Management Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Maintaining Beliefs in the Face of Negative News: The Moderating Role of Experience

Bradley R. Staats, Diwas S. KC, Francesca Gino

To cite this article:
Bradley R. Staats, Diwas S. KC, Francesca Gino (2018) Maintaining Beliefs in the Face of Negative News: The Moderating Role of Experience. Management Science 64(2):804-824. https://doi.org/10.1287/mnsc.2016.2640

http://pubsonline.informs.org/journal/mnsc/

MANAGEMENT SCIENCE
Vol. 64, No. 2, February 2018, pp. 804–824
ISSN 0025-1909 (print), ISSN 1526-5501 (online)

Maintaining Beliefs in the Face of Negative News: The Moderating Role of Experience

Bradley R. Staats,[a] Diwas S. KC,[b] Francesca Gino[c]

[a] Kenan-Flagler Business School, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina 27599; [b] Goizueta Business School, Emory University, Atlanta, Georgia 30322; [c] Harvard Business School, Harvard University, Boston, Massachusetts 02163

Contact: bstaats@unc.edu (BRS); diwas.kc@emory.edu (DSK); fgino@hbs.edu (FG)

Received: August 10, 2015
Revised: March 30, 2016; July 18, 2016
Accepted: August 11, 2016
Published Online in Articles in Advance: February 23, 2017

https://doi.org/10.1287/mnsc.2016.2640

Abstract. Many models in operations management involve dynamic decision making that assumes optimal updating in response to information revelation. However, behavioral theory suggests that rather than updating their beliefs, individuals may persevere in their prior beliefs. In particular, we examine how individuals' prior experiences and the experiences of those around them alter their belief perseverance in operational decisions after the revelation of negative news. We draw on an exogenous announcement of negative news by the Food and Drug Administration and explore how it affects interventional cardiologists deciding between two types of cardiac stents. Analyzing 147,000 choices over six years, we find that individuals do respond to negative news by using the focal production tool less often. However, we find that both individuals' own experiences and others' experiences alter their responses. Moreover, although individual and other experience act as substitutes before negative news, we find that this substitution significantly curtails following the negative announcement. Finally, we find that experience leads doctors to discount negative news more rapidly over time. Two lab studies replicate our main findings and show that behavioral biases due to differences in perceptions of expertise drive the effect. Our research contributes not only to operations research but also to the practice of healthcare and operations.

History: Accepted by Serguei Netessine, operations management.
Supplemental Material: The online appendix is available at https://doi.org/10.1287/mnsc.2016.2640.

Keywords: behavioral operations • egocentric bias • empirical operations • experience • healthcare operations

1. Introduction

I feel sure we are as near perfection as experience can direct.
—Robert Scott (Huxley 1913, p. 369)

In 1910, the British explorer Captain Robert Scott launched his second attempt to become the first human to reach the South Pole. Given that he had come within several hundred miles of the Pole on a prior mission and spent subsequent years immersed in Antarctic exploration, Scott was considered likely to accomplish the task. He sailed to his base camp on the Ross Ice Shelf and began preparations. He spent his first season arranging equipment and setting up supply depots. The operational challenges were many, given the hundreds of miles to the Pole and the inhospitable surroundings. During these preparations, Scott learned that explorer Roald Amundsen would have a lengthy head start, that the ponies he'd chosen for the journey were ill-equipped for the polar conditions, and that his team placed their main supply depot in the wrong site. Still, the experienced Scott decided to press on. Having reached the South Pole five weeks after Amundsen, Scott and his entire five-man team died just 11 miles from the next supply depot.

The challenge Scott faced when he received negative news—incorporating the new information and updating his beliefs—is fundamental to the field of operations management. From scientific management (Smiddy and Naum 1954) to the development of analytical models for decision making (Wagner and Whitin 1958) to the empirical examination of processes for enhancement (Fisher and Ittner 1999), the field has a tradition of identifying gaps in prior practice and filling them with new quantitative tools and theory. Although some situations are single period (e.g., newsvendor) or multiperiod but static (e.g., economic order quantity or M/M/c queues), increasingly both the models and the practice they represent are multiperiod and dynamic. As such, decision makers observe the consequences of a particular action and then must use this information to determine their next action. Examples can be seen in many contexts, including labor scheduling (Kesavan et al. 2014, Tan and Netessine 2014), production tool choice (Ramdas et al. 2017), and Bayesian models (Brown et al. 1964) more generally.

However, recent work in behavioral operations, psychology, and economics challenges the notion

that individuals act rationally when updating beliefs (Bendoly et al. 2006, Gino and Pisano 2008). In this paper, we examine how individuals respond to the revelation of negative news, i.e., news that casts doubt on their previous choices, when making subsequent choices. We consider not only negative news but also a central, previously unexamined factor that may affect belief updating: *experience*. Research in operations has focused on the benefits of experience, highlighting how one's own and others' experience may improve performance through better knowledge (e.g., Lapré and Nembhard 2010, Bolton et al. 2012, KC et al. 2013, Arlotto et al. 2014). However, although experience leads to the development of expertise—one's knowledge in a domain (Van Wesep 2016)—unfortunately, expertise may lead an individual to become rooted in existing beliefs even after receiving negative news. Returning to Scott in response to his choice to rely on his expertise, one of his men said, "Sir, I'm afraid you'll come to regret not taking my advice" (Crane 2005, p. 466). Anecdotally, this was true for Scott. In this paper, we ask and answer the following question: How do individual experience and the experience of others affect an individual's response to negative news?

2. Hypotheses Development

2.1. Field Context

Our field study exploits a novel empirical setting, i.e., interventional cardiology and the operational choice of coronary stent (i.e., the production technology that cardiologists use in their work). Here, we examine the decisions of interventional cardiologists who perform percutaneous coronary interventions (PCI), commonly known as angioplasties. PCI is a nonsurgical procedure that treats narrowed arteries of the heart. A candidate for an angioplasty has one or multiple levels of obstruction in the coronary arteries that supply oxygenated blood to the heart muscle. Extensive blockage can lead to limited physiological functioning for the patient and increases the risk of a heart attack. During an angioplasty, a cardiologist inserts an intravenous catheter and guides it to the site of the blockage in the vessel. The catheter is then used to clear the blockage. In many cases, the coronary vessels have an increased likelihood of collapsing following the removal of the arterial blockage. To prevent such a collapse, a cardiac stent (i.e., a hollow, cylindrical metal mesh) is inserted inside the vessel at the location of the blockage; this stent thus serves as a scaffolding to hold the vessel walls in place. This procedure has been used to benefit many patients over the last few decades; initially, bare-metal stents were used. However, even after insertion of the stent, there is a likelihood of a blockage reoccurring at the site of the metal stent (i.e., restenosis).

To reduce the likelihood of restenosis, several medical device companies developed drug-eluting stents, which release small amounts of drugs to prevent the formation of blockages. Procedurally, inserting a drug-eluting stent is similar to inserting a bare-metal stent. When the Food and Drug Administration (FDA) approved drug-eluting stents for marketplace use in April 2003, key stakeholders, including Medicare and the leading private insurance companies, agreed to incur the additional costs of the use of the drug-eluting stents. As such, there was no financial disincentive for physicians to adopt the new stents. Given the procedural similarity of the drug-eluting stents to the existing bare-metal stents, and given the lack of a financial disincentive, the adoption of the drug-eluting stents was rapid and significant, rising to 90% of the entire cardiac stent market in a short period of time (Grines 2008).

However, by the fall of 2006, reports of adverse outcomes, specifically associated with late stent thrombosis (or the formation of blood clots) emerged. So the FDA convened a panel of experts to study the risks of the drug-eluting stents (Grines 2008). The panel concluded that the risks of late stent thrombosis did not offset the benefits of drug-eluting stents, when used appropriately. However, the panel warned that there were greater risks when the stents were used off-label (on patients with more complex conditions). Finally, the FDA noted that it "does not regulate how drug-eluting stents are used by individual clinicians in the practice of medicine" (as cited in Grines 2008, p. 615). Over the next several months after the announcement, the drug-eluting share of the stent market fell from over 90% to around 60% (Naidu 2010).

It is important to note that the FDA did not issue a product recall or take any punitive measures for use of the new stent. The FDA announcement amounted to guidance stating that physicians were best able to understand the risks of the drug-eluting stents and that they should exercise caution, particularly when treating off-label cases. The nature of this announcement permits scholars to answer important questions about how individuals (in this case, interventional cardiologists) respond to negative information. Specifically, to what extent do individuals respond to the news? How does reaction to the news vary across physicians? In particular, is an individual's response tempered by personal experience with the drug-eluting stents? Similarly, cardiologists may view the experience of their peers as (imperfect) substitutes for their own experiences. Therefore, they may be less influenced by the FDA announcement when surrounded by peers with extensive experience with the new stents.

This setting is ideal for examining the hypotheses described below for several reasons. First, for an interventional cardiologist performing a highly specialized task with PCI, it is not always obvious which tool is ideal to use. Therefore, specialists rely on various sources of information, including experts (such as

the FDA), their peers, and their own experience with the product. Our data set allows us to track choices over a six-year period and to examine the impact of past experience on current choice decisions. Second, because the FDA's announcement was not anticipated, it constituted an exogenous shock. As such, this allows us to generate a clean identification for the effect of a negative announcement on technology choice. Finally, cardiac care is a high-volume sector of healthcare, accounting for over a third of all Medicare spending (AHA 2008). According to a report by MediPoint (2014), the coronary stent market in the United States will exceed $5.6 billion by 2020. The sheer economic significance and impact on public health in this setting make it worthy of extensive research.

After analyzing the cardiology data, we turn to the lab. Using lab studies, we gain internal validity, without the external validity the field study provides. In the lab, we seek to conceptually copy the key findings from the field and show that the effect is driven by bias, not rational expectations.

2.2. Belief Perseverance and Negative News

Prior operations research has focused on operational predictors of negative information or how negative information affects subsequent performance. Research in this tradition examines product recalls (Thirumalai and Sinha 2011, Shah et al. 2017), supply chain disruptions (Hendricks and Singhal 2005, Schmidt and Raman 2015) or operational failures (KC et al. 2013). In this paper, we consider how individuals' beliefs persevere in response to negative news.

A number of paradigms can be used to consider how people update beliefs and make decisions. Perhaps the most basic, albeit one with significant theoretical and empirical power, is expected utility (Good 1962). In this framework, individuals seek to maximize, or at least "satisfice," along an outcome (Simon 1959). For example, a doctor considers available information about various medical devices and their potential fit with a given patient and then selects the one that is expected to provide the best result. After receiving negative news, individuals should reassess expected utility by incorporating the new information. Assuming that the negative news does not affect all of the choice set equally—for example, in our field setting, the warning referred to drug-eluting stents, not to the alternative bare-metal stents—then a decision maker would update her calculation of expected utility and potentially change a decision. Prior studies have shown that consumers respond to new knowledge on doctor quality (Cutler et al. 2004), university quality (Pope 2009), and car seat safety (Simonsohn 2011).

Behavioral decision-making research finds that individuals do not always rationally maximize, as seen by work examining the response to others' advice (Bonaccio and Dalal 2006). Several reasons explain why individuals may prefer their prior opinion. First, since individuals have access to their own logic, they may exhibit a preference for the outcome of that logic (Yaniv 2004). Second, individuals may hold to their prior viewpoint and then, when new information is presented, fail to sufficiently adjust (Harvey and Fischer 1997). Third, individuals may prefer their own view, believing it to be more accurate than the information presented by others (Krueger 2003). Finally, when presented with an opposing view, one may show confirmation bias, evaluating negative news using a tougher standard than used with the initial view (Nickerson 1998). Thus, negative news may be, at least partially, rejected.

Despite these behavioral reasons suggesting that people do not follow advice as they should, prior work shows that, on average, individuals respond somewhat to new information, even when it differs from their initial opinion (Cutler et al. 2004, Pope 2009, Simonsohn 2011). With this hypothesis, we extend what is known in consumer choice to the operational decision maker:

Hypothesis 1 (H1). *After receiving negative news about an operational decision, individuals will be less likely to choose the same prior decision.*

2.3. Belief Perseverance, Negative News, and Self-Experience

Although we expect that, on average, individuals will respond to negative news by updating their beliefs and altering their choice, an important question is how an individual's personal experience, or self-experience, affects that choice. Traditionally, the operations management literature has focused on how experience with a task can build expertise, which leads to improved performance. The positive effects of self-experience can be seen in literature on learning curves and decisions in inventory models (e.g., Lapré and Nembhard 2010, Bolton et al. 2012, Arlotto et al. 2014). When one examines the interaction between self-experience and negative news, though, the impact on decisions grows equivocal. There are theoretical reasons suggesting that experienced individuals might be more or less likely than their less experienced counterparts to respond more strongly to negative news. Next, we consider possible effects.

Returning to the expected utility framework, by definition, a more experienced individual will have more knowledge with which to evaluate negative information than a less experienced individual. It is unclear, however, if that knowledge will make an individual more or less likely to persist in a decision. There may be times when greater knowledge allows one to understand that negative news is not as bad it appears. For example, when someone learns that the probability of experiencing a defect in production has increased by an

order of magnitude, he is likely to become concerned. However, an experienced individual who realizes that the base rate is 0.00001% will still respond to the new information but appreciate that it is an unlikely outcome. Alternatively, it is possible that greater knowledge could lead an experienced individual to take negative news even more seriously than a less experienced individual. For example, in casting metal parts, tiny bubbles known as blowholes can occur as defects in the casting. An inexperienced person might assume a small defect is not problematic, while an experienced individual would know that the defect could require that the part be scrapped.

In addition, a less experienced individual may have a greater standard deviation around a possible outcome after receiving negative news, since she should have less certainty about the causal relationships. Assuming the person is even somewhat risk averse, a higher degree of uncertainty is associated with a lower level of utility, as the utility reduction corresponding to the risk premium is higher with a greater uncertainty in possible outcomes. So, an individual with less experience may be more apt to switch to another choice as compared to a more experienced individual. Thus, we expect a stronger reaction to the negative news for the less experienced individual as compared to the more experienced individual.

Turning a behavioral view, the arguments strongly suggest that experienced individuals may discount negative news more than less experienced individuals. The question of how individuals process information is a key area of psychological study. As individuals accrue experience, they build expertise in an area, and this development of expertise shapes how they investigate and interpret negative information. When people receive negative news, they are confronted with two cognitions, i.e., one from their prior world view and a second based on the new information. The presence of these different views creates a state of cognitive dissonance that individuals try to resolve (Festinger 1957). Self-justification theory posits that individuals resolve this dissonance by rationalizing that their prior view was correct (Sleesman et al. 2012). "Like a totalitarian government," writes Krueger (2003), "the ego has been said to shape perception in such a way that it protects a sense of its own good will, its central place in the social world and its control over relevant outcomes (p. 585)." Relatedly, research on escalation of commitment finds that people are likely to continue on the same course of action, even when they receive negative news (Staw 1981, Bazerman et al. 1984, Sleesman et al. 2012).

In Section 2.2, we highlighted four reasons that individuals might show a bias for a prior opinion: (1) access to one's own logic, (2) anchoring, (3) overconfidence, and (4) confirmation bias. Each of these reasons might be exacerbated by the perceptions of expertise that experience creates. First, with expertise, one is likely to view the logical process one followed to be superior to that of a typical outsider. Second, anchoring may prove problematic because the initial decision was made by an expert, not a novice; consequently, the expert may give it even more weight. Third, greater expertise may lead an individual to regard her own outcomes more favorably. Finally, with greater expertise, it is easier to generate counterexamples to the negative news and thus be susceptible to confirmation bias.

Interestingly, the limited empirical literature on the topic shows both positive and negative effects from experience (see Table A1 for more detail). In a questionnaire study, Jeffrey (1992) found that more experienced auditors were less likely to continue a negative course of action than their less experienced counterparts when personally involved in a decision. However, Bragger et al. (2003) found in the lab that when individuals had success with a task six weeks before, they were more likely than a control group to continue on the same path, even after receiving negative news. Note that of the studies in Table A1, only Staw et al. (1997) conducted a field study. They show that when managers change, new managers are more likely to write down the company's loan portfolio; note that this study does not consider a response to negative news, but rather to management changes in general.

Ultimately, this question's answer is an empirical one, but we think it likely that more experience will, on average, increase the odds of continuing with a present choice in the face of negative news as compared to less experience. Thus, we hypothesize the following:

Hypothesis 2 (H2). *After receiving negative news about an operational decision, individuals with more self-experience will be more likely to choose the same prior decision than individuals with less self-experience.*

2.4. Belief Perseverance, Negative News, and Peer Experience

We next consider how others' experience, or what we call peer experience, may affect how individuals update their beliefs in response to negative news. Using the same approach as for an individual's experience, we consider both an expected utility viewpoint and potential behavioral factors. The expected utility model works much as it did in the case above. When others have experience with an operational decision, then a focal individual can benefit from their knowledge to understand any negative news that occurs. The idea of learning from others is well established in the literature on learning in organizations (Reagans et al. 2005, KC et al. 2013). Although peer experience provides a reservoir of knowledge, that knowledge could lead an individual to a greater or lesser change in a decision, as compared to individuals without such access, depending on the context. However, having

access to others' knowledge should, on average, reduce the uncertainty that individuals face and thus yield higher expected utility and consequently a greater likelihood of continuing with a decision.

While the expected utility argument is again somewhat equivocal, the behavioral argument is much less so. A long line of research shows how strongly individuals respond to the expertise and opinions of others. For example, marketing research shows that word of mouth has a strong effect on consumer choice (Godes and Mayzlin 2004). More generally, individuals often respond to pressure from groups. Research finds that individuals change their own opinion to match that of others in the group even if there is no explicit requirement for such unanimity (Janis 1982, Whyte 1993). Typically, this research has occurred in a context of group decision making. However, it is likely the same logic applies to individual decision making in the presence of related others making decisions, as individuals working together have the opportunity to exert pressure on each other, which may lead to social influence or contagion (Sleesman et al. 2012). Together, this suggests that individuals' responses to negative news are likely affected by the expertise generated from the experience of their peers. Thus, we hypothesize the following:

Hypothesis 3 (H3). *After receiving negative news about an operational decision, individuals with more peer experience will be more likely to make the same decision as those around them than individuals around others with less peer experience.*

2.5. Interaction of Self and Peer Experience

Next, we consider the joint effect that individual and other experience may have on an individual's updating of beliefs. We consider the effect in steady state as well as after negative news is received. In steady state, the two are likely to be substitutive. Individuals gain expertise from their own experience with an operational decision, and they have the ability to access knowledge when others around them make an operational decision. The idea that different types of experience may show interactive effects has been examined in literature on learning. For example, Clark et al. (2013) find that individual and organizational customer experience serve as substitutes in learning from customers in outsourced radiology. They argue that each knowledge type is partially duplicative, thus, making the joint learning benefit of the two types of experience less than the sum of the individual learning benefits.

If the two types of experience may have a substitutive relationship in steady state, how might negative news lead to a different relationship? From an expected utility standpoint, it is not clear that it would. The same logic from above applies, as either type of experience could help an individual better understand the implications of negative news. However, it is from a behavioral standpoint that the relationship may change. Prior work examining escalation of commitment has considered either the individual effect or the effect of a group making decisions (Bazerman et al. 1984, Sleesman et al. 2012). Here we apply this logic of both effects to the eventual decision of the individual. As discussed above, individual experience may enhance an egocentric bias that leads to a greater likelihood of choosing the same decision after negative news is received. Greater group experience may reinforce and amplify this effect. Simply put, an individual looking for reasons to self-justify his decision may find it easier to do so when those surrounding him are going through the same process. Thus, the individual's experience and the experiences of others may jointly interact, showing less of a substitutive relationship than before.

These discussions lead to two propositions that we test. Before negative news, we expect an individual's self-experience with an operational decision and peer experience with the same decision to have a substitutive relationship on subsequent decisions (H4A). After negative news, we expect to see a weaker substitutive relationship (H4B).

Hypothesis 4A (H4A). *In steady state, self-experience and peer experience will show a substitutive relationship with the likelihood that the individual makes the same operational decision.*

Hypothesis 4B (H4B). *After receiving negative news about an operational decision, the substitutability of self-experience and peer experience declines.*

2.6. Experience and Discounting Negative News Over Time

Finally, we examine how experience affects the discounting of negative news over time. Little research has studied the long-term effect of information-revelation strategies, given the longitudinal data required. One study, by Allcott and Rogers (2014), found that when individuals received information about how their energy use compared to neighbors, the effect of the news decayed over time, although there was still an effect. Another analog for this topic is learning research that has examined forgetting and found that knowledge decays over time (Agrawal and Muthulingam 2015, Ramdas et al. 2017).

In the present study, we do not ask whether news is discounted over time, as this would be a straightforward expectation given that additional information is accruing. Instead, we ask whether experience affects the discount rate of negative news over time. Beginning with expected utility, it is not clear that experience should impact the rate of discounting. Individuals

with more (less) experience initially would adjust to the negative news, but then the rate of discounting would likely be similar as more time passes.

The question then exists as to whether behavioral biases could lead to differential discounting. Examining the same four drivers as in Sections 2.2 and 2.3—(1) access to own logic, (2) anchoring, (3) overconfidence, and (4) the confirmation bias—it seems that individuals with more experience might be more likely to discount the negative news faster than less experienced individuals. In particular, focusing on items (1) and (4), individuals with more experience may give preference to their own logic and engage in a biased approach to information processing. This may lead them to discount negative information more on an ongoing basis. As more time passes, it grows easier to "forget" the disconfirming information and value the preferred approach and outcome even more. As a result, we hypothesize the following:

Hypothesis 5 (H5). *Individuals with greater self-experience will discount negative news more quickly than those with less self-experience with respect to making the same operational decision.*

3. Study 1: Cardiologists, Stent Selection, and Negative News

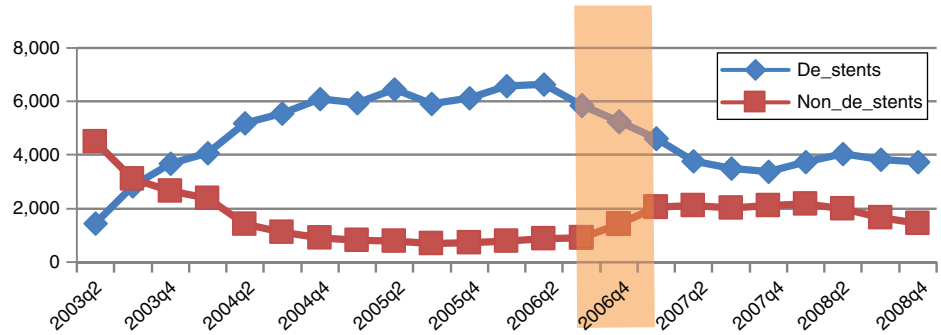
3.1. Data

The data for our study come from the Pennsylvania Health Cost Containment Council (PHC4). The data set consists of all PCI procedures performed in Pennsylvania between 2003 (when the drug-eluting stents (DES) first became available in the marketplace) and 2008. This includes information on a total of 147,010 PCI procedures performed by 399 cardiologists over the six-year period. Our outcome variable of interest is the technology choice of the cardiologists performing the angioplasties; of all the PCI procedures performed during the period of observation, 38,707 involved a bare-metal stent, and 108,303 involved a drug-eluting stent. We observe several sources of patient-level heterogeneity, including demographic factors such as age, gender, and race; we also observe clinical variables, including patient risk and indication of off-label usage. Because 10 patients are missing controls and one hospital had only two procedures, both with the same outcome, these 12 observations are dropped from our full model, leaving us with a sample of 146,998.

Each observation in the data set provides information on the quarter and year in which the procedure was performed. This allows us to account for various temporal sources of heterogeneity, including trends and seasonality. Figure 1 provides a time series of the overall choice of stents (both bare-metal and drug-eluting) during the period of study. The FDA panel convened on December 7–8, 2006, immediately after which the announcement was made. However, there had been earlier reports and studies about potential FDA concerns with the drug-eluting stents around late summer, 2006 (Joner et al. 2006, Park et al. 2006). For this reason, in our primary analyses, we excluded two quarters, which are the periods when the earlier studies became available and when the FDA panel convened (the shaded area in Figure 1). This allows us to generate cleanly demarcated pre- and postintervention periods, with a total of 134,674 observations with non-missing covariates. We see a dramatic drop in the overall market-level adoption of drug-eluting stents that coincides with a significant uptake of bare-metal stents.

There is an unequivocal impact of the FDA panel on the overall choice of the drug-eluting stents; the goal of our study is to quantify the magnitude of this effect. Moreover, because a number of factors are likely to impact the technology choice of stent for any given patient, we obtain patient characteristics, including demographics such as age, gender, and race. In addition, we observe the payer type and hospital where the patient was admitted. We obtained a unique identifier for each operating cardiologist, which allows us to control for various unobserved sources of physician-level heterogeneity. Collectively, these factors are used

Figure 1. (Color online) Total Volumes of Drug-Eluting and Non-Drug-Eluting Stents



Note. The shaded bar denotes when studies on drug-eluting stents became available, leading to the FDA panel meeting convened on December 7–8, 2006.

to control for the physician's choice of the type of stent (drug-eluting or bare-metal).

We also observe a unique sequence number associated with each patient, which allows us to determine the order in which a given physician treated the assigned patient. The combination of the unique physician identifier and the sequence of the patients (along with the technology choice for the patients treated) allow us to track the experience of the physician with the drug-eluting stents (based on their completed procedure volume) over the period of study.

We also observe the hospital in which the cardiologist performed the procedure. This not only allows us to account for the organization-specific drivers of physician choice (using a hospital fixed effect) but also to identify the peers of a given cardiologist. Specifically, for any cardiologist p, we define her peers as the set of cardiologists who practice in the same hospital. One of our hypotheses is that the technology choice of a given physician depends on the choices made by the other cardiologists in her peer group. To estimate the experience of the peers, we define cumulative peer experience by aggregating the experience of drug-eluting stents for all of the peers of a given physician up to a given time t.

Collectively, the aforementioned variables allow us to examine the technology choice by individual physicians in determining the type of stent used in a given patient and the extent to which the decision is affected by their experience with the stent, the experience of their peers with the stent, the FDA panel, and a number of patient-, hospital-, and physician-level factors. Table A2 of the online appendix describes the key variables used in our analysis. Table 1 displays summary statistics and correlations in our sample; Tables A3 and A4 of the online appendix provide these for the pre- and postannouncement period.

3.2. Empirical Analysis Strategy

The goal of our study is to estimate the choice of a cardiologist to use a drug-eluting stent, as compared to its alternative (bare-metal stent), and the extent to which a cardiologist's prior experience with drug-eluting stents, and the experience of peers with the drug-eluting stents, moderates the effect of negative news on the stent decision. In the discussions below, the subscript i denotes the patient, p denotes the physician, h denotes the hospital, and t denotes time. As described earlier, the decision variable we study is the choice to use a drug-eluting stent. Specifically, $DE_{ipht} = 1$ if patient i, who had an angioplasty performed by physician p at hospital h at time t, had a drug-eluting stent inserted, and 0 otherwise. We control for a number of patient-level variables, collectively denoted by the vector $\mathbf{X}_{it}$.

3.2.1. Effect of FDA Announcement.

The identification in our model is driven by the FDA announcement. We denote $POST_t = 1$ for periods that occur after the FDA panel announcement and $POST_t = 0$ for periods preceding it.

To investigate the impact of the FDA announcement on the adoption likelihood, we begin with the following empirical specification:

$$\ln\left[\frac{\Pr(DE_{ipht} = 1 \mid X_{it})}{1 - \Pr(DE_{ipht} = 1 \mid X_{it})}\right] = \alpha + \mathbf{X}_{it}\beta + P_p + H_h + T_t + \gamma, POST_t + \varepsilon_{ipht},$$

where P_p denotes the physician fixed effect. This allows us to account for unobserved physician-level heterogeneity, including reputation, training, and medical background. The hospital fixed effect, denoted by H_h, allows us to account for hospital-specific sources of heterogeneity, including patient mix and geographic considerations. The vector T_t includes temporal factors, including the time period (specifically a unique identifier for the quarter and year of the procedure). The time fixed effects allow us to account for sources of seasonality and trends. The stochastic error term is ε_{ipht}. The vector $\mathbf{X}_{it}$ includes the patient-level control variables, including demographic and risk factors. Our key objective is to estimate γ, which captures the average reduction in odds that a physician will use the drug-eluting stent following the FDA announcement. Hypothesis 1 predicts that $\gamma < 0$.

Table 1. Summary Statistics

	Mean	Std. dev.	(1)	(2)	(3)	(4)	(5)	(6)
1. *DES*	0.736	0.440						
2. *Age*	64.6	11.99	−0.0485***					
3. *Severity*	0.759	0.925	−0.158***	0.2631***				
4. *Off-Label*	0.183	0.387	0.0211	0.0190***	−0.0108***			
5. *Post-Announcement*	0.405	0.491	−0.069***	0.0050	0.0022***	0.3076***		
6. *Self-Experience*	196.7	210.88	0.101***	0.0330***	−0.0913***	0.2179***	0.4853***	
7. *Peer Experience*	1,269.7	1,551.29	0.0559***	0.0237***	−0.0080	0.1742***	0.4328***	0.3738***

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

3.2.2. Effect of Experience. One of our primary explanatory variables is the cumulative volume of procedures performed by physician p at time t (beginning with the study period t_0) using a drug-eluting stent. Specifically, we define the physician's cumulative experience with the drug-eluting stents as follows:

$$SELF_{pt} = \sum_{t'=t_0}^{t} \sum_{i} I_{ipt'},$$

where $I_{ipt} = 1$ if physician p performed an angioplasty on patient i at time t using a drug-eluting stent, and 0 otherwise. To investigate the impact of physician experience on the physician's decision to continue using the technology, we begin with the following empirical specification:

$$\begin{aligned}\ln\left[\frac{\Pr(DE_{ipht}=1 \mid X_{it})}{1-\Pr(DE_{ipht}=1 \mid X_{it})}\right] &= \alpha + \mathbf{X}_{it}\beta + P_p + H_h + T_t + \gamma POST_t + \theta_1 SELF_{pt} \\ &\quad + \theta_2 POST_t \times SELF_{pt} + \varepsilon_{ipht}.\end{aligned}$$

Here, θ_1 provides a baseline effect of the impact of prior experience on the likelihood of a physician continuing to use drug-eluting stents. In estimating the models above, we standardize $SELF_{pt}$ by mean-centering and dividing by the standard deviation. θ_2 provides our estimate for the moderating effect of the physician's prior experience on the relationship between FDA announcement and stent use. Hypothesis 2 predicts that after negative news, an experienced individual will be more likely to continue to use a drug-eluting stent than a less experienced individual. The net effect of experience is based on the combination of baseline self-experience (θ_1) and the postannouncement change of self-experience (θ_2) on the likelihood of using a drug-eluting stent. Thus, the net impact of experience on the likelihood of choice is $\theta_1 + \theta_2\ POST$. Hypothesis 2 postulates that this effect will be positive, i.e., $\theta_1 + \theta_2 > 0$.

As discussed in the hypothesis section, we postulate that a physician may rely on the experience of her peers to substitute for her own experiences with the drug-eluting stents. Our definition of a peer of physician p is any cardiologist who performed an angioplasty at the same hospital where physician p operates. A similar definition of others' experience has been used by related work in the literature (KC and Staats 2012, KC et al. 2013). As such, we construct a variable for the experience of the peers of any given physician as follows:

$$PEER_{pt} = \sum_{t'=t_0}^{t} \sum_{h \in H(p)} \sum_{p' \neq p} \sum_{i} IH_{ip'ht'}.$$

In the specification above, $H(p)$ denotes the set of hospitals where physician p treats patients. $IH_{ip'ht'}$ is a binary variable that is equal to 1 if the peer of physician p performed an angioplasty on patient i at time t using a drug-eluting stent, and 0 otherwise. In determining $PEER_{pt}$, we therefore simply count all incidences of an angioplasty involving a drug-eluting stent performed by peer physicians at the set of hospitals $H(p)$ associated with physician p. To examine the effect of peer experience on a given physician's technology decision, we augment our base model with the following specification:

$$\begin{aligned}\ln\left[\frac{\Pr(DE_{ipht}=1 \mid X_{it})}{1-\Pr(DE_{ipht}=1 \mid X_{it})}\right] &= \alpha + \mathbf{X}_{it}\beta + P_p + H_h + T_t + \gamma POST_t + \theta_1 SELF_{pt} \\ &\quad + \theta_2 POST_t \times SELF_{pt} + \mu_1 PEER_{pt} + \mu_2 POST_t \\ &\quad \times PEER_{pt} + \varepsilon_{ipht}.\end{aligned}$$

Here, μ_1 provides a baseline effect of the impact of a peer experience on the likelihood of a physician continuing to use drug-eluting stents. To facilitate interpretation of the coefficient, we normalize the explanatory variable $PEER_{pt}$ by mean-centering and dividing by the standard deviation. We expect that the peer effect (μ_1) is positive; that is, a physician is more likely to use the stent if her peers also use the product. However, the impact of the experiences of the peers on the likelihood of the physician continuing to use the drug-eluting stent is likely to be moderated by the effect of the FDA announcement during the postannouncement period. Hypothesis 3 predicts that the net effect of peer experience continues to be positive in the postannouncement period; in other words, we expect that the effect of $\mu_1 + \mu_2 > 0$.

3.2.3. Interaction of Self- and Peer Experience. We next examine the interaction effects of self- and peer experience. As postulated in H4A, one's own experience and the experience of peers are likely to serve as substitutes prior to the disclosure of negative news. To examine these effects, we use the following specification:

$$\begin{aligned}\ln\left[\frac{\Pr(DE_{ipht}=1 \mid X_{it})}{1-\Pr(DE_{ipht}=1 \mid X_{it})}\right] &= \alpha + \mathbf{X}_{it}\beta + P_p + H_h + T_t + \gamma POST_t + \theta_1 SELF_{pt} \\ &\quad + \mu_1 PEER_{pt} + \varphi_1 SELF_{pt} \times PEER_{pt} + \varepsilon_{ipht}.\end{aligned}$$

A negative coefficient for φ_1 would provide support for H4A, namely that peer experience and one's own experience with the stent are substitutes.

However, the announcement of the negative news may alter how individuals perceive the role of one's own experience and the experience of their peers. As

discussed in H4B, after the announcement of negative news, the substitutability of self- and peer experience may decline. To examine this possibility, we augment our empirical specification to include the postannouncement interaction terms:

$$\ln\left[\frac{\Pr(DE_{ipht}=1\mid X_{it})}{1-\Pr(DE_{ipht}=1\mid X_{it})}\right] = \alpha + \mathbf{X}_{it}\beta + P_p + H_h + T_t + \gamma POST_t + \theta_1 SELF_{pt} + \theta_2 POST_t \times SELF_{pt} + \mu_1 PEER_{pt} + \mu_2 POST_t \times PEER_{pt} + \varphi_1 SELF_{pt} \times PEER_{pt} + \varphi_2 POST \times SELF_{pt} \times PEER_{pt} + \varepsilon_{ipht}.$$

A positive coefficient for the term φ_2 would provide support for H4B, that individuals start to perceive peer experiences as less effective substitutes for their self-experiences.

3.2.4. Discounting Negative News. Finally, we examine how individuals with varying levels of experience discount negative news over time. We use the following empirical specification to assess the role of time:

$$\ln\left[\frac{\Pr(DE_{ipht}=1\mid X_{it})}{1-\Pr(DE_{ipht}=1\mid X_{it})}\right] = \alpha + \mathbf{X}_{it}\beta + P_p + H_h + \tau TimeSince_t + \theta SELF_{pt} + \mu PEER_{pt} + \vartheta TimeSince_t \times SELF_{pt} + \rho TimeSince_t \times PEER_{pt} + \varepsilon_{ipht}.$$

$TimeSince_t$ is the time transpired (measured in quarters) since the FDA announcement. We look at the number of quarters after the fourth quarter in 2006, which is when the FDA announcement was made. By construction, $TimeSince_t$ takes on only nonnegative values, and so we examine the postannouncement period. $SELF_{pt}$ and $PEER_{pt}$ are the units of cumulative experience for the physician and peers up to time t. A baseline level of discounting of the negative news would suggest a positive value for τ. The discounting of negative news based on experience described in H5 would suggest a positive value for ϑ.

3.3. Results

Table 2 examines the impact of the FDA announcement on the likelihood of physicians continuing to use the drug-eluting stents. We estimated the robustness of this result using various model specifications. Specification 1 provides the baseline effect without the patient-level controls. We find that the estimate is −0.801 ($p < 0.01$); the negative announcement reduces the likelihood of the choice of the drug-eluting stents. The exclusion of the physician fixed effect (specification 2) or the hospital fixed effect (specification 3) has little appreciable impact on the magnitude of the estimates. Specification 4 is the full model, which includes the patient-, physician-, and hospital-level sources of heterogeneity. We find that older patients and patients with a higher level of severity are less likely to be prescribed the drug-eluting stent. Off-label indication, however, does not appear to have a statistically significant impact. We find that the net effect (−0.815, $p < 0.01$) of the announcement is similar to that obtained using the other models. Given that the

Table 2. Effect of Negative Announcement on Choice of Drug-Eluting Stent Using Logistic Regression

	(1)	(2)	(3)	(4)
Hospital fixed effect	Yes	Yes	No	Yes
Physician fixed effect	Yes	No	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Race	No	Yes	Yes	Yes
Gender	No	Yes	Yes	Yes
Payer type	No	Yes	Yes	Yes
Age		−0.0134***	−0.0135***	−0.0136***
				(0.000881)
	—	(0.000876)	(0.000880)	
Severity	—	−1.217***	−1.188***	−1.189***
		(0.0950)	(0.0944)	(0.0948)
Off-Label	—	0.0114	−0.00563	−0.00795
		(0.0205)	(0.0203)	(0.0204)
Post-Announcement	−0.801***	−0.793***	−0.806***	−0.815***
	(0.0514)	(0.0569)	(0.0518)	(0.0519)
Constant	0.565***	1.995***	1.616***	1.373***
	(0.191)	(0.207)	(0.241)	(0.257)
AIC	127,160.6	128,444.5	126,388.9	126,137.8
Number of observations	134,684	134,674	134,686	134,674

Note. Standard errors in parentheses clustered by hospital and time.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Table 3. Moderating Effect of Self- and Peer Experience on Choice of Drug-Eluting Stent Using Logistic Regression

	(1)	(2)	(3)	(4)	(5)
Age	−0.0136***	−0.0137***	−0.0136***	−0.0136***	−0.0136***
	(0.000880)	(0.000880)	(0.000881)	(0.000881)	(0.000880)
Severity	−1.186***	−1.186***	−1.196***	−1.196***	−1.192***
	(0.0948)	(0.0949)	(0.0950)	(0.0951)	(0.0950)
Off-Label	−0.0130	−0.0120	−0.00971	−0.0119	−0.0133
	(0.0204)	(0.0204)	(0.0204)	(0.0205)	(0.0205)
Post-Announcement	−0.808***	−0.810***	−0.798***	−0.801***	−0.794***
	(0.0528)	(0.0528)	(0.0525)	(0.0525)	(0.0530)
Self-Experience	0.526***	0.513***		0.0806**	0.432***
	(0.0833)	(0.0830)		(0.0384)	(0.0822)
Self-Experience × Post-Announcement	−0.363***	−0.364***			−0.300***
	(0.0595)	(0.0594)			(0.0587)
Peer Experience		0.0805***	0.467***	0.451***	0.385***
		(0.0262)	(0.0690)	(0.0688)	(0.0686)
Peer Experience × Post-Announcement			−0.316***	−0.311***	−0.254***
			(0.0502)	(0.0498)	(0.0498)
Constant	1.360***	1.350***	1.402***	1.379***	1.384***
	(0.259)	(0.261)	(0.260)	(0.261)	(0.262)
AIC	125,986.0	125,958.7	126,012.0	125,992.8	125,897.0
Number of observations	134,674	134,674	134,674	134,674	134,674

Notes. Standard errors in parentheses clustered by hospital and time. This table includes fixed effects, but results are not shown for hospital, physician, time, patient race, patient gender, and payer type.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

FDA announcement effectively functions as an exogenous shock, independent of physician-, hospital-, or patient-level considerations, this result in not unexpected. However, the net effect of this announcement—a sizeable 55.7% ($e^{-0.815} - 1$) reduction in the odds of using the drug-eluting stents—constitutes a significant impact on the decisions of interventional cardiologists.

Next, we look at the independent effects of self- and peer experience on response to the announcement. Our models include the physician fixed effects, which allow us to account for physician-specific sources of heterogeneity; in other words, the identification is driven by intraphysician intertemporal variation in the level of experience with the product and the exogenous shock due to the negative announcement. We find (see Table 3, specification 1) that a higher level of self-experience in the absence of the negative announcement increases the likelihood of adoption, as evidenced by the coefficient for *Self-Experience* (0.526, $p < 0.01$). The effect of the FDA announcement is to lower the impact of prior self-experience, as indicated by the negative coefficient for *Self-Experience × Post-Announcement* (−0.363, $p < 0.01$). Because the physician continues to generate experience even after the announcement (in other words, *Self-Experience* continues to increase in the postannouncement period), the net effect of the announcement on adoption is obtained by combining the coefficients corresponding to *Self-Experience* and *Self-Experience × Post-Announcement*. We find that the net difference is 0.163 ($p < 0.05$). Thus, the negative announcement has the effect of attenuating the role of experience; however, a physician with greater experience with the drug-eluting stent is more likely to choose the same prior decision than individuals with less self-experience. All the estimates corresponding to the differences between self-experience and the postannouncement self-experience are positive (specifications 1, 2, and 5). Our logistic regression model and the estimated coefficients allow us to compute the marginal effect of experience on the probability of using the drug-eluting stents as suggested by Ai and Norton (2003). From specification 1, we find that in the preannouncement period, the associated impact of a standard deviation increase in self-experience increases the probability of drug-eluting stent use by 6.3% ($p < 0.01$) on average. In the postannouncement period, the corresponding effect of self-experience is a 2.8% ($p < 0.01$) increase in the probability of adoption on average. That is, self-experience continues to have a positive impact on the likelihood of adoption, even after the announcement, thus supporting H2.

We next examine whether peer experience moderates the impact of the FDA announcement on subsequent stent selection (see Table 3, specifications 3, 4, and 5). We see (specification 3) that the coefficient representing peer experience has a value of 0.467 ($p < 0.01$). On the other hand, the coefficient representing the interaction effect of peer experience and the

Table 4. Interaction Effects of Self- and Peer Experience on Choice of Drug-Eluting Stent Using Logistic Regression

	(1)	(2)	(3)	(4)
Age	−0.0135***	−0.0136***	−0.0137***	−0.0136***
	(0.000880)	(0.000882)	(0.000882)	(0.000881)
Severity	−1.185***	−1.191***	−1.203***	−1.206***
	(0.0950)	(0.0950)	(0.0952)	(0.0953)
Off-Label	−0.00769	−0.0110	−0.00688	−0.00973
	(0.0204)	(0.0205)	(0.0204)	(0.0204)
Post-Announcement		−0.825***	−0.879***	−0.839***
		(0.0518)	(0.0530)	(0.0531)
Self-Experience	0.132***	0.142***	0.198***	0.363***
	(0.0426)	(0.0426)	(0.0424)	(0.0845)
Self-Experience × Post-Announcement				−0.172***
				(0.0619)
Peer Experience	0.147***	0.155***	0.229***	0.525***
	(0.0315)	(0.0311)	(0.0317)	(0.0697)
Peer Experience × Post-Announcement				−0.281***
				(0.0510)
Self-Experience × Peer Experience	−0.0637***	−0.0672***	−0.702***	−0.724***
	(0.0176)	(0.0175)	(0.0765)	(0.0696)
Self-Experience × Peer Experience × Post-Announcement			0.622***	0.685***
			(0.0723)	(0.0650)
Constant	0.458*	1.358***	1.500***	1.533***
	(0.258)	(0.261)	(0.261)	(0.263)
AIC	126,499.5	126,047.8	125,772.7	125,632.0
Number of observations	134,674	134,674	134,674	134,674

Notes. Standard errors in parentheses clustered by hospital and time. This table includes fixed effects, but results are not shown for hospital, physician, time, patient race, patient gender, and payer type.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

announcement is negative (−0.316, $p < 0.01$). The net effect of *Peer Experience* on the adoption decision is 0.151 ($p < 0.05$). This means that although the negative announcement has a tendency to deter continued choice, it is not significant enough to offset the effect of peer experience. These coefficient estimates suggest that following the policy announcement, each standard deviation increase in the experience of peers leads to a 2.6% increase in the probability that a physician uses drug-eluting stents, on average. These results provide support for H3.[1]

Next, we consider the interaction effects of peer and self-experience. In the preannouncement period, the interaction between peer and self-experience has a negative coefficient (see Table 4). The direction of this coefficient is unchanged across specifications 1–3, which vary with the inclusion of the FDA announcement variable. This set of results provides support for H4A, which posits that in the preannouncement period, peer experiences and one's own experiences serve as substitutes.

Columns (3) and (4) explore the effect of the interaction term after implementation of the policy. We find that the coefficient on the interaction term (*Self-Experience × Peer Experience × Post-Announcement*) is positive. In column (4), the magnitude of the coefficient with the three-way interaction terms is 0.685 ($p < 0.1$). To evaluate the net impact of the announcement, self-experiences, and peer experiences, we estimate the marginal impact on the probability of using drug-eluting stents. In the preannouncement period, we find the marginal effect of the self-peer interaction is −9.34% ($p < 0.01$), on average. However, in the postannouncement period, the marginal effect is −1.16% ($p < 0.01$), on average. This difference in the marginal effect is statistically significant and represents a substantial decrease in the substitutability of peer experiences for self-experiences, thus providing support for H4B.

Table 5 explores the effect of time since the FDA announcement quarter (beginning in the first quarter of 2007, measured in units of quarters) on the drug-eluting stent decision. By definition, we can only look at the observations in the postannouncement period. We find that both self-experience and the experience of peers have the effect of increasing the choice of adoption of the drug-eluting stents (specifications 1 and 2). We find that time since announcement has a positive and statistically significant effect (specifications 3 and 4). In other words, individuals gradually discount the negative news over time. Based on specification 4, which includes a number of patient-level controls, we

Table 5. Effect of Time Since Announcement on Choice of Drug-Eluting Stent Using Logistic Regression

	(1)	(2)	(3)	(4)
Hospital fixed effect	Yes	Yes	Yes	Yes
Physician fixed effect	Yes	Yes	Yes	Yes
Race	Yes	Yes	No	Yes
Gender	Yes	Yes	No	Yes
Payer type	Yes	Yes	No	Yes
Age	−0.0135	−0.0136		−0.0136
	(0.0014)***	(0.001)***	—	(0.0014)***
Severity	−1.55	−1.547		−1.551
	(0.197)***	(0.20)***	—	(0.198)***
Off-Label	0.0581	0.0597		0.0551
	(0.0251)***	(0.0238)**	—	(0.025)**
Time Since Announcement	—	—	0.0593	0.0604
			(0.0122)***	(0.0123)**
Self-Experience	0.287	0.1392	−0.659	−0.629
	(0.082)***	(0.073)*	(0.25)***	(0.256)**
Self-Experience × Time Since Announcement	—	—	0.031	0.030
			(0.011)***	(0.0109)***
Peer Experience	—	0.253	−0.414	−0.485
		(0.08)***	(0.334)	(0.335)
Peer Experience × Time Since Announcement	—	—	0.0189	0.0216
			(0.0125)	(0.0125)*
Constant	−1.039	3.290	−0.910	3.377
	(0.567)*	(2.205)	(0.645)	(0.682)***
AIC	56,129.6	56,129.6	51,349.5	50,875.7
Number of observations	43,851	43,851	43,851	43,851

Note. Standard errors in parentheses clustered by hospital and time.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

find that each additional quarter that has elapsed since the announcement is associated with increased odds of 6.2% ($e^{0.0604} - 1$). However, the interaction effect of *Self-Experience* and *Time Since Announcement* is positive (0.030, $p < 0.01$). In other words, in addition to the baseline level of discounting over time, a higher level of experience means that the physician is quicker to discount the negative announcement over time. Similarly, although we did not hypothesize about it, we find an interaction effect between the time since announcement and peer experience (coefficient 0.0216, $p < 0.1$).

We performed several robustness tests to confirm the validity of our findings. We first note that even though the FDA panel convened in December 2006, there had been earlier reports and studies about potential concerns with the drug-eluting stents around late summer 2006 (Joner et al. 2006, Park et al. 2006). For this reason, in our analysis we excluded periods when the reports became available and when the FDA panel convened (the shaded area in Figure 1) to generate clean pre- and postperiods. However, as robustness tests, we added back the earlier excluded periods and report the results in Tables A5 and A6 of the online appendix. We find that these results are similar to our original findings.

Next, we examined whether the percentage of drug-eluting stents (DES) changes over time. Specifically, we considered each quarter as the unit of analysis and estimate the percentage of drug-eluting stents for each quarter of observation. We then track this percentage over time (see Figure A2 of the online appendix). We find that the percentage drops after the announcement. We also examined whether this drop is moderated by the extent of DES experience. Specifically, we model the fraction of drug-eluting stents ($DES\_Fraction_{pt}$) for physician p over time t:

$$\begin{aligned} DES\_Fraction_{pt} = {} & \alpha + H_h + P_p + POST_t + \beta_1 SELF_{pt} \\ & + \beta_2 PEER_{pt} + \beta_3 POST_t \times SELF_{pt} \\ & + \beta_4 POST_t \times PEER_{pt}. \end{aligned}$$

The model includes the hospital and physician fixed effects, (H_h and P_p, respectively). Self- and peer experiences are estimated for the end of the previous quarter. We find (see Table A7 in the online appendix) that the fraction of DES use decreases after the announcement (negative coefficient for *Post-Announcement*, −0.868, $p < 0.01$). However, the announcement is less likely to impact more experienced physicians, as we had hypothesized. Although this aggregate analysis does not allow us to control for individual patient-level factors (including severity levels), the results confirm our earlier findings and further strengthen our earlier results.

Next, to examine the possible impact of patient referral patterns on our results, we obtained data on whether a patient was referred for the procedure by a primary care doctor or another cardiologist. If the patient was referred, this indicates a level of joint medical decision making (about inserting a stent and/or possibly the type of stent) involving a physician who did not perform the procedure. We then estimated our model for these referred patients and find that our hypotheses continue to hold.

Finally, to test whether our results are robust to alternative functional forms, we estimated the specifications in Section 3.2 using linear probability models. Our coefficients are directionally similar and statistically significant, providing further support for our hypotheses.

In our field data, although we observe actions consistent with our hypotheses, we do not have mechanism data to support these hypotheses. This raises the question of whether the discounting of the negative announcement (attributed to experience) is optimal. Should the physicians have discounted the negative news? We examined the effect of patient quality outcomes (measured by postoperative mortality rates and 30-day hospital revisit rates) to estimate the optimality of decisions and did not find a statistically significant impact. Therefore, we now turn to the laboratory to examine our hypotheses in more detail. We first investigate whether greater individual experience leads to belief perseverance in an operational decision following negative news (H2) and then explore whether greater experience from others leads to belief perseverance in an operational decision following negative news (H3).

4. Study 2: Self-Experience, Negative News, and Belief Perseverance

Hypothesis 2 posits that individuals who have more experience are less likely to react to negative news than those who have less experience. We tested this hypothesis using an escalation of commitment paradigm, where participants learn that a previous operational decision they made turned out to be wrong. In this study, we use a paradigm of deciding where to allocate funding in a business. This is a common operational decision that can be found in the research-and-development (R&D) context (Chao et al. 2009) and settings such as capacity allocation (Campbell and Frei 2011). Belief perseverance after negative news in this study is assessed as continuing to invest more money in the same decision even after learning that an alternative course of action would be more beneficial.

A key choice concerns how to model experience in the lab. To conceptually replicate and extend our field results, we need an experience manipulation that taps into similar concepts but that can be done in the short time permitted by lab studies. One choice would be to have individuals repeat the same exercise. Although repetition of an experiment can build knowledge, it is difficult to imagine building the deep expertise and sense of expertise on a topic that exists in the cardiology field study.

However, it is possible to directly manipulate an individual's feelings of expertise, such that she feels more (or less) like an expert when making a decision. Our hypotheses are based, in part, on an individual's self-perception of expertise. When they have a high self-perception of expertise, individuals are more likely to engage in the cognitive biases discussed earlier, as compared to individuals with a lower self-perception of expertise. This self-perception of expertise is naturally generated by cardiologists as they accrue experience; in our lab setting, our experimental design allows us to manipulate the subject's perception of expertise. Our lab study extends the field evidence obtained in Study 1 in another important way: Rather than measuring experience, we directly manipulated a key component of it, i.e., perceptions of expertise, thus allowing us to causally test the prediction that perceived expertise leads people to be less responsive to negative news.

Participants. Three hundred sixty U.S.-based participants on Amazon MTurk (M_{age} = 33.97, SD = 8.84, 54.7% male) engaged in the study in exchange for a $1.50 payment. We calculated our sample size based on an estimate of an effect size $d = 0.3$, requiring a sample size of approximately 350 participants for a study powered at 80%.

Manipulation of Expertise. In this study, we manipulated participants' perceived expertise by asking them to answer easy or difficult multiple-choice questions about finance and investing. This is a commonly used manipulation prior work has used to vary participants' perceived sense of expertise (McKenzie et al. 2008). Participants were randomly assigned to either a condition that asked 15 easy questions or to a condition that asked 15 difficult questions. We pretested questions on a separate sample of 205 MTurk participants who answered 40 questions for $2. We identified easy questions by selecting 15 questions that over 82% of participants answered correctly. We identified difficult questions by selecting 15 questions that between 3% and 23% of participants answered correctly.

Procedure. Participants were told that the study consisted of two different tasks. They first completed the first part of a decision-making task developed by Staw (1976). Participants played the role of financial vice president for a fictional company. In this role, they were asked to choose which of two company divisions should receive $5 million in R&D funds. They reviewed past-earnings data, with which the future

earnings of each division would ostensibly be simulated, and learned that if earnings in their chosen division exceeded earnings in the other division, they would be entered into a lottery in which they could win $20. After making this choice, participants were told that the simulation of financial data would take a few minutes and were asked to complete the second task.

The second task consisted of our expertise manipulation. Half of the participants received 15 easy questions; half received 15 difficult questions. The instructions for answering the questions read as follows:

> In this second task, you will respond to a set of 15 trivia questions. Please only rely on your knowledge to answer these questions. If you are one of the 10 participants chosen at random at the end of the study, you will earn $1 for each correct answer you provide. You will have 40 seconds to answer each question. At the end of 40 seconds, even if you have not answered the question, the computer will automatically advance to the next question. Please try to provide at least your best guess for each question or choose "Don't know" if you do not know the answer, but only give one answer. You are not penalized for wrong answers.

Upon completion of the quiz, participants were shown the correct answers to the quiz together with the answers they had provided so that they could correctly record the number of questions they had answered. They did not receive information on how others performed. They were then asked to indicate how well they felt they had performed on the quiz on a 7-point Likert scale (ranging from 1 = extremely poorly to 7 = extremely well). Using a similar 7-point Likert scale (ranging from 1 = very little to 7 = extremely), they also answered three questions we used as a manipulation check: (1) "How much of an expert do you feel right now?" (2) "How capable do you feel right now?" and (3) "How accomplished do you feel right now?" We averaged participants' answers across these three items to create a measure of perceived expertise that we used in our analyses as a manipulation check ($\alpha = 0.94$).

Next, all participants viewed the results of the simulation of financial data for the next five years, which always indicated that the division not chosen to receive the $5 million in R&D funds had achieved higher earnings. Everyone then learned that $10 million more in R&D funds were now available, and they were asked to choose how to allocate these funds between the two divisions (in any proportion they chose). They further learned that this second investment would also be simulated and could earn them another entry in the $20 lottery. As in Staw (1976), reinvestment in the underperforming division that received the original R&D funds was the primary measure of escalation of commitment. To avoid misleading participants, regardless of investment choice, all participants were entered into the lottery.

Dependent Measure. Reinvestment in the underperforming division was assessed using a multichoice question. Participants were asked to indicate how they would like to allocate the $10 million R&D funding by choosing one of the following 11 options:

- $10 M to industrial products and $0 M to consumer products
- $9 M to industrial products and $1 M to consumer products
- ...
- $0 M to industrial products and $10 M to consumer products

Depending on the first division they chose, the labels of the two divisions varied in the options participants saw. We used participants' answers to this question as the main dependent measure in our analyses. The more participants decided to keep investing in their initial investment decision (after they received information that it led to a poor outcome), the higher their escalation of commitment. Escalation of commitment was assessed on the 1–11 scale above, with 1 representing no investment in the initially chosen products and $10 M in the alternative products (no escalation of commitment), and 11 representing investment of the full $10 M in the initially chosen products (highest level of escalation of commitment).

4.1. Results

Table 6 shows the descriptive statistics of the variables captured in Study 2 by condition.

Manipulation Check. As expected, participants reported feeling they had performed better in the easy-quiz than in the difficult-quiz condition, $t(358) = 35.08$, $p < 0.001$. They also reported feeling more like experts in the easy-quiz condition than in the difficult-quiz condition, $t(358) = 22.62$, $p < 0.001$. When examining actual quiz performance, we found that participants who took the easy quiz answered more questions correctly, on average, than those who took the difficult quiz, $t(358) = 43.66$, $p < 0.001$.

Escalation of Commitment. Consistent with H2, participants with higher perceived expertise (i.e., those in the easy-quiz condition) reinvested larger amounts of money in the underperforming division as compared to participants who felt less like experts (i.e., those in the difficult-quiz condition), $t(358) = 2.78$, $p = 0.006$. Note that the concept of escalation of commitment does not require an individual to invest more money than before, but rather suggests that someone will be more likely to continue on a failed course of action. Thus, expert participants escalated their commitment more than those who felt less expert. This is similar to what we found in our field study. Looking at the response

Table 6. Descriptive Statistics of the Variables Captured in Study 2 (n = 181 High and 179 Low)

	High perceived expertise (i.e., easy questions)	Low perceived expertise (i.e., difficult questions)
Perceived performance on the quiz	6.06 (1.10)	1.98 (1.10)
Perceived expertise	5.15 (1.21)	2.24 (1.23)
Actual performance on the quiz	13.48 (2.39)	3.13 (2.09)
Escalation of commitment	5.73 (2.73)	4.97 (2.43)

Note. Numbers are reported as means followed by standard deviations in parentheses.

values, we see that participants with higher perceived expertise were likely to spend $760,000 more on the worse option than were individuals with lower perceived expertise. For robustness, we also conducted ANOVA analyses using our measure of escalation of commitment as the dependent measure and our expertise manipulation as the independent measure; we controlled for the type of allocation participants chose in round 1 of the decision-making task (consumer versus industrial products). Confirming our main result, we found that participants who felt more like experts showed greater escalation of commitment than those who felt less like experts, $F(1,357) = 8.18$, $p = 0.004$. We note that whether an individual chose the industrial products or consumer products firm in round 1 did not significantly influence their escalation of commitment, $F(1,357) = 2.07$, $p = 0.15$.

4.2. Discussion

Study 2 provides additional support for H2. Individuals with higher perceived expertise are less likely to react to negative news than individuals with lower perceived expertise.

5. Study 3: Peer Experience, Negative News, and Belief Perseverance

Hypothesis 3 suggested that after receiving negative news, individuals who are around others with more experience are more likely to stick to their initial decision than individuals who are around others with less experience because the former are affected by the choice of the perceived expert. That is, we predicted that those around others with more experience would be less likely to react to negative news as compared to individuals around others with less experience. Similar to the approach used in Study 2, we tested this hypothesis using another escalation of commitment paradigm, where participants learned that a previous investment decision they made is likely to be wrong. Reacting to negative news in this study is assessed as continuing to invest more money in the same decision even after learning that not doing so would likely be more beneficial. In addition, to provide further evidence for the effects of perceived expertise, we used a different manipulation of expertise. Rather than asking participants to answer a quiz with questions in the same domain as the decision-making task participants completed afterwards, we used general knowledge questions. This allowed us to test whether even general feelings of being an expert carry over to subsequent tasks.[2] Finally, we chose a different escalation of commitment exercise. This choice provided additional replication power for H2 and also allowed us to manipulate expertise before placing individuals in a group, thus permitting us to more cleanly separate our intended effects. Thus, in this study, participants are presented with a first decision (made by us) and then chose whether to continue or change direction.

Participants. One hundred eighty-nine students from local universities in a city in the Northeastern United States (M_{age} = 22.5, SD = 2.94, 48% male) participated in the study in exchange for a $20 payment. The study was the first in a series of three unrelated studies that kept participants in the lab for an hour. Upon arrival at the laboratory, participants were randomly assigned to a three-person group.

Design. The study included two conditions: a high-expertise condition and a low-expertise condition. Each team was randomly assigned to one of the two conditions.

Procedure. After receiving initial instructions, participants sat in private cubicles in front of a computer and answered demographic questions about their age, race, and gender. Next, the instructions informed them that their first task was to respond to a series of 20 questions individually and that they had 45 seconds to type in an answer to each question. After the 45 seconds, the survey would advance automatically, regardless of whether they had answered the question. There were two versions of the quiz, each with general-knowledge questions: difficult and easy. The easy quiz had questions such as: "In what North American country is the city of Toronto located?" and the difficult quiz included questions such as, "Who is credited with inventing the wristwatch in 1904?" These questions had been pretested in prior research to be easy or difficult to answer correctly (Moore and Healy 2008).

Upon quiz completion, participants were shown the correct answers so that they could record their number of correct answers. Participants also answered a short questionnaire. They first indicated how well they felt they performed on the quiz (from 1 = extremely poorly to 7 = extremely well). They also indicated how much of an expert, how capable, and how accomplished they felt in that moment, using 7-point scales (from 1 = very little to 7 = extremely), as in Study 2. We averaged their answers across these three items to create a measure of perceived expertise ($\alpha = 0.88$), which we used as a manipulation check. Next, the instructions informed participants that they would complete a decision-making task:

> In just a minute, you'll meet with the members of your team to discuss the following situation. Please take a minute or two to read this carefully and think through your answer, and then click on ≫.
> As the president of an airline company, you have invested 10 million dollars of the company's money into a research project. The purpose was to build a plane that would not be detected by conventional radar, in other words, a radar-blank plane. When the project is 90% completed, another firm begins marketing a plane that cannot be detected by radar. Also, it is apparent that their plane is much faster and far more economical that the plane your company is building. The question is: should you invest the last 10% of the research funds to finish your radar-blank plane?

The scenario is an escalation-of-commitment task (Arkes and Blumer 1985). Investing the $1 million, an affirmative response, indicates escalation of commitment despite the initial poor results.

The experimenter handed out a sheet of paper with the problem-solving task on it to each team so that they could discuss the scenario. Team members were asked to indicate their team number and test scores on the paper so that they could identify the person with the highest quiz score, the person with the second-highest quiz score, and the person with the lowest quiz score. We used this procedure to encourage members in the high-expertise condition groups to believe that one of them was an expert. Participants were told that the ranking of their score determined the sequence they would follow in reporting their answers to the decision-making task. In this way, we were able to measure whether group members were affected by the choices of the expert in the high-expertise condition groups and whether this influence was greater than that of the person with the highest score in the low-expertise condition groups. In groups where two group members had the same quiz score, they were asked to randomly decide the order in which those two members would report their answers.

5.1. Results

Manipulation Check. Table 7 presents the study's descriptive statistics. As expected, individuals who took the easy quiz reported feeling they had performed better than those who took the difficult quiz, $t(187) = 10.29$, $p < 0.001$. They also reported feeling more like experts, $t(187) = 7.16$, $p < 0.001$.

Escalation of Commitment. Consistent with H2, a larger percentage of participants with higher perceived expertise (i.e., who took the easy quiz and had the highest score in the high-expertise condition groups) decided to invest the last 10% of the research funds to finish their radar-blank plane (84.4%, 27 out of 32) as compared to participants who had the highest score in groups in the low-expertise condition (i.e., who took the difficult quiz, 58.1%, 18 out of 31), $\chi^2(1, N = 63) = 5.34$, $p = 0.021$.

Influence of the Perceived Expert. Consistent with H3, a larger percentage of group members who had the second-highest score in the high-expertise condition made the same decision as the perceived expert (the group member with the highest score) (87.5%, 28 out of 32) as compared to participants who had the second-highest score in groups in the low-expertise condition (64.5%, 20 out of 31), $\chi^2(1, N = 63) = 4.59$, $p = 0.032$. Similarly, a larger percentage of group members who had the lowest score made the same decision as

Table 7. Descriptive Statistics of the Variables Captured in Study 3 ($n = 32$ Teams High and 31 Teams Low)

	High perceived expertise (i.e., easy questions)	Low perceived expertise (i.e., difficult questions)
Actual performance on the quiz	14.41 (1.24)	5.51 (2.11)
Perceived performance on the quiz	4.81 (0.93)	2.63 (1.12)
Perceived expertise	4.58 (1.01)	3.05 (1.12)
Escalation of commitment by expert (%)	84.4	58.1
Second-highest score copied expert (%)	87.5	64.5
Third-highest score copied expert (%)	90.6	67.7
Number of members that copied expert	1.78 (0.49)	1.32 (0.75)

Note. Numbers are reported as means followed by standard deviations in parentheses (where appropriate).

the perceived expert in the high-expertise condition (90.6%, 29 out of 32) than in the low-expertise condition (67.7%, 21 out of 31), $\chi^2(1, N = 63) = 5.04$, $p = 0.025$.

We also calculated the number of group members who made the same decision as the person with the highest score (0, 1 or 2). As above, this number was higher in the high-expertise condition (M = 1.78, SD = 0.49) than in the low-expertise condition (M = 1.32, SD = 0.75), $t(61) = 2.89$, $p = 0.005$.

To test our effects' robustness, we used the number of group members who made the same decision as the person with the highest score as the dependent measure in an ANOVA with our expertise manipulation and the type of decision the perceived expert made as between-subjects factors. We found a significant main effect for our expertise manipulation, $F(1, 59) = 6.05$, $p = 0.017$, such that more group members were influenced by the decision of the perceived expert in the high-expertise condition than in the low-expertise condition. The main effect of the perceived expert's decision was also significant, $F(1, 59) = 6.36$, $p = 0.014$, such that more group members were influenced by the decision of the perceived expert when she chose to continue investing versus not (M = 1.73, SD = 0.50 versus M = 1.11, SD = 0.83).

5.2. Discussion

The results of Study 3 provide further support for H2, which predicted that individuals with greater perceived expertise would be less likely to react to negative news than those who perceived themselves as having less expertise. Our results also support H3, which predicted that people who are around peers with more experience are more likely to imitate the choice of the perceived experts as compared to those who are around peers with less experience. Given that those who feel they are expert are less likely to react to negative news, those around them show the same tendency, thus making worse decisions than those in groups with less perceived expertise.

6. Discussion and Conclusion

Increasingly, operational decisions occur dynamically over multiple periods. Work examining one or two period settings or multiperiod, static environments finds that individuals behave irrationally for many reasons, including anchoring (Schweitzer and Cachon 2000), anticipated regret (Davis et al. 2011), demand chasing (Kremer et al. 2010), loss aversion (Davis et al. 2014), and incorrectly incorporating relevant information (Croson and Donohue 2006, Kremer et al. 2011). After one moves to a multiperiod, dynamic setting, a new challenge arises. That is, individuals must weigh new information received and update their beliefs if they are to make subsequent decisions that maximize expected utility. Such processes can be seen in many contexts, including labor scheduling (Kesavan et al. 2014, Tan and Netessine 2014), production tool choice (Ramdas et al. 2017), capacity decisions (Campbell and Frei 2011), inventory ordering (van Donselaar et al. 2010), and R&D investment (Chao et al. 2009).

In our paper, we used a field study and two lab studies to explore how individuals update their beliefs when exposed to negative news. Our empirical investigation led to five main findings. First, we find that, overall, individuals do update their beliefs in response to negative news. Following the FDA's cautionary announcement about drug-eluting stents, cardiologists were 56% less likely, on average, to use these stents than before the announcement. Second, we explore one important individual difference in such choices, i.e., experience. Our field setting reveals that cardiologists with more experience are more likely to continue to use drug-eluting stents after negative news than are cardiologists with less experience. In our lab study, we focus on the fact that experience leads to perceptions of expertise and so manipulate perceptions of expertise. We find that individuals with higher perceptions of expertise are less likely to respond to negative news as compared to individuals with lower perceptions of expertise.

Third, we find that peer experience plays an important role in individuals' responses to negative news. Cardiologists surrounded by more experienced peers are more likely to continue using drug-eluting stents than are cardiologists surrounded by less experienced peers. Our lab study shows similar effects of peer expertise. Fourth, we find that the relationship between the interaction of self- and peer experience changes after negative news. Although self- and peer experience are substitutes prior to the negative news, after the negative news this substitutive relationship lessens significantly. Finally, we find that more experienced individuals discount negative news more rapidly than do less experienced individuals.

Each of these five results leads to significant contributions for this paper. The first contribution shows that individuals do in fact update their beliefs after negative news in multiperiod, dynamic settings. Prior research shows that consumers make similar adjustments in their choices (e.g., Simonsohn 2011, Zhao et al. 2011). There is value in extending this baseline result into the operational decision-making setting, given that operational decision makers might be expected to allocate more attention than consumers to a decision and also face significant reputational costs from a decision. Moreover, use of an exogenous shock permits us to show a causal effect that (to our knowledge) has only been found in the literature in Simonsohn's (2011) paper. In addition, documenting the effect size is valuable in better understanding this process. In particular, the size of the finding, 56%, is normatively quite

large and highlights the value to policymakers of sharing negative news with operational decision makers. Our result lends baseline support to standard operations management models that assume that individuals dynamically receive new information and then update their beliefs and make new decisions.

This result suggests a number of opportunities for ongoing work. For example, modeling partial updating is important in analytical research. In empirical research, with careful field data it may be possible to explore how individuals update their beliefs based on new information. In addition, understanding other drivers of belief updating would be worthwhile. Possible variables to explore could include workload (KC and Terwiesch 2009, Tan and Netessine 2014), prior variety in experience (Narayanan et al. 2009, Staats and Gino 2012), or hierarchical role (Tucker 2007, 2016).

Our second contribution examines how individual difference in experience affects belief persistence. While experience is valuable in many settings, here we show that it may add a problematic element to belief updating. Our field results are consistent with the ill effects of egocentric bias, where individuals escalate commitment in response to negative news. Our lab studies allow us to trade external validity for internal validity; thus, we show that feelings of expertise can lead to escalation of commitment after receiving negative news. Work is needed to understand the role of experience in belief updating. For analytical research, this may involve modeling differences across populations in experience. Empirical work can examine whether inadequate updating results in lower rates of learning or instead yields negative learning rates. An unanswered question from our study is how prior successful or failed experience may drive our effect. We control for prior failure and show the same pattern of results. However, future work would benefit from measuring success and failure experience differently: For example, might individuals with only successful experience overcorrect even more?

Third, we incorporate the role of peer experience in individual response. Prior research highlights the social nature of operations. Individuals often perform better when surrounded by familiar others (Huckman et al. 2009, Schultz et al. 2010, Huckman and Staats 2011, Chan et al. 2014). Here we find that peer experiences may prove maladaptive when negative news is shared. Peer experience may provide additional knowledge but may also lead to social pressure that results in suboptimal updating. This creates multiple opportunities for further research. One direction for future work would be to consider the diffusion of experience across an organization and evaluate how different paths and rates alter individual decisions. Empirically, there would be value in considering other contexts and evaluating moderators. This could include an exploration of whether or not individuals have experience working with the others in the group (i.e., team familiarity). Together, our finding suggests that future work must incorporate others' actions in individuals' belief-updating process.

Our fourth contribution consists of exploring the interaction between self-experience and peer experience. Under normal conditions, we find that the two are substitutive, in line with prior learning research (Clark et al. 2013). However, after negative news is shared, we find that this substitution drops dramatically. The lesson is an important one in operating-system design. In this case, after negative news, individuals no longer capture all of the information content possible from those around them.

Our fifth and final contribution shows how experience affects the discounting of negative news. We hypothesize and find that individual experience leads to more rapid discounting of negative news. Extending the updating process over time is an important extension of prior work. Further research is needed to understand how and why experienced individuals discount negative news.

6.1. Limitations

We performed additional analyses to examine whether a negative outcome impacts the stent decision. Specifically, does a patient death impact the future stent choice decision of a cardiologist? In our data, we find that mortality events are rare (0.75%). In addition, in our empirical analysis, we find that such adverse outcomes do not predict stent choice; specifically, the coefficient representing adverse outcomes is not statistically significant in explaining subsequent stent choice. Also, the medical literature on the topic during the period of study appears equivocal on the topic (Camenzind et al. 2006, Eisenstein et al. 2007, Farb and Boam 2007). We therefore believe that the FDA announcement provides the most important explanation for stent choice variation. Specifically, the exogenous shock provides the most significant basis for the updating of physician belief, which then drives stent choice. However, other factors could also play a role in this decision, and future research should seek contexts wherein belief updating and operational performance can be more closely and simultaneously examined. One interesting question would be to consider how manufacturer considerations affect this decision. For example, would promotional efforts lead cardiologists to develop a preference for a particular stent?

A limitation of our field study is that we are able to observe decisions but not their underlying mechanism. In this paper, we overcome this limitation by turning to the lab, where we can more precisely investigate a causal pathway. Still, future work directly measuring

the mechanism in the field would be valuable. In general, in the lab we lose external validity in exchange for internal validity. The combination of lab and field data helps to address this loss, but future work that implements field experiments to address both concerns would be valuable. Finally, we manipulate perceptions of expertise, rather than experience directly in our lab study. We think this choice is appropriate, as we cannot directly manipulate experience to provide a similar level of expertise to match that in the field study. Therefore, we choose to manipulate perceived expertise with domain (in this case, investing) and general knowledge questions. However, if future work can find ways to directly manipulate experience or, even better, find ways to manipulate news and measure mechanisms directly in the field, even more could be learned.

6.2. Managerial Implications

Our study has important implications for both medical professionals and operations managers, more generally, as they think about how to help individuals update beliefs in an uncertain world. The good news is that individuals do update their beliefs after the announcement of negative news. In our field context, we see an average change of 56%. This suggests that managers and policymakers should clearly communicate negative news that occurs in operating environments to facilitate better decisions.

However, our findings show that simply presenting new negative information should not be taken as a panacea. Managers must be prepared for challenges in belief persistence. A necessary step is to understand where differences in belief updating may occur. Assuming that all individuals will similarly update their beliefs is wrong. While data analytical tools may reveal important new information for decision making, and operations management models may yield better decision-making algorithms, our work shows that these approaches do not operate in a vacuum. Rather, it is also important to incorporate behavioral work to design decision settings that present the necessary information, along with tools for interpreting it in ways that help decision makers respond successfully. People have the capacity to make excellent decisions, however, individuals are not algorithms and so the strengths and weaknesses of individual decision makers must be factored into system design.

Our research shows that managers must be prepared to address experienced individuals differently from those less inexperienced. Managerial awareness is one step, but managers also will need to design interventions. These interventions could include educating experienced individuals about the risk or engaging them in perspective-taking exercises to clarify how a less experienced person might understand the situation better. Experienced individuals may need to be encouraged to directly pursue additional disconfirming information. As a way to provide learning, managers could share stories of experienced individuals who changed their perspective. Also, our result on the discounting that occurs over time suggests that, counterintuitively, managers might need to share negative news more frequently with experienced individuals than they do with inexperienced individuals.

In addition, when working with experienced groups, managers must be aware that peer experience may alter individuals' decisions. Sharing this danger with groups may help, but managers must also think about operational system design when communicating information, and then monitoring and supporting subsequent decisions. For example, they might ask groups to assign a "devil's advocate" to argue in support of the negative news (perhaps even placing the expert in that role). Overall, managers must incorporate data, models, and behavior to improve their operations and make better decisions. Behavioral operations management is a valuable approach for tackling these topics.

6.3. Conclusion

Dynamic operations models rely on individuals to update their beliefs based on new information. In this paper, we investigate that process in the field and the lab. We find that although individuals do respond to negative news, how they do so is influenced by self-experience, peer experience, and their interaction. Addressing such biases is important for operational scholars in the development of analytical models, operating managers involved in system design, and everyday decision makers.

Acknowledgments

The authors thank Ryan Buell, Rachel Croson, Andrew Davis, Uri Simonsohn, and Tom Tan for insightful comments that helped develop this work. The authors also thank the department editor, the associate editor, and three reviewers for their developmental suggestions during the review process. Any errors are the responsibility of the authors. The Pennsylvania Health Care Cost Containment Council (PHC4) is an independent state agency responsible for addressing the problem of escalating health costs, ensuring the quality of healthcare, and increasing access to healthcare for all citizens. Although PHC4 has provided data for this study, PHC4 specifically disclaims responsibility for any analyses, interpretations, or conclusions herein.

Endnotes

[1] Interaction plots for H2 and H3 are provided in the online appendix.

[2] We also conducted Study 2 using general knowledge questions and generated the same pattern of results.

References

Agrawal A, Muthulingam S (2015) Does organizational forgetting affect vendor quality performance?—An empirical investigation. *Manufacturing Service Oper. Management* 17(3):350–367.

AHA (2008) American Hospital Association Annual Survey of Hospitals, American Hospital Association, Chicago.

Ai C, Norton EC (2003) The interaction terms in logit and probit models. *Econom. Lett.* 80(123–129).

Allcott H, Rogers T (2014) The short-run and long-run effects of behavioral interventions: Experimental evidence from energy conservation. *Amer. Econom. Rev.* 104(10):3003–3037.

Arkes H, Blumer C (1985) The psychology of sunk cost. *Organ. Behav. Human Decision Processes* 35(1):124–140.

Arlotto A, Chick SE, Gans N (2014) Optimal hiring and retention policies for heterogeneous workers who learn. *Management Sci.* 60(1):110–129.

Bazerman MH, Giuliano T, Appelman A (1984) Escalation of commitment in individual and group decision making. *Organ. Behav. Human Decision Processes* 33(2):141–152.

Bendoly E, Donohue K, Schultz KL (2006) Behavior in operations management: Assessing recent findings and revisiting old assumptions. *J. Oper. Management* 24(6):737–752.

Bolton GE, Ockenfels A, Thonemann UW (2012) Managers and students as newsvendors. *Management Sci.* 58(12):2225–2233.

Bonaccio S, Dalal RS (2006) Advice taking and decision-making: An integrative literature review, and implications for the organizational sciences. *Organ. Behav. Human Decision Processes* 101(2):127–151.

Bragger JD, Hantula DA, Bragger D, Kirnan J, Kutcher E (2003) When success breeds failure: History, hysteresis, and delayed exit decisions. *J. Appl. Psych.* 88(1):6–14.

Brown GW, Lu JY, Wolfson RJ (1964) Dynamic modeling of inventories subject to obsolescence. *Management Sci.* 11(1):51–63.

Camenzind E, Steg G, Wijns W (2006) Safety of drug-eluting stents: A meta-analysis of 1st generation DES programs. Presentation, European Society of Cardiology 2006 World Congress, September 2–6, Barcelona.

Campbell D, Frei FX (2011) Market heterogeneity and local capacity decisions in services. *Manufacturing Service Oper. Management* 13(1):2–19.

Chan TY, Li J, Pierce L (2014) Compensation and peer effects in competing sales teams. *Management Sci.* 60(8):1965–1984.

Chao R, Kavadias S, Gaimon C (2009) Revenue driven resource allocation and effective NPD portfolio management. *Management Sci.* 55(9):1556–1569.

Clark JR, Huckman RS, Staats BR (2013) Customer specificity and learning: Evidence from outsourced radiological services. *Organ. Sci.* 24(5):1539–1557.

Crane D (2005) *Scott of the Antarctic: A Life of Courage, and Tragedy in the Extreme South* (HarperCollins, London).

Croson R, Donohue K (2006) Behavioral causes of the bullwhip effect and the observed value of inventory of information. *Management Sci.* 52(3):323–336.

Cutler DM, Huckman RS, Landrum MB (2004) The role of Information in medical markets: An analysis of publicly reported outcomes In cardiac surgery. *Amer. Econom. Rev.* 94(2): 342–346.

Davis AM, Katok E, Kwasnica AM (2011) Do auctioneers pick pptimal reserve prices? *Management Sci.* 57(1):177–192.

Davis AM, Katok E, Santamaría N (2014) Push, pull, or both? A behavioral study of how the allocation of inventory risk affects channel efficiency. *Management Sci.* 60(11):2666–2683.

Eisenstein EL, Anstrom KJ, Kong DF, Shaw LK, Tuttle RH, Mark DB, Kramer JM, et al. (2007) Clopidogrel use and long-term clinical outcomes after drug-eluting stent implantation. *JAMA* 297(2):159–168.

Farb A, Boam A (2007) Stent thrombosis redux-The FDA perspective. *N. Engl. J. Med.* 356(10):984–987.

Festinger L (1957) *A Theory of Cognitive Dissonance* (Stanford University Press, Stanford, CA).

Fisher ML, Ittner CD (1999) The impact of product variety on automobile assembly operations: Empirical evidence and simulation analysis. *Management Sci.* 45(6):771–786.

Gino F, Pisano GP (2008) Toward a theory of behavioral operations. *Manufacturing Service Oper. Management* 10(4):676–691.

Godes D, Mayzlin D (2004) Using online conversations to study word-of-mouth communication. *Marketing Sci.* 23(4):545–560.

Good IJ (1962) How rational should a manager be? *Management Sci.* 8(4):383–393.

Grines CL (2008) Off-label use of drug-eluting stengs: Putting it in perspective. *J. Amer. College Cardiology* 51(6):615–617.

Harvey N, Fischer I (1997) Taking advice: Accepting help, improving judgment, and sharing responsibility. *Organ. Behav. Human Decision Processes* 70(2):117–133.

Hendricks KB, Singhal VR (2005) An empirical analysis of the effect of supply chain disruptions on long-run stock price performance and equity risk of the firm. *Production Oper. Management* 14(1):35–52.

Huckman RS, Staats BR (2011) Fluid tasks and fluid teams: The impact of diversity in experience and team familiarity on team performance. *Manufacturing Service Oper. Management* 13(3): 310–328.

Huckman RS, Staats BR, Upton DM (2009) Team familiarity, role experience, and performance: Evidence from Indian software services. *Management Sci.* 55(1):85–100.

Huxley L (1913) *Scott's Last Expedition, Volume I: Being the Journals of Captain R.F. Scott, R.N., C.V.O.* (Smith Elder & Company, London).

Janis IL (1982) *Groupthink: Psychological Studies of Policy Decisions and Fiascoes* (Houghton Mifflin, Boston).

Jeffrey C (1992) The relation of judgment, personal involvement, and experience in the audit of bank loans. *Accounting Rev.* 67(4): 802–819.

Joner M, Finn AV, Farb A, Mont EK, et al. (2006) Pathology of drug-eluting stents in humans: Delayed healing and late thrombotic risk. *J. Amer. College Cardiology* 48(1):193–202.

KC D, Staats BR (2012) Accumulating a portfolio of experience: The effect of focal and related experience on surgeon performance. *Manufacturing Service Oper. Management* 14(4):618–633.

KC D, Terwiesch C (2009) Impact of workload on service time and patient safety: An econometric analysis of hospital operations. *Management Sci.* 55(9):1486–1498.

KC D, Staats BR, Gino F (2013) Learning from my successes and others' failure: Evidence from minimally invasive cardiac surgery. *Management Sci.* 59(11):2435–2449.

Kesavan S, Staats BR, Gilland WG (2014) Labor-mix and volume flexibility: Evidence from a retailer. *Management Sci.* 60(8): 1884–1906.

Kremer M, Minner S, Van Wassenhove LN (2010) Do random errors explain newsvendor behavior? *Manufacturing Service Oper. Management* 12(4):673–681.

Kremer M, Moritz B, Siemsen E (2011) Demand forecasting behavior: System neglect and change detection. *Management Sci.* 57(10):1827–1843.

Krueger JI (2003) Return of the ego–Self-referent information as a filter for social prediction: Comment on Karniol (2003). *Psych. Rev.* 110(3):585–590.

Lapré MA, Nembhard IM (2010) Inside the organizational learning curve. *Foundations Trends Tech., Inform. Oper. Management* 4(1): 1–103.

McKenzie CRM, Liersch MJ, Yaniv I (2008) Overconfidence in interval estimates: What does expertise buy you? *Organ. Behav. Human Decision Processes* 107:179–191.

MediPoint (2014) *Coronary Stents—U.S. Analysis and Market Forecasts* (GlobalData, New York).

Moore DA, Healy PJ (2008) The trouble with overconfidence. *Psych. Rev.* 115(2):502–517.

Naidu SS (2010) Three years since the FDA advisory panel on drug-eluting stents: What have we learned about off-label use and stent thrombosis? *J. Invasive Cardiology* 22(1):20–21.

Narayanan S, Balasubramanian S, Swaminathan JM (2009) A matter of balance: Specialization, task variety, and individual learning in a software maintenance environment. *Management Sci.* 55(11):1861–1876.

Nickerson RS (1998) Confirmation bias: A ubiquitous phenomenon in many guises. *Rev. General Psych.* 2(2):175–220.

Park D-W, Park S-W, Park K-H, Lee B-K, Kim Y-H, Lee CW, Hong M-K, Kim J-J, Park S-J (2006) Frequency of and risk factors for stent thrombosis after drug-eluting stent implantation during long-term follow-up. *Amer. J. Cardiology* 98(3):352–356.

Pope DG (2009) Reacting to rankings: Evidence from "America's Best Hospitals and Colleges." *J. Health Econom.* 28(6):1154–1165.

Ramdas K, Saleh K, Stern S, Liu H (2017) Variety and experience: Learning and forgetting in the use of surgical devices. *Management Sci.*, ePub ahead of print August 2, https://doi.org/10.1287/mnsc.2016.2721.

Reagans R, Argote L, Brooks D (2005) Individual experience and experience working together. *Management Sci.* 51(6):869–881.

Schmidt W, Raman A (2015) When supply-chain disruptions matter. HBS Working Paper 13-006, Harvard Business School, Boston.

Schultz KL, Schoenherr T, Nembhard D (2010) An example and a proposal concerning the correlation of worker processing times in parallel tasks. *Management Sci.* 56(1):176–191.

Schweitzer ME, Cachon GP (2000) Decision bias in the newsvendor problem with a known demand distribution: Experimental evidence. *Management Sci.* 46(3):404–420.

Shah R, Ball GP, Netessine S (2017) Plant operations and product recalls in the automotive Industry: An empirical investigation. *Management Sci.* 63(8):2439–2459.

Simon HA (1959) Theories of decision-making in economics and behavioral science. *Amer. Econom. Rev.* 49(3):253–283.

Simonsohn U (2011) Lessons from an "Oops" at Consumer Reports: Consumers follow experts and ignore invalid information. *J. Marketing Res.* 48(1):1–12.

Sleesman DJ, Conlon DE, McNamara G, Miles JE (2012) Cleaning up the big muddy: A meta-analytic review of the determinants of escalation of commitment. *Acad. Management J.* 55(3):541–562.

Smiddy HF, Naum L (1954) Evolution of a "science of managing" in America. *Management Sci.* 1(1):1–31.

Staats BR, Gino F (2012) Specialization and variety in repetitive tasks: Evidence from a Japanese bank. *Management Sci.* 58(6): 1141–1159.

Staw BM (1976) Knee-deep in the big muddy: A study of escalating commitment to a chosen course of action. *Organ. Behav. Human Decision Processes* 16(1):27–44.

Staw BM (1981) The escalation of commitment to a course of action. *Acad. Management Rev.* 6(4):577–587.

Staw BM, Barsade SG, Koput KW (1997) Escalation at the credit window: A longitudinal study of bank executives' recognition and write-off of problem loans. *J. Appl. Psych.* 82(1):130–142.

Tan TF, Netessine S (2014) When does the devil make work? An empirical study of the impact of workload on server's performance. *Management Sci.* 60(6):1574–1593.

Thirumalai S, Sinha KK (2011) Product recalls in the medical device industry: An empirical exploration of the sources and financial consequences. *Management Sci.* 57(2):376–392.

Tucker AL (2007) An empirical study of system improvement by frontline employees in hospital units. *Manufacturing Service Oper. Management* 9(4):492–505.

Tucker AL (2016) The impact of workaround difficulty on frontline employees' response to operational failures: A laboratory experiment on medication administration. *Management Sci.* 62(4): 1124–1144.

van Donselaar K, Gaur V, van Woensel T, Broekmeulen R, Fransoo J (2010) Ordering behavior in retail stores and implications for automated replenishment. *Management Sci.* 56(5):766–784.

Van Wesep ED (2016) The quality of expertise. *Management Sci.* 62(10):2937–2951.

Wagner H, Whitin T (1958) Dynamic version of the economic lot size model. *Management Sci.* 5(1):89–96.

Whyte G (1993) Escalating commitment in individual and group decision making: A prospect theory approach. *Organ. Behav. Human Decision Processes* 54(3):430–455.

Yaniv I (2004) Receiving other people's advice: Influence and benefit. *Organ. Behav. Human Decision Processes* 93(1):1–13.

Zhao Y, Zhao Y, Helsen K (2011) Consumer learning in a turbulent market environment: Modeling consumer choice dynamics after a product-harm crisis. *J. Marketing Res.* 48(2):255–267.