative, 61% identified as somewhat liberal, liberal, or very liberal, 14% identified as moderate, and 6% reported that they did not know. Table 1 summarizes the demographic statistics of this study sample.

Procedure

In this study, participants rated the quality of light in four photographs. Each photo is labeled as taken using either an energy efficient CFL or an incandescent light.

Before they evaluate any photos, participants answer questions about their prior expectations of the relative performance of energy efficient CFLs and incandescent lights and their motivation for energy efficient CFLs to perform well. Then they are shown a camera and its specifications, a lamp and its specifications, and both the energy efficient CFL bulb and incandescent light bulb. They are told that each photo was taken using the same camera without a flash, the same lamp, and one of the two light bulbs. Before each photo is shown and evaluated, they are told that the photo was taken with either the energy efficient CFL or the incandescent light. These labels are randomized across participants, and each participant evaluates two photos with the energy efficient CFL label and two photos with the incandescent light label.

³Sixteen participants were dropped because they had taken earlier pilot studies.

	Study 1	Study 2 & 3	Study 4
Gender			
Female	46%	56%	43%
Male	54%	44%	57%
Age			
18-24	46%	43%	28%
25-30	27%	17%	21%
31-40	12%	14%	20%
41-50	10%	11%	14%
51-60	4%	6%	12%
61+	2%	9%	5%
Education			
Less than high school	0%	5%	2%
High school degree or equivalent (e.g. GED)	11%	31%	15%
Some college but no degree	38%	30%	20%
Associate degree	10%	12%	9%
Bachelor degree	32%	13%	34%
Graduate degree	9%	10%	20%
Household Income			
\$0-\$29,999	25%	30%	27%
\$30,000-\$59,999	33%	31%	31%
\$60,000-\$89,999	20%	24%	18%
\$90,000-\$119,999	11%	8%	10%
\$120,000-\$149,999	6%	4%	7%
\$150,000+	5%	3%	6%

Table 1: Demographic Statistics for Study Participants

Participants rate each photo on four different light qualities on a 6-point numeric scale: bluishness, yellowishness, brightness, and pleasantness. For each light quality, 1 is labeled as “Not at all bluish/yellowish/bright/pleasant” and 6 is labeled as “Very bluish/yellowish/bright/pleasant.”

After evaluating the lighting in all four photos, they are asked a number of questions on demographics as well as their political and environmental beliefs.

5.2 Study 1: Results

Using an OLS regression with errors clustered at the individual, we employ the following model to analyze the relationship between expectations and perception as well as motivation and perception:

$$y_i = \beta_0 + \beta_1 CFL_i + \beta_2 Exp_i + \beta_3 Exp_i * CFL_i + \beta_4 Mot_i + \beta_5 Mot_i * CFL_i + \gamma_1 P1 + \gamma_2 P2 + \gamma_3 P3 + \epsilon \quad (3)$$

- y_i : Rating of light pleasantness on a 6-point scale where 1=“Not at all Pleasant” and 6 = “Very Pleasant”
- Exp_i : Expectations about the relative performance of CFLs and incandescent lights
 - $Exp_i = 1$ when individual responds that CFLs perform worse than incandescent lights
 - $Exp_i = 0$ when individual responds that CFLs perform about the same or better than incandescent lights
- Mot_i : Motivations for CFLs to perform well on a 5-point numeric scale
- CFL_i : Dummy for photo labeled as lit with a CFL light
- $P1, P2, P3$: Dummy variables for individual photographs

We focus our analysis on the perception of light pleasantness because it best captures preference while allowing for heterogeneity in tastes for levels of bluishness, yellowishness, and brightness.

First, Hypothesis 1 predicts that those who have low expectations of the overall performance of energy efficient CFLs, they will perceive light labeled as CFL to be less pleasant. Thus, in our model above, the variation of interest is β_3 . After controlling for ratings of CFLs and incandescents for all participants, β_3 measures the additional impact on pleasantness ratings of light labeled as CFL from those who expect CFLs to perform worse than incandescent lights.

The results confirm H1 (Table 2, Regression 4: $p=0.018$). Those who expect CFL light to perform worse than incandescent light give lower ratings to light when it is labeled as CFL than when it is labeled as incandescent compared to the ratings of those who have higher expectations of the relative performance of CFLs.

Figure 1 shows the marginal impact of expectations on pleasantness ratings using the following equations:

Light Labeled as Incandescent: Light Pleasantness Rating by Expectation

$$\tilde{y} = \tilde{\beta}_0 + \tilde{\beta}_2Exp + \tilde{\beta}_3Exp * 0 + \tilde{\beta}_4\overline{Mot} + \tilde{\beta}_5\overline{Mot} * 0 + \tilde{\gamma}_1\overline{P1} + \tilde{\gamma}_2\overline{P2} + \tilde{\gamma}_3\overline{P3} \quad (4)$$

Light Labeled as CFL: Light Pleasantness Rating by Expectation

$$\tilde{y} = \tilde{\beta}_0 + \tilde{\beta}_2Exp + \tilde{\beta}_3Exp * 1 + \tilde{\beta}_4\overline{Mot} + \tilde{\beta}_5\overline{Mot} * 1 + \tilde{\gamma}_1\overline{P1} + \tilde{\gamma}_2\overline{P2} + \tilde{\gamma}_3\overline{P3} \quad (5)$$

Hypothesis 2 posits that individuals who have a stronger motivation for energy efficient CFLs to perform well will perceive light labeled as CFLs to be more pleasant than when it is labeled as incandescent. Using the same model specified above, the variable of interest for H2 is β_5 which measures the impact on pleasantness ratings of light labeled as CFL interacted with the 5-point numeric measure of “happiness” if CFLs perform well.

We find that H2 is not supported by the results of Study 1. They gave slightly higher pleasantness ratings when the photo was labeled as taken with a CFL than when it was labeled as incandescent compared to those who said they would not be as happy if CFLs performed well, but the result was not statistically significant ($p=0.256$).

	(1)	(2)	(3)	(4)
	Pleasant	Pleasant	Pleasant	Pleasant
CFL	0.225** (0.0773)	0.299*** (0.0804)	-0.210 (0.375)	-0.123 (0.364)
Expectations		0.122 (0.237)		0.129 (0.229)
Expectations x CFL		-0.610* (0.252)		-0.609* (0.255)
Motivations			0.211* (0.0864)	0.212* (0.0864)
Motivations x CFL			0.0968 (0.0854)	0.0939 (0.0824)
Photo 1	0.00112 (0.0908)	0.00898 (0.0879)	0.00379 (0.0908)	0.0115 (0.0878)
Photo 2	0.0876 (0.0832)	0.0991 (0.0836)	0.0902 (0.0826)	0.102 (0.0832)
Photo 3	0.389*** (0.0885)	0.396*** (0.0885)	0.393*** (0.0886)	0.399*** (0.0886)
Constant	4.019*** (0.0879)	3.997*** (0.0885)	3.064*** (0.390)	3.039*** (0.393)
N	818	818	818	818
R-sq	0.032	0.043	0.064	0.075

Table 2: Study 1 - Online Study: Perception of Energy Efficient Lighting. OLS Regression of light pleasantness (6-point scale) on moderating variables with errors clustered at the individual. Standard errors in parentheses. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

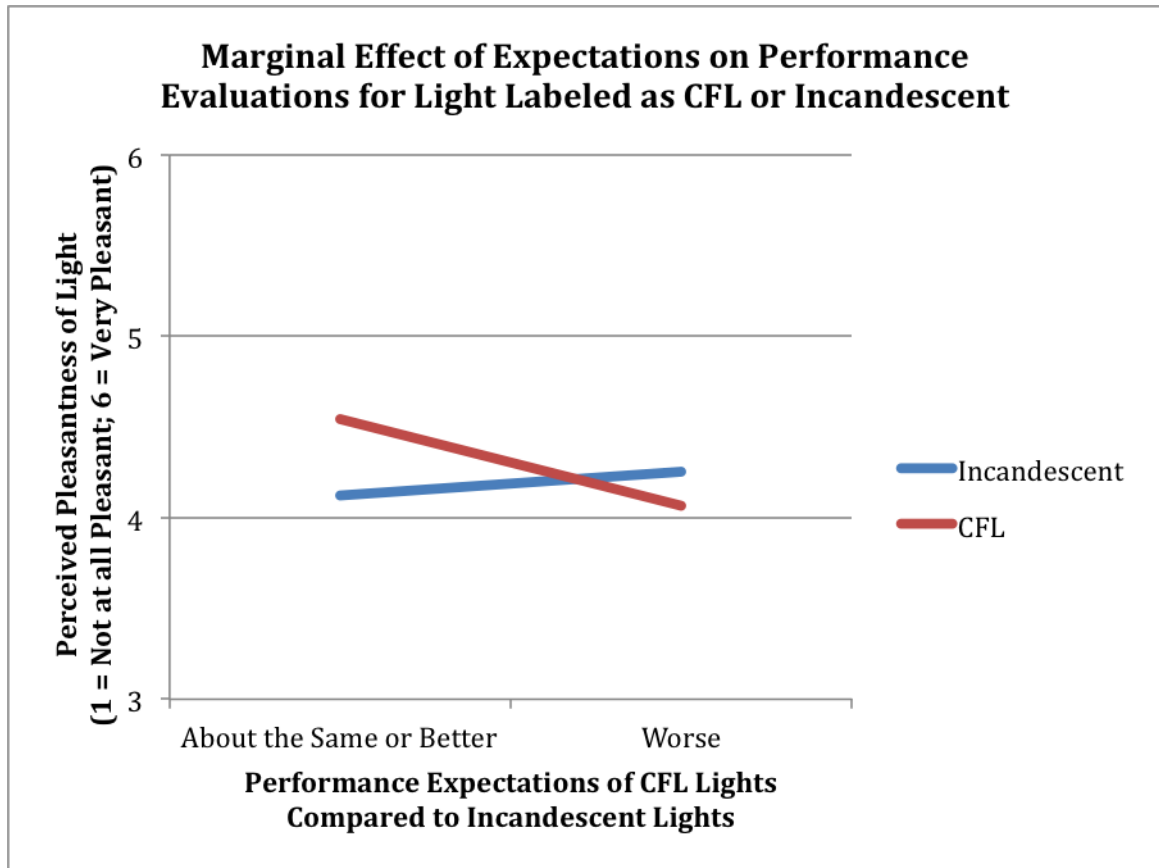


Figure 1: Marginal Effect of Expectations on Performance Evaluations for Light Labeled as CFL or Incandescent in Online Study (Study 1)

We explored the possibility that motivation and expectations may be intertwined. First, we ran a t-test that compares the mean motivation ratings between those who expect CFLs to perform worse than incandescents and those who expect them to perform the same or better. The one-sided t-test finds that the motivation ratings are not significantly different between the two groups ($p=0.4161$). Second, we ran a few different specifications of the OLS model. The magnitude of the coefficients and their standard errors are nearly identical when the both the expectation and motivation variables are run together compared to when they are run separately. This indicates low collinearity between the variables. In other words, the motivation variable does not capture the same variation in the pleasantness rating as the expectation variable, thus causing the motivation variable to appear insignificant when in fact it has the same impact as expectation variable.

Finally, we examine the average effect of the CFL label on the rating of light pleasantness. Without considering the effects of the moderating variables, CFL lights were given higher ratings of pleasantness compared to incandescent lights ($p=0.004$). However, the positive bias is moderated by the motivation for CFLs to perform well. After controlling for expectations and motivation, there is a slight negative bias against light labeled as CFL, but the effect is insignificant ($p=0.737$).

6 Study 2 - Field Study: Perception of Energy Efficient Lighting

To study how expectations affect the experience of actual lighting (as opposed to just photographs over the internet), and also to study other eco-products, we conducted two artefactual field experiments in a shopping mall in a Boston suburb.

In Study 2, we examined how expectations of product performance affected the subjective experience of energy-efficient compact fluorescent light bulbs and incandescent light bulbs.

We test the same two hypotheses that were tested in Study 1:

H1: When people expect an eco-product to perform less well than a standard

version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

H2: When people are motivated for an eco-product to perform less well than a standard version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

Study 2 showed that expectations about the relative performance of CFL bulbs and incandescent bulbs influenced participants' subjective experience of the performance of the light bulbs. Those who expected CFL bulbs to perform poorly compared to incandescent light bulbs experienced what they expected, and vice versa for those participants who expected the opposite. We also find that individuals' expectations of the relative performance of the two light bulbs affect their preference for the light bulbs after they have viewed and evaluated both light bulbs.

6.1 Study 2: Methods

Participants

Study 2 took place at a shopping mall kiosk in a Boston suburb from April 3, 2012 to May 1, 2012. We recruited 380 passersby at a shopping mall in a Boston suburb by offering \$5 gift cards to Dunkin Donuts.⁴ The political ideology of the study sample varied with 19% identifying as somewhat conservative, conservative, or very conservative, 21% as moderate, 22% as somewhat liberal, liberal, or very liberal, and the remaining 38% answered that they did not know where they would place themselves on a scale of political ideology. Table 1 summarizes the demographic statistics of this study sample. Those who participated in Study 2 also took part in Study 3.

⁴Of those, we determined that 22 completed surveys should be dropped from the analysis due to research assistant implementation errors during the experiment or because the participants were ineligible for the study due to language barriers or mental disabilities.

Procedure

In Study 2, we asked participants to evaluate the quality of lighting from two lamps. We set up two light boxes each with identical reading lamps. Lamp A illuminated a sock monkey cookie jar and lamp B illuminated a teal vase with colorful fake flowers. Each lamp was positioned so participants could not see the bulb in the lamp. Before participants evaluated the lighting, they took a brief survey about their past experiences with, and expectations of, CFL and incandescent light bulbs. Then, they looked into each box and rated the quality of the lighting produced by the bulbs.

In order to isolate the effect of expectations on perceptions, we randomly varied the labels on the light boxes: in one treatment we said that light box A contained an incandescent bulb and light box B contained a CFL bulb; in the other treatment the labels were reversed.

After participants examined both bulbs, we gave them a hypothetical purchasing scenario to elicit their willingness to pay for each type of bulb.⁵ We provided them with information about the expected lifetime and the relative electricity consumption of each bulb. Then, while holding a four-pack of each bulb type and reminding them which bulb was used in each light box, we asked them what is the most they would be willing to pay for a four-pack of each type of bulb.

After completing the experiment, participants took a brief survey with demographic questions as well as questions about their political ideology and environmental beliefs.

6.2 Study 2: Results

Similar to our analytical approach in Study 1, we use an OLS regression of moderating variables on ratings of light pleasantness with errors clustered at the individual level. The model described by equation (4) is similar to the model in Study

⁵Willingness to pay for the two types of light bulbs will be analyzed in a separate paper. It is included in the study description for completeness.

1. We used a slightly different measurement of expectations of the performance of CFLs compared to incandescent lights. Instead of dichotomizing a 3-point labeled scale of expectations, we use a 7-point labeled scale ranging from “Much Worse” to “Much Better.”

$$y_i = \beta_0 + \beta_1 CFL_i + \beta_2 Exp_i + \beta_3 Exp_i * CFL_i + \beta_4 Mot_i + \beta_5 Mot_i * CFL_i + \epsilon \quad (6)$$

- y_i : Rating of light pleasantness on a 6-point scale where 1=“Not at all Pleasant” and 6 = “Very Pleasant”
- Exp_i : Expectations about the relative performance of CFLs and incandescent lights on a 7 point scale labeled as Much Worse, Worse, Somewhat Worse, About the Same, Somewhat Better, Better, Much Better
- Mot_i : Motivations for CFLs to perform well on a 5-point numeric scale
- CFL_i : Dummy for light box labeled as lit with a CFL light

H1 predicts that those who have lower prior expectations of the performance of CFLs compared to incandescent lights will perceive the light labeled as CFL to be less pleasant than when it is labeled incandescent compared to those with higher expectations of the performance of CFLs. The variable of interest is β_3 which measures the marginal impact of prior expectations on ratings of pleasantness when the light is labeled as a CFL.

The results of Study 2 support H1. Those who expect CFL light to perform worse than incandescent light give lower ratings to light when it is labeled as CFL than when it is labeled as incandescent compared to those who have higher expectations of the relative performance of CFLs (Table 3; $p=0.006$). The marginal effect of expectations on perception of light pleasantness is illustrated in Figure 2.

Hypothesis 2 posits that individuals who have a stronger motivation for energy efficient CFLs to perform well will perceive light labeled as CFLs to be more pleasant than when it is labeled as incandescent. Using the same model specified above, the variable of interest for H2 is β_5 which measures the impact on pleasantness ratings of light labeled as CFL interacted with the 5-point numeric measure of “happiness” if CFLs perform well.

	(1)	(2)	(3)	(4)
	Pleasant	Pleasant	Pleasant	Pleasant
CFL	1.063*** (0.0913)	-0.105 (0.355)	-0.901 (0.537)	-1.499* (0.610)
Expectations		-0.0726 (0.0487)		-0.0808 (0.0494)
Expectations x CFL		0.231*** (0.0659)		0.185** (0.0676)
Motivation			0.0327 (0.0772)	0.0678 (0.0801)
Motivation x CFL			0.449*** (0.122)	0.371** (0.126)
Constant	3.632*** (0.0687)	3.999*** (0.258)	3.488*** (0.332)	3.744*** (0.389)
N	707	705	707	705
adj. R-sq	0.161	0.180	0.208	0.217

Table 3: Study 2 - Field Study: Perception of Energy Efficient Lighting. OLS Regression of pleasantness rating (6-point scale) on moderating variables with errors clustered at the individual. Standard errors in parentheses. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

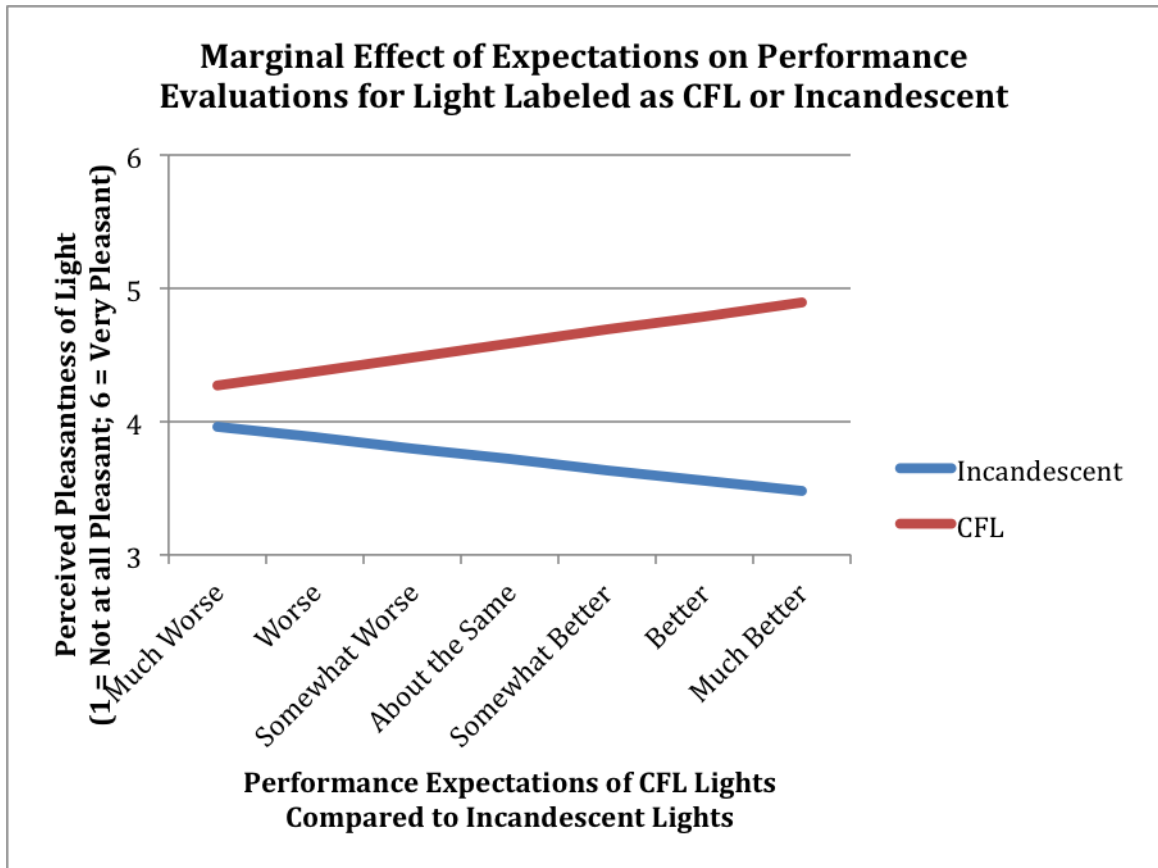


Figure 2: Marginal Effect of Expectations on Performance Evaluations for Light Labeled as CFL or Incandescent in Mall Study (Study 2)

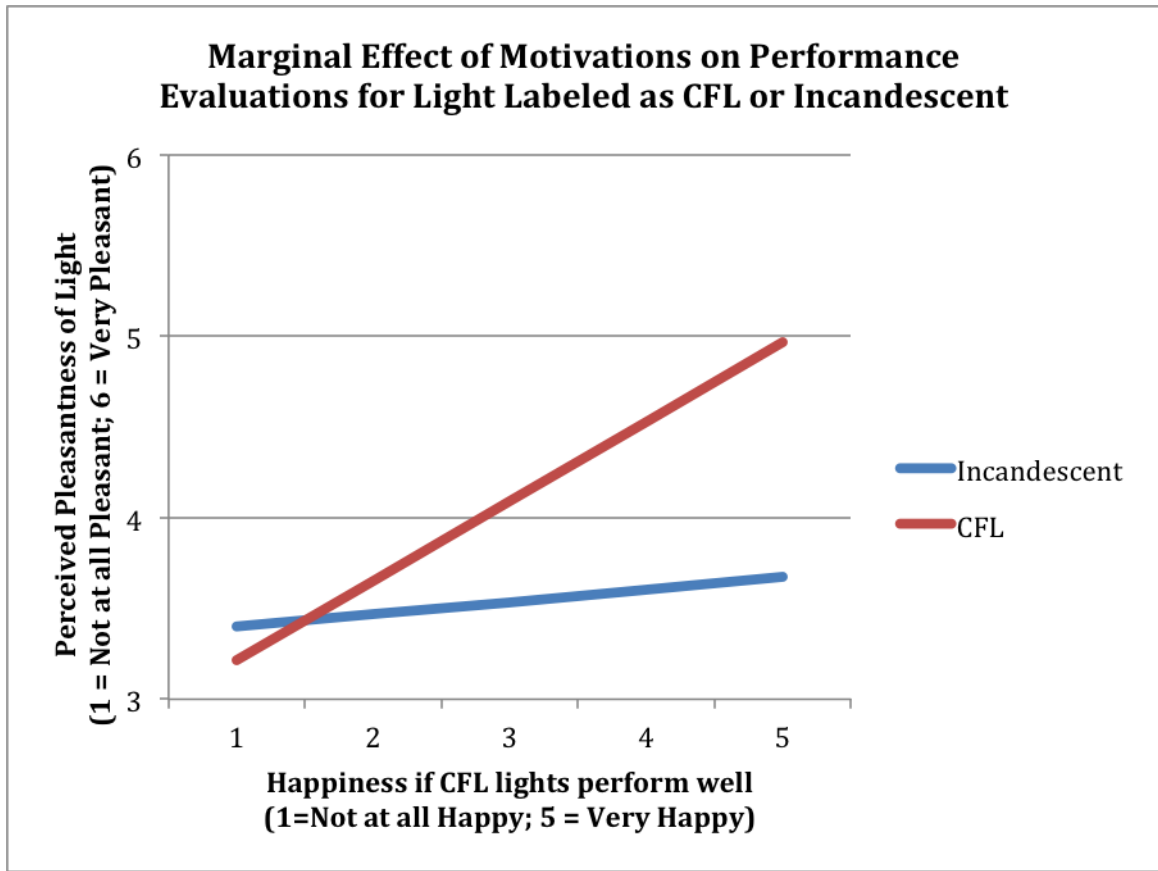


Figure 3: Marginal Effect of Motivation on Performance Evaluations for Light Labeled as CFL or Incandescent in Mall Study (Study 2)

In contrast to Study 1, H2 is supported by the results of Study 2. Those who would be happy if energy efficient CFL lights perform well gave higher pleasantness ratings of the light when it was labeled as CFL than when it was labeled as incandescent compared to those who said they would not be as happy if CFLs performed well ($p=0.004$). Figure ?? shows the marginal effect of motivations on the ratings of pleasantness for both CFL and incandescent labeled lighting.

Unlike in Study 1, we find that motivation and expectations are fairly strongly correlated. The simple correlation of the two measures is $\rho = 0.2235$. To compare the data in Study 2 with the data in Study 1, we dichotomize the expectations variable so that those who respond that CFLs will perform “Much Worse”, “Worse”, or “Somewhat Worse” are in one group and those responding with “About the

Same”, “Somewhat Better”, “Better”, or “Much Better” are in the other group. We then compare the motivation variable between the two groups with a one-sided t-test. In contrast to Study 1, those who expect CFLs to perform worse than incandescent lights have lower levels of motivation for CFLs to perform well ($p = 0.0244$).

Without considering the effects of moderating variables, CFL lights were given higher ratings of pleasantness compared to incandescent lights ($p < 0.001$). However, the positive bias is moderated both by expectations of the performance of CFLs and motivation for CFLs to perform well. After controlling for expectations and motivation, we see a significant negative bias against light labeled as CFL. The eco-product label is associated with a 25% reduction in the rating of pleasantness ($p = 0.014$).

7 Study 3 - Field Study: Perception of Eco-Friendly Toilet Paper

Study 3 examined how expectations about the performance of regular toilet paper and toilet paper made from recycled paper affects the physical softness participants experience when feeling toilet paper they are told is either regular or made from recycled paper. In Study 3, we also measure participants revealed preference between the two types of toilet paper.

We test the same two hypotheses as in Studies 1 and 2:

H1: When people expect an eco-product to perform less well than a standard version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

H2: When people are motivated for an eco-product to perform less well than a standard version of the product, people will subjectively perceive this performance gap (even when it objectively does not exist).

However, extending these hypotheses from light bulbs to toilet paper adds addi-

tional clarity and depth to the analysis. First, we are testing whether the perception bias extends beyond visual sensory perception. Second, we are testing whether these hypotheses hold for a much different eco-product category. Third, toilet paper has a less complex definition of “performance” compared to lights. Incandescent lights and CFL lights have widely disparate electricity costs associated with their use: incandescent light bulbs require approximately five times as much electricity to use than CFLs. CFLs also last up to twelve times longer than incandescent lights. For these reasons we were concerned that our general measure of performance expectations of CFL lights may have been influenced by factors other than the quality of lighting. For example, someone who says that CFLs perform well may be referring to the fact that they last a long time and they consume little electricity instead of focusing on the performance of the light quality.

Additionally, testing toilet paper allowed us to include a behavioral measure of revealed preference. At the end of the experiment, we offer participants a bonus gift of a roll of one of the toilet papers they tested.

Study 3 showed that expectations of performance of toilet paper made from recycled paper strongly influenced the softness they reported experiencing when touching the toilet paper. We see the same pattern carry through from experience of softness to product preference: participants who expect toilet paper made from recycled paper to perform better are more likely to prefer toilet paper made from recycled paper over regular toilet paper.

7.1 Study 3: Methods

Participants

Those who participated in Study 2 also took part in Study 3. See Study 2 for participant details.

Procedure

We displayed two rolls of toilet paper labeled A and B. For the two rolls, we randomized labels of toilet paper made from recycled paper and regular toilet paper. Each participant evaluated one roll labeled as regular toilet paper and one roll labeled as recycled. Participants first answered questions about their experiences and expectations of the performance of regular and toilet paper made from recycled paper. Then, we gave each participant a four-sheet sample of toilet paper A to test for softness and strength and then a sample of toilet paper B to test for softness and strength. After evaluating each toilet paper individually, participants were asked which they preferred and how much they would be willing to pay for a four-pack of toilet paper A and B.⁶

7.2 Study 3: Results

We test H1 and H2 with two different measures of toilet paper performance: softness and strength. We use a similar analytical model to that used to analyze light pleasantness in Study 2 to analyze the softness and strength ratings in Study 3:

OLS Regression Equation: Toilet Paper Softness Rating

$$y_i = \beta_0 + \beta_1 Rec_i + \beta_2 Exp_i + \beta_3 Exp_i * Rec_i + \beta_4 Mot_i + \beta_5 Mot_i * Rec_i + \epsilon \quad (7)$$

- y_i : Rating of toilet paper softness on a 6-point scale where 1=“Not Very Soft” and 6 = “Very Soft”
- Exp_i : Expectations about the relative performance of CFLs and incandescent lights on a 7 point scale labeled as Much Worse, Worse, Somewhat Worse, About the Same, Somewhat Better, Better, Much Better
- Mot_i : Motivations for CFLs to perform well on a 5-point numeric scale
- Rec_i : Dummy for toilet paper labeled as made from recycled paper

⁶Willingness to pay for the two types of toilet papers will be analyzed in a separate paper. It is included in the study description for completeness.

OLS Regression Equation: Toilet Paper Strength Rating

$$y_i = \beta_0 + \beta_1 Rec_i + \beta_2 Exp_i + \beta_3 Exp_i * Rec_i + \beta_4 Mot_i + \beta_5 Mot_i * Rec_i + \epsilon \quad (8)$$

- y_i : Rating of toilet paper strength on a 6-point scale where 1=“Not Very Strong” and 6 = “Very Strong”
- Exp_i : Expectations about the relative performance of CFLs and incandescent lights on a 7 point scale labeled as Much Worse, Worse, Somewhat Worse, About the Same, Somewhat Better, Better, Much Better
- Mot_i : Motivations for CFLs to perform well on a 5-point numeric scale
- Rec_i : Dummy for toilet paper labeled as made from recycled paper

H1 predicts that when evaluating toilet paper labeled as made from recycled paper, those with higher expectations of the relative performance of toilet paper made from recycled paper will perceive the toilet paper to be softer compared to those who have lower expectations of the performance of toilet paper made from recycled paper. Our variable of interest for this hypothesis, β_3 , is positive and significant with a p-value of 0.001. Those who expect toilet paper made from recycled paper to perform worse than regular toilet paper give relatively lower ratings to toilet paper when it is labeled as recycled than they do to toilet paper labeled as regular compared to those who have higher expectations of toilet paper made from recycled paper.

H2 predicts that those with higher levels of motivation for toilet paper made from recycled paper to perform well will perceive the toilet paper labeled as made from recycled paper to be softer compared to those who have lower levels of motivation for toilet paper made from recycled paper to perform well. The results of Study 3 support H2. We find that those who would be happy if toilet paper made from recycled paper performs well gave higher ratings to the softness of toilet paper when it was labeled as made from recycled paper compared to those who said they would not be as happy if toilet paper made from recycled paper performed well (Table ??; p=0.019).

In contrast to the results that confirmed H1 and H2 when the rating of softness

	(1)	(2)	(3)	(4)
	Softness	Softness	Softness	Softness
Recycled Label	0.442*** (0.0819)	-0.430 (0.327)	-0.311 (0.333)	-1.288** (0.427)
Expectations		-0.0487 (0.0643)		-0.0640 (0.0632)
Expectations x Recycled		0.234** (0.0828)		0.260** (0.0804)
Motivation			0.0455 (0.0645)	0.0551 (0.0654)
Motivation x Recycled			0.181* (0.0817)	0.183* (0.0784)
Constant	3.433*** (0.0659)	3.627*** (0.246)	3.254*** (0.263)	3.467*** (0.361)
N	707	653	705	651
adj. R-sq	0.028	0.041	0.041	0.058

Table 4: Study 3 - Field Study: Perception of Eco-Friendly Toilet Paper. OLS Regression of softness rating (6-point scale) on moderating variables with errors clustered at the individual. Standard errors in parentheses. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

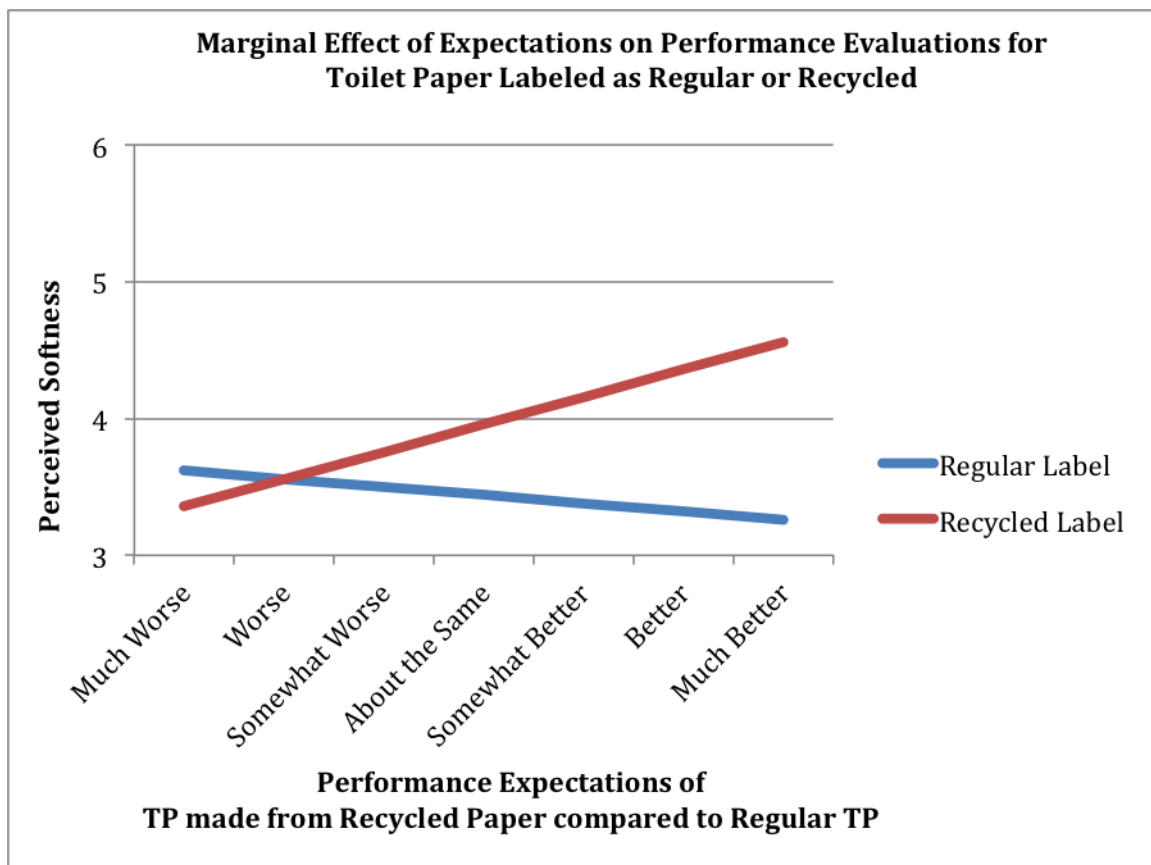


Figure 4: Study 3 - Field Study: Perception of Eco-Friendly Toilet Paper. Marginal Effect of Expectations on Performance Evaluations for Toilet Paper Labeled as Made from Recycled Paper

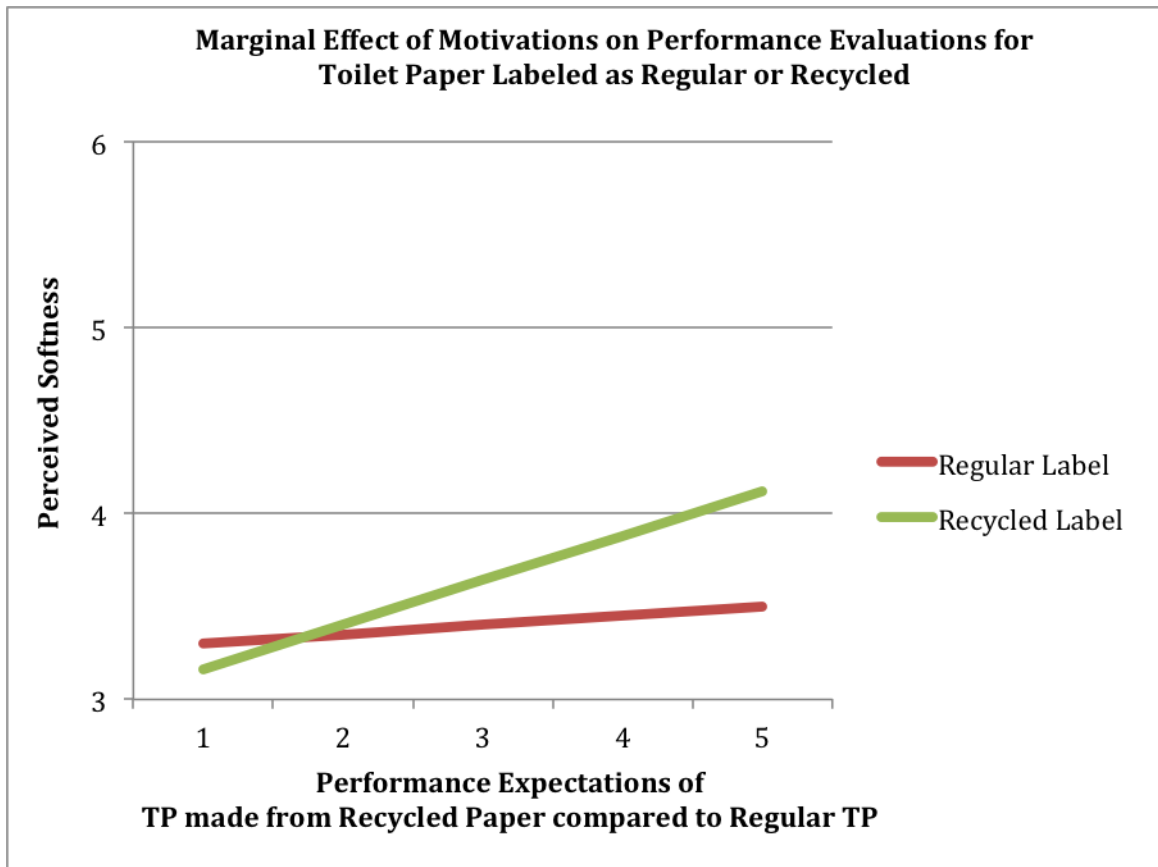


Figure 5: Study 3 - Field Study: Perception of Eco-Friendly Toilet Paper. Marginal Effect of Motivations on Performance Evaluations for Toilet Paper Labeled as Made from Recycled Paper

is used as a proxy for overall performance, the ratings of toilet paper strength do not support H1 or H2 (Table 5). For H1, expectations of the relative performance of regular and recycled paper had no effect on the perception of strength of toilet paper. For H2, motivation did not predict ratings of strength for toilet paper made from recycled paper. However, those with higher levels of motivation did give higher ratings of strength to both regular and toilet paper made from recycled paper.

We do not find that the dependent variable of toilet paper strength supports either H1 or H2. This could be due to the fact that we did not differentiate between two aspects of strength, which have positive and negative impacts on overall performance. Strength between sheets affects ease of tearing. This is considered a positive quality. Strength overall is generally positive. During the testing of the toilet paper many people noted the strength or lack thereof when the sheets were torn off of the roll. Others also tore individual sheets of toilet paper to test overall strength. Thus, some participants were rating strength as a positive contribution to performance and others were rating strength as a negative contribution to performance.

After participants completed the study, they were told that in addition to the gift card, they would also receive a free roll of toilet paper. They were asked to choose one of the two rolls they tested. We analyzed the choice of toilet paper in a logistical regression model. For approximately half of the participants, toilet paper A was labeled as recycled while toilet paper B was labeled as regular. We parameterized the model so that the dependent variable equals to 1 when the toilet paper labeled as “Regular” was chosen and 0 when the toilet paper labeled as “Made from recycled paper” was chosen.

Logistic Regression Model: Toilet Paper Choice

- $y_i = 1$ when the individual chooses the toilet paper labeled as “Regular”
- $y_i = 0$ when the individual chooses the toilet paper labeled as “Made from recycled paper”
- Exp_i : Expectations about the relative performance of CFLs and incandes-

	(1)	(2)	(3)	(4)
	Strength	Strength	Strength	Strength
Recycled Label	0.369*** (0.0823)	0.0759 (0.307)	0.107 (0.317)	-0.239 (0.445)
Expectations		0.0404 (0.0655)		0.0537 (0.0653)
Expectations x Recycled		0.0776 (0.0829)		0.0774 (0.0842)
Motivation			0.133* (0.0669)	0.139* (0.0678)
Motivation x Recycled			0.0642 (0.0788)	0.0775 (0.0809)
Constant	3.881*** (0.0666)	3.741*** (0.255)	3.332*** (0.271)	3.117*** (0.371)
N	705	651	703	649
adj. R-sq	0.019	0.022	0.033	0.041

Table 5: Study 3 - Field Study: Perception of Eco-Friendly Toilet Paper. OLS Regression of strength rating (6-point scale) on moderating variables with errors clustered at the individual. Standard errors in parentheses. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

cent lights on a 7 point scale labeled as Much Worse, Worse, Somewhat Worse, About the Same, Somewhat Better, Better, Much Better

- Mot_i : Motivations for CFLs to perform well on a 5-point numeric scale

$$y_i = \beta_0 + \beta_1 Exp_i + \beta_2 Mot_i + \epsilon \quad (9)$$

Motivation for toilet paper made from recycled paper to perform well is the strongest predictor of toilet paper choice (Table 6). Those who would be happiest if toilet paper made from recycled paper performs well are more likely to choose toilet paper made from recycled paper than those who would be less happy if toilet paper made from recycled paper performs well ($p < 0.001$). Those with higher expectations of the performance of toilet paper made from recycled paper were more likely to choose to take home the toilet paper made from recycled paper, but the result is not statistically significant ($p = 0.083$).

8 Study 4 - Field Study: Blind Variation with Perception of Eco-Friendly Toilet Paper

In the final study, we delve deeper into the eco-product perception bias with additional treatment variations. We examine whether we can reduce the effect of the expectation bias on product preference. The key question, which is especially relevant for economic theory is whether expectations and preferences linked directly or through biased perception. Economic theory would predict that expectations inform preferences and that expectations would follow Bayesian updating when new information is incorporated, such as the information obtained through direct product testing. However, standard economic theory does not predict that preferences and expectations can be linked primarily through expectation biased perception. As discussed in Section 4, this concept has significant implications for the widespread economic problem of imperfect information.

While the effect of motivation on perception of product quality is not well incor-

	(1)	(2)	(3)
	Choose Regular	Choose Regular	Choose Regular
Motivations	-0.447*** (0.136)		-0.470** (0.153)
Expectations	-0.209 (0.121)		-0.169 (0.135)
Softness rating of "regular" TP		0.657*** (0.153)	0.581*** (0.157)
Softness rating of "recycled" TP		-0.403** (0.144)	-0.303 (0.156)
Strength rating of "regular" TP		0.218 (0.151)	0.365* (0.166)
Strength rating of "recycled" TP		-0.460*** (0.133)	-0.444** (0.137)
Constant	1.476* (0.713)	-0.951 (0.655)	0.801 (0.918)
N	274	294	272
Pseudo R-Sq	0.045	0.155	0.181

Table 6: Study 3 - Field Study: Perception of Eco-Friendly Toilet Paper. Logistic regression of choosing regular toilet paper over recycled toilet paper on moderating variables. Standard errors in parentheses. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

porated into economic theory, the effect of motivation on product preference is a fairly straightforward economic prediction. We expect consumers to gain positive utility from a “warm glow” that arises from knowing that the product they are consuming has a low impact on the environment. If we assume that the level of motivation they have for environmental products to perform well is directly related to the magnitude of the utility gain from the warm glow, then motivation should correlate with preference for eco-products.

To explore these questions we follow a methodology used in a paper by Lee, Frederick, and Ariely [20]. We add a treatment group where we have participants evaluate the toilet paper without disclosing whether the toilet paper is made from recycled paper or from virgin wood fiber. This prevents the eco-bias found in the earlier studies from affecting the actual experience of the product evaluation. After participants in this treatment record their ratings of toilet paper softness, we “reveal” the labels of regular and made from recycled paper. Then, participants choose which toilet paper they would like to take home.

In addition to H1 and H2, Study 4 tests a new hypothesis that posits a chain of causality where prior expectations affect product perception which then goes on to influence product preference:

H3: Prior performance expectations of eco-products influence post-testing product choice solely through the mechanism of biased perception.

The results of Study 4 provide a good deal of insight into how expectations and motivations affect both perception of a products performance and how those perceptions go on to inform product preference.

Perception of toilet paper softness is biased by prior expectations of product performance. These biased perceptions go on to inform product preference. When we neutralize the bias using a blind test, then reveal the eco-label before a preference is expressed; prior expectations play no role in product preference. Motivation for toilet paper made from toilet paper made from recycled paper to perform well influences product preference, but does not appear to bias perception of softness.

8.1 Study 4: Methods

Participants

Study 4 took place in the South Station Boston T-Stop between July 31, 2012 and August 8, 2012. We recruited passersby by offering \$4 Dunkin Donuts gift cards. The experiment took each participant approximately 4 minutes to complete. There were 470 eligible participants included in the analysis.⁷ We asked participants to place themselves on a 7-point numeric scale of political ideology where 1 = Very Liberal and 7 = Very Conservative. Of those who answered the question, 56% placed themselves on the liberal side of the scale, 27% chose the middle value, and 15% placed themselves on the conservative side of the scale.⁸ Table 1 summarizes the demographic statistics of the study sample.

Procedure

Study 4 has a similar procedure to Study 3, but we include a blind treatment and a blind-reveal treatment in addition to the standard labeled treatment, which we employed in Study 3. Participants first take a survey about their expectations and motivations regarding regular toilet paper. They also answer a number of demographic and political questions. Then, participants test both types of toilet paper and rate it for softness and strength. Next, they answer a question about the willingness to pay for a four-pack of toilet paper B from a list of 15 prices in descending order from \$8.00 to \$0.00 with an anchor price for toilet paper A of \$4.00.⁹ Finally, we tell them that in addition to the gift card, we would like to give them a bonus gift of a roll of one of the toilet papers they tested. They can choose to take home either a roll of toilet paper A and toilet paper B.

⁷482 people completed the study and 12 were excluded from the analysis due to research assistant implementation errors in the experiment procedure, language barriers, and mental disabilities.

⁸We did not include an “I don’t know” option, but 10 out of 470 participants (2%) chose to leave the question blank.

⁹WTP measures will be analyzed in a separate paper, but are included in the procedures for completeness.

Study 4 included the following treatment groups:

- Blind Treatment: Toilet paper A & B are unlabeled throughout the experiment
- Labeled Treatment: Toilet paper A & B are labeled throughout the experiment.
 - Subtreatment 1: Toilet paper A is labeled as made from recycled paper; Toilet paper B is labeled as made from wood pulp (regular)
 - Subtreatment 2: Toilet paper A is labeled as made from wood pulp (regular); Toilet paper B is labeled as made from recycled paper
- Blind-Reveal Treatment: Toilet paper A & B are unlabeled during the testing phase of the experiment, where individuals feel the toilet paper and rate its softness. Then the labels are revealed and participants give their willingness to pay for toilet paper B and choose to take home either toilet paper A or toilet paper B.
 - Subtreatment 1: Toilet paper A is labeled as made from recycled paper; Toilet paper B is labeled as made from wood pulp (regular)
 - Subtreatment 2: Toilet paper A is labeled as made from wood pulp (regular); Toilet paper B is labeled as made from recycled paper

8.2 Study 4: Results

We use the same analytical model from the previous studies to analyze the ratings of toilet paper softness. Then we analyze the model separately for the blind, labeled, and blind-reveal treatments.

$$y_i = \beta_0 + \beta_1 Rec_i + \beta_2 Exp_i + \beta_3 Exp_i * Rec_i + \beta_4 Mot_i + \beta_5 Mot_i * Rec_i + \gamma D1 + \epsilon \quad (10)$$

- y_i : Rating of toilet paper softness on a 6-point scale where 1=“Not Very Soft” and 6 = “Very Soft”

- *Exp_i*: Expectations about the relative performance of CFLs and incandescent lights on a 7-point numeric scale
- *Mot_i*: Motivations for CFLs to perform well on a 5-point numeric scale
- *Rec_i*: Dummy for toilet paper labeled as made from recycled paper
- *D1*: Dummy for comparison of two different types of toilet paper¹⁰

The results from the ratings of softness in Study 4 support H1. In the labeled treatment, those who expect toilet paper made from recycled paper to perform worse than regular toilet paper give lower ratings to toilet paper when it is labeled as recycled compared to when it is labeled as regular (Table 7; $p=0.059$). While the results are only marginally statistically significant, they confirm our earlier findings. Due to the multiple treatment groups, we had a smaller sample size for this question.

In contrast to Study 3, we find that motivation for toilet paper made from recycled paper to perform well appears to have no effect on the evaluation of softness. This contrasts with findings from the earlier toilet paper study (Study 2), but is in line with findings from the online light study (Study 1).

In the blind treatment and the blind-reveal treatments, those who have higher expectations of the performance of toilet paper made from recycled paper give higher ratings to all toilet paper. This is likely due to the fact that even without the labels, they suspected that they were evaluating toilet paper made from recycled paper due to the questions about regular and toilet paper made from recycled paper that preceded the toilet paper testing. Those with higher expectations of toilet paper made from recycled paper do not give higher ratings to the toilet paper

¹⁰On the first day of the experiment, we used two different brands of toilet paper from the ones used in Study 3. We switched to these brands because they were available at a nearby store, thus decreasing the logistical issues of carrying 100 rolls of toilet paper through the Boston subway. However, we found that one brand of toilet paper was strongly preferred over the other. In order to keep the quality fairly equal between the two toilet papers, on the remaining 3 days of the experiment we switched back to the original two brands. The ratings and toilet paper choice of the toilet paper used on the first day differ significantly from those used on the other days. However, the results follow the same patterns with regards to our hypotheses on expectations and motivations. For this reason, we kept the data in the analysis and simply controlled for the variance with a dummy variable for day 1.

	Labeled Treatment	Blind-Reveal Treatment	Blind Treatment
	(1) Softness	(2) Softness	(3) Softness
Recycled Label	-0.239 (0.921)	1.031 (0.799)	
Expectations	0.0685 (0.0878)	0.201* (0.0930)	0.195*** (0.0538)
Expectations*Recycled	0.245* (0.124)	-0.114 (0.134)	
Motivation	0.0638 (0.0861)	0.0769 (0.0851)	0.0485 (0.0457)
Motivation*Recycled	-0.0510 (0.137)	-0.0775 (0.121)	
Day 1	-0.604** (0.195)	-0.758*** (0.184)	-0.895*** (0.159)
Constant	3.349*** (0.644)	2.775*** (0.577)	3.064*** (0.328)
N	374	400	558
adj. R-sq	0.095	0.055	0.088

Table 7: Study 4 - Field Study: Blind Variation with Perception of Eco-Friendly Toilet Paper. OLS Regression of softness rating (7-point scale) on moderating variables with errors clustered at the individual. Standard errors in parentheses.
* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

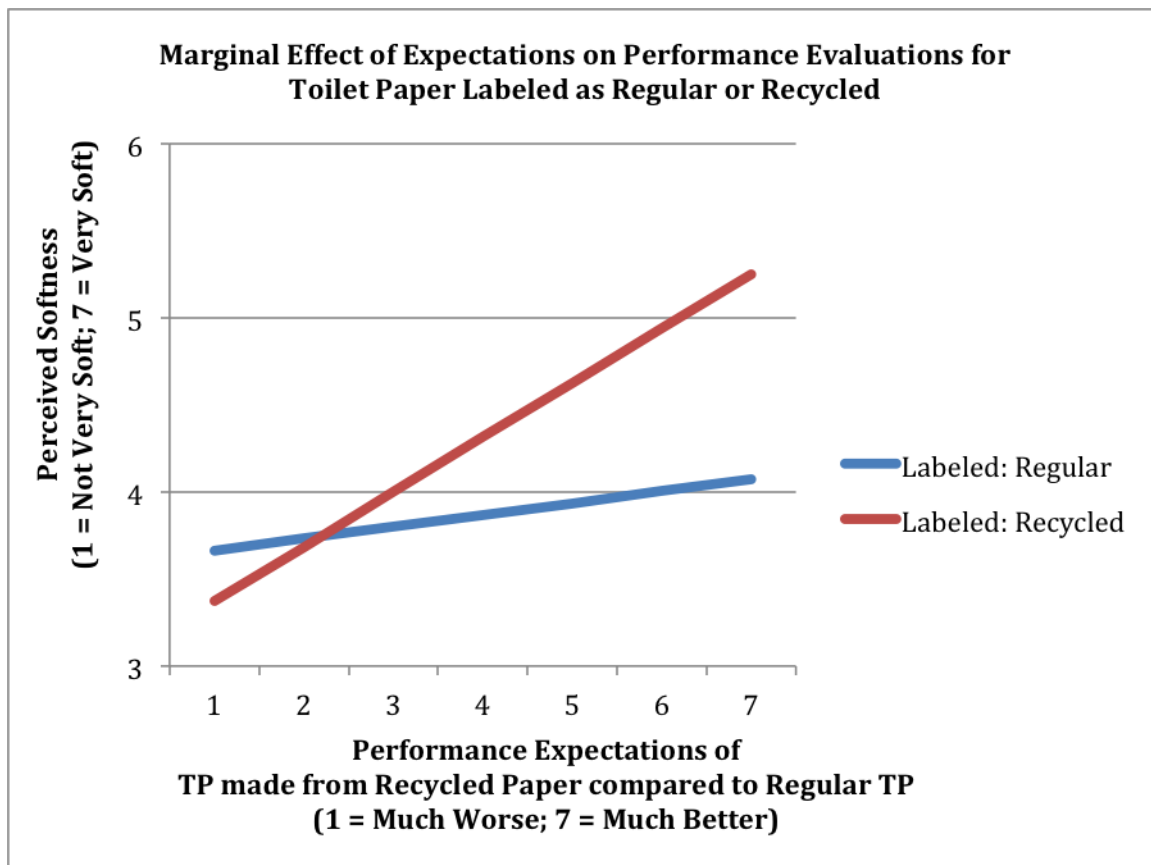


Figure 6: Study 4 - Field Study: Blind Variation with Perception of Eco-Friendly Toilet Paper. Marginal Effect of Expectations on Performance Evaluations for Toilet Paper Labeled as Made from Recycled Paper

labeled as recycled, which is revealed after the evaluations.

As in Study 3, after participants completed the study, they were told that in addition to the gift card, they would also receive a free roll of toilet paper. They were asked to choose one of the two rolls they tested.

We test our final hypothesis, H3, with a comparison of product choice between the labeled treatment and the blind-reveal treatment.

H3: Prior performance expectations of eco-products influence post-testing product choice solely through the mechanism of biased perception.

Basic economic theory predicts that product preference is influenced by information the consumer holds about the product. In our experiment, participants are given the opportunity to gain information about the performance of the product through product testing. The main contribution of this paper is the idea that expectations of product performance based on the eco-product label bias the consumer's perception of product performance. When a consumer tries a product, her expectations bias the product performance information she uses to determine her preferences.

H3 takes this idea step further and posits that the perception bias is the main mechanism through which product preference is biased. In other words, H3 predicts that expectations will influence product preference because they cause a perception bias while the participant is evaluating each type of toilet paper.

In Study 3, H3 predicts that expectations will influence product choice in the labeled treatment, but not in the blind-reveal treatment. In the blind-reveal treatment, prior expectations could not influence the perceptual experience of product quality because participants did not know which toilet paper was an eco-product when they tested the two rolls. If product choice is influenced by the perceptual experience of the product testing instead of the participant's prior expectations, then we would not see any influence of expectations on product choice in the blind-reveal treatment. In contrast, in the labeled treatment, prior expectations would bias the perceptual experience of the product testing. Thus we would see an influence of prior expectations on product preference.

As in Study 3, we employ a logistical regression model where the dependent variable equals to 1 when the participant chooses to take home the toilet paper labeled as regular and 0 when the participant chooses the toilet paper labeled as made from recycled paper.

Logistic Regression Model: Toilet Paper Choice

- $y_i = 1$ when the individual chooses the toilet paper labeled as “Regular”
- $y_i = 0$ when the individual chooses the toilet paper labeled as “Made from recycled paper”
- Exp_i : Expectations about the relative performance of CFLs and incandescent lights on a 7-point numeric scale
- Mot_i : Motivations for CFLs to perform well on a 5-point numeric scale
- $D1$: Dummy for comparison of two different types of toilet paper

$$y_i = \beta_0 + \beta_1 Exp_i + \beta_2 Mot_i + \gamma D1 + \epsilon \quad (11)$$

The results support H3. In the labeled treatment, those who have low expectations of the performance of toilet paper made from recycled paper compared to that of regular toilet paper are more likely to choose the regular toilet paper over the toilet paper made from recycled paper (Table 8; $p=0.042$). In the blind-reveal treatment, where the participant tests the toilet paper before the labels are revealed, expectations do not affect the choice of whether to take home regular or toilet paper made from recycled paper ($p=0.725$). These results support the hypothesis that the perception bias is the primary driver of the influence of expectations on product preference.

In summary, Study 4 demonstrates a causal relationship between a heuristic bias in the perception of product quality and a bias in product preference. Expectations of the performance of toilet paper made from recycled paper bias perception. Motivations for toilet paper made from recycled paper to perform well do not bias perception, but do influence product preference. Those with low expectations of the performance of toilet paper made from recycled paper experience a

	Labeled Treatment	Blind-Reveal Treatment	Labeled Treatment	Blind-Reveal Treatment
	(1)	(2)	(3)	(4)
Motivation	-0.177 (0.119)	-0.235 (0.126)	-0.234 (0.150)	-0.289* (0.138)
Expectation	-0.310* (0.152)	-0.0516 (0.147)	-0.255 (0.174)	-0.0748 (0.156)
Softness Rating for Regular TP			0.870*** (0.206)	0.277* (0.141)
Softness Rating for Recycled TP			-0.674*** (0.172)	-0.505** (0.154)
Day1	0.0522 (0.456)	0.685 (0.436)	0.276 (0.542)	0.408 (0.482)
Constant	0.835 (0.845)	-0.204 (0.833)	0.0647 (1.239)	1.022 (1.097)
N	186	198	186	198
pseudo R-sq	0.044	0.034	0.233	0.115

Table 8: Study 4 - Field Study: Blind Variation with Perception of Eco-Friendly Toilet Paper. Logistic Regression of choosing regular toilet paper over recycled toilet paper on moderating variables. Standard errors in parentheses. * $p < 0.05$
** $p < 0.01$ *** $p < 0.001$

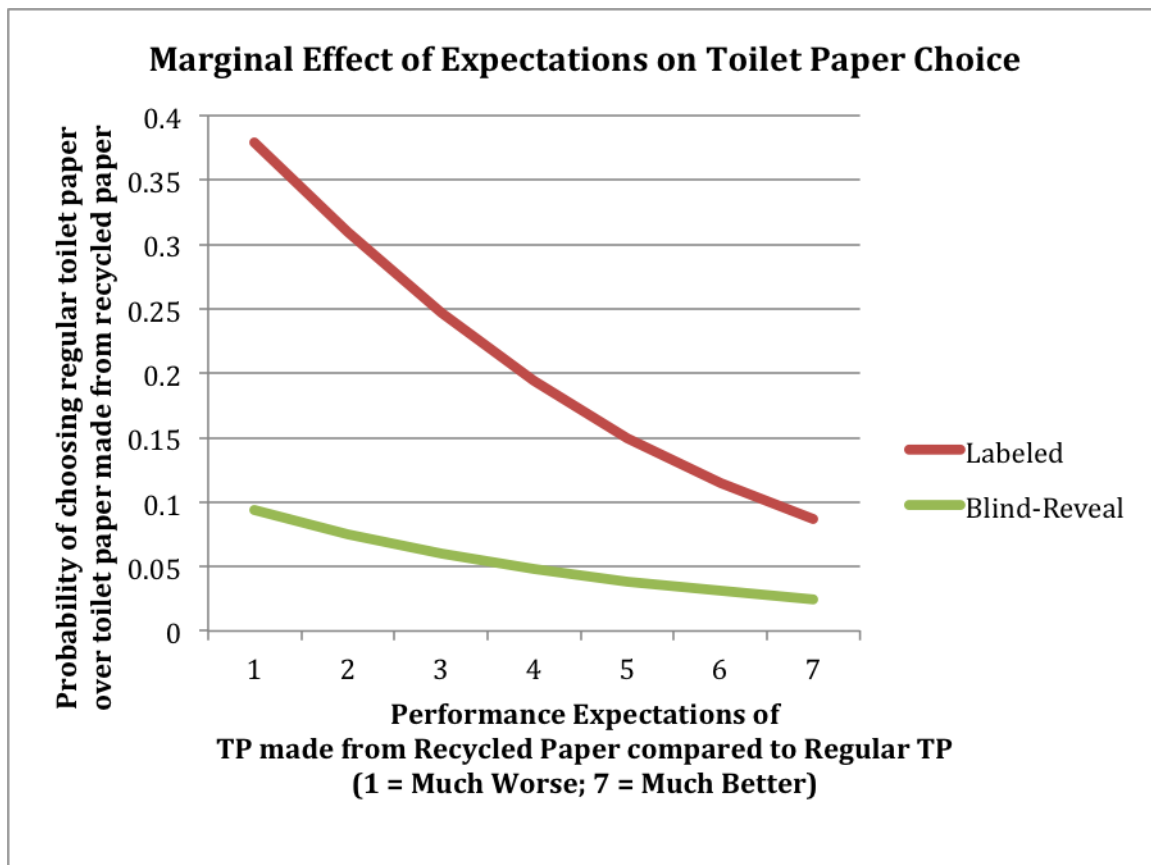


Figure 7: Study 4 - Field Study: Blind Variation with Perception of Eco-Friendly Toilet Paper. Marginal Effect of Expectations on Toilet Paper Choice in Labeled and Blind-Reveal Treatments

more negative perception of the quality of toilet paper when it is labeled as made from recycled paper. By implementing a blind test before revealing the “recycled” label, we eliminate the effect of the bias on product preference. Preference for regular toilet paper over toilet paper made from recycled paper no longer shows any relationship with prior expectations. This suggests that the bias affects how individuals experience the quality of the product.

9 General Discussion

In this manuscript, we proposed a connection between self-perpetuating perceptions of energy efficient products and the energy efficiency gap. We found that those who expected eco-products to perform poorly compared to regular products experienced what they expected and those who expected eco-products to perform better than regular products experienced what they expected (Studies 1, 2, 3, and 4). We demonstrate that the eco-product bias occurs in two very different product categories. The eco-product bias influences perception of light quality for energy efficient compact fluorescent lights (Studies 1 and 2) and of toilet paper softness for toilet paper made from recycled paper (Studies 3 and 4). Expectations influence both perceptual experience and subsequent product preference (Studies 3 and 4).

We find that the influence of the expectations bias on eco-product preference can be eliminated if consumers can test the product without an eco-product label (Study 4). This shows that the bias on product preference is a direct result of the perceptual bias caused by prior expectations of the performance of an eco-product.

We also examine the role of motivation for eco-products to perform well in the perception of eco-product performance and find mixed results (Studies 1, 2, 3, and 4). There are significant differences in the study population between Studies 2 and 3 and Studies 1 and 4, which may contribute the disparate results. We do consistently find that motivation for eco-products to perform well influences product choice (Studies 3 and 4).

Motivation for eco-products to perform well are a strong predictor of ratings of eco-product quality in Studies 2 and 3, which use the same study population (suburban

mall study). This population differs in a number of ways from the populations in Study 1 (online study) and Study 4 (Boston subway study), where motivation had no relationship to ratings of eco-product quality. First, the suburban mall population differs in political ideology from the online population in Study 1 and the Boston subway population in Study 4. While the proportion of conservatives is similar, the proportion of liberals is much lower (21% vs. 61% in the online study and 56% in the Boston subway study). The mall population also appears to be far less political with 38% unable or unwilling to identify their political ideology. Second, the mall population is less educated than the online or Boston subway population. Among the mall study sample, 23% had earned a bachelor's degree and/or graduate degree compared to 41% in the online study sample and 54% in the Boston subway population. Third, the mall sample population may have been more prone to experimental demand. There was far more interaction with the experiment facilitator in the mall experiment than in the South Station experiment or the online experiment.

From these studies, we cannot draw any conclusions about the effect of motivation on perception of eco-products. If the underlying hypothesis is valid, then it is likely that our measure of motivation was flawed. In future studies, it would be better to ask a direct question about the importance of energy efficiency or low environmental impact.

These studies suggest that the slow take-up of eco-products may not simply be due to slow updating of expectations of product performance. When expectations influence actual experience, updating is limited by a recursive problem: poor expectations result in subjectively perceived poor performance, regardless of objective performance. This suggests that eco-products that improve their performance will continue to (mistakenly) be experienced as performing poorly.

This bias has significant implications for economics and environmental policy. Economic theory predicts optimal consumer behavior when the consumer has full information. Our findings suggest that biased perceptual experience prevents consumers from reaching full information, even after they use an eco-product and have the opportunity to experience and evaluate the product's objective attributes. As a

result, consumers may fail to optimize their consumption of eco-friendly products. Significant empirical evidence suggests that eco-products are under utilized. The failure to choose products that have relatively low environmental impact reduces social welfare due to environmental externalities. There is also evidence that for energy-consuming products, the failure to choose energy efficient products may also reduce the welfare of individual consumers. The energy efficiency gap describes the widely documented phenomenon that individuals do not utilize the optimal level of energy efficient appliances, home weatherization, and products [15]. There have been many explanations proposed and explored, but none can fully explain the gap that remains. This study points to a new contributing factor to the energy efficiency gap, and may help us better understand why we have seen sluggish market take-up of eco-friendly products.

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Appendix: Survey Questions

Study 1 - Online Study: Perception of Energy Efficient Lighting

Prior expectations of light performance: “In general, compared to standard incandescent light bulbs do you expect energy efficient compact fluorescent light bulbs to perform worse, about the same, or better?”

- Worse
- About the Same
- Better

Motivation for CFLs to perform well: “If energy efficient compact fluorescent light bulbs performed as well as or better than incandescents, how happy would you be?”

- 5-point numeric scale: 1 labeled “Not at all Happy”, 5 labeled “Very Happy”

Light pleasantness: “On a scale of 1 to 6, how pleasant is the light from the energy efficient compact fluorescent light bulb [incandescent bulb]?”

- 6-point numeric scale: 1 labeled “Not at all Pleasant”, 5 labeled “Very Pleasant”

Study 2 - Field Study: Perception of Energy Efficient Lighting

Prior expectations of light performance: “In general, compared to standard incandescent light bulbs do you expect energy efficient compact fluorescent light bulbs to perform worse, about the same, or better?”

- 7 choices labeled as: Much Worse, Worse, Somewhat Worse, About the Same, Somewhat Better, Better, Much Better

Motivation for CFLs to perform well: “If energy efficient compact fluorescent light bulbs performed as well as or better than incandescents, how happy would you be?”

- 5-point numeric scale: 1 labeled “Not at all Happy”, 5 labeled “Very Happy”

Light pleasantness: “On a scale of 1 to 6, how pleasant is the light from the energy efficient compact fluorescent light bulb [incandescent bulb]?”

- 6-point numeric scale: 1 labeled “Not at all Pleasant”, 5 labeled “Very Pleasant”

Study 3 - Field Study: Perception of Eco-Friendly Toilet Paper

Prior expectations of toilet paper performance: “In general, do you expect toilet paper made from recycled paper to perform worse than, about the same as, or better than regular toilet paper?”

- 7 choices: Much Worse, Worse, Somewhat Worse, About the Same, Somewhat Better, Better, Much Better

Motivation for toilet paper made from recycled paper to perform well: “If toilet paper made from recycled paper performed as well as or better than regular toilet paper, how happy would you be?”

- 5-point numeric scale: 1 labeled “Not at all Happy”, 5 labeled “Very Happy”

Toilet paper softness: “On a scale of 1 to 6, how soft is the toilet paper made from recycled paper [regular toilet paper]?”

- 6-point numeric scale: 1 labeled “Not at all Soft”, 5 labeled “Very Soft”

Toilet paper strength: “On a scale of 1 to 6, how strong is the toilet paper made from recycled paper [regular toilet paper]?”

- 6-point numeric scale: 1 labeled “Not at all Strong”, 5 labeled “Very Strong”

Study 4 - Field Study: Blind variation with Perception of Eco-Friendly Toilet Paper

Prior expectations of toilet paper performance: “In general, how do you expect toilet paper made from recycled paper to perform in comparison to regular toilet paper?”

- 7-point numeric scale: 1 labeled “Much Worse,” 7 labeled “Much Better”

Motivation for toilet paper made from recycled paper to perform well: “If toilet paper made from recycled toilet paper performed better than regular toilet paper, how happy would you be?”

- 7-point numeric scale: 1 labeled “Not at all Happy”, 7 labeled “Very Happy”

Toilet paper softness: “On a scale of 1 to 7, how soft is the toilet paper made from recycled paper [regular toilet paper]?”

- 7-point numeric scale: 1 labeled “Not at all Soft”, 7 labeled “Very Soft”