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Risk as Feelings in the Effect of Patient Outcomes on Physicians' Subsequent Treatment Decisions: A Randomized Trial and Manipulation Validation

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Abstract

The present study tested predictions derived from the *Risk as Feelings* hypothesis about the effects of prior patients' negative treatment outcomes on physicians' subsequent treatment decisions. Two experiments at The University of Chicago, U.S.A., utilized a computer simulation of an abdominal aortic aneurysm (AAA) patient with enhanced realism to present participants with one of three experimental conditions: AAA rupture causing a watchful waiting death (WWD), perioperative death (PD), or a successful operation (SO), as well as the statistical treatment guidelines for AAA. Experiment 1 tested effects of these simulated outcomes on (n=76) laboratory participants' (university student sample) self-reported emotions, and their ratings of valence and arousal of the AAA rupture simulation and other emotion inducing picture stimuli. Experiment 2 tested two hypotheses: 1) that experiencing a patient WWD in the practice trial's experimental condition would lead physicians to choose surgery earlier, and 2) experiencing a patient PD would lead physicians to choose surgery later with the next patient. Experiment 2 presented (n=132) physicians (surgeons and geriatricians) with the same experimental manipulation and a second simulated AAA patient. Physicians then chose to either go to surgery or continue watchful waiting. The results of Experiment 1 demonstrated that the WWD experimental condition significantly increased anxiety, and was rated similarly to other negative and arousing pictures. The results of Experiment 2 demonstrated that, after controlling for demographics, baseline anxiety, intolerance for uncertainty, risk attitudes, and the influence of simulation characteristics, the WWD experimental condition significantly expedited decisions to choose surgery for the next

patient. The results support the *Risk as Feelings* hypothesis on physicians' treatment decisions in a realistic AAA patient computer simulation. Bad outcomes affected emotions and decisions, even with statistical AAA rupture risk guidance present. These results suggest that bad patient outcomes cause physicians to experience anxiety and regret that influences their subsequent treatment decision-making for the next patient.

Introduction

There is a growing appreciation that decisions involving risk, such as those concerning surgical treatment for life-threatening medical problems, are not solely based on cognitive analysis of options but are also impacted by emotions linked to past experiences. For decades, the “availability heuristic” provided explanation for why easily remembered events lead to subjective overestimates of the future likelihood of those events (Carrol, 1978; Schwarz et al., 1991; Tversky & Kahneman, 1973, 1974). Subsequent research suggests that dramatic and visually-based mental exemplars cause elevated probability estimates of bad outcomes. These findings have led to the development of the “affect heuristic” (Finucane et al., 2000; Slovic et al., 2002) and in the past decade the conception of “Risk as Feelings”. “Risk as feelings refers to our fast, instinctive and intuitive reactions to danger” and has been shown to be a companion to “Risk as Analysis” (Slovic et al., 2004). Described as emotions or “visceral factors”, affective states have been observed to influence decision making and can supersede information-based goals (Loewenstein, 1996; Loewenstein et al., 2001). Risk-related emotions can cause decision making to diverge from cognitive-based assessments of risk when responses to risky situations decisions result in part from sub-cortical emotional influences, including feelings such as worry, fear, dread, or anxiety. Decision makers cognitively evaluate risky alternatives on the probability and desirability of associated consequences. Cognitive evaluations impact affective states, and affective states reciprocally influence cognitive judgment. Because their determinants are different, emotional reactions to risks can diverge from cognitive evaluations of the same risks (Loewenstein et al., 2001). But the affect heuristic is not without counter-examples. The Risk as Feelings portion of the model does not provide additional predictive power beyond that provided by the Theory of Planned Behavior, in the case of students' intention to have back surgery in a hypothetical scenario (Kobbeltvedt & Wolff, 2009). It is thus currently unclear under what decision scenarios Risk as Feelings effects come into play.

Regardless, a theoretical framework has emerged in which risk appears to have two primary mechanisms affecting decision making: Risk as Analysis brings logical deliberation to bear when making a decision and Risk as Feelings influences decision making through instinctive reactions to danger (Slovic et al., 2005). We believe that poor patient treatment outcomes can lead physicians to experience regret and subsequent desire to avoid such regret in the future. This desire to avoid regret impacts physicians' emotions and decision making. The influence of decision makers' affective states on medical decisions has been theoretically outlined, but it has not been thoroughly tested and is not well understood (Connolly & Reb, 2005; Loewenstein, 2005). A more thorough understanding of how affect can influence decisions in medicine and surgery would be beneficial to clinicians and their patients who are faced with difficult decisions.

Accordingly, we hypothesize that bad patient outcomes, particularly Abdominal Aortic Aneurysms (AAA) ruptures, cause surgeons to experience regret and anxiety about future decisions leading to a divergence from evidence-based guidelines in a predicted direction.

Abdominal Aortic Aneurysm

The treatment of expanding asymptomatic AAA, a “ballooning” in the aorta, exemplifies an important decision problem involving competing risks. The increase in the use of modern scanning technology over the past decade has led to a higher asymptomatic AAA detection rate (Thompson, 2002). Asymptomatic patients, with an incidentally found AAA, present to their physicians a series of decisions between undergoing risky surgery and continuing surveillance of a slowly expanding AAA.

Surgeons have noted that learning *when* to operate for AAA is often more difficult than learning *how* to operate, as currently available algorithms fail to provide accurate predictions of mortality and morbidity in 20% to 25% of cases and are not sufficiently reliable to completely guide experienced clinicians' decisions. Consequently, surgeons usually rely to some degree on their own judgments of risks and relevant predictive information, which means they can be influenced by both their experiential and analytic decisional processes (Fillinger, 2007).

Both experiments presented here utilized a computer-based AAA simulation programmed with statistics from the risk of the open resection procedure and rupture rates observed from surveillance of expanding aneurysms. Open resection has a reported perioperative mortality rate of approximately 5% (Hallin et al., 2001). The average annual AAA expansion range is 0.2 to 0.4 cm (Nevitt et al., 1989). The overall mortality rate for patients with a ruptured AAA is 65 to 85% (Kniemeyer et al., 2000). At 5.5 cm, the risk of AAA rupture surpasses the perioperative mortality risk (Nevitt et al., 1989). Consequently the published guideline recommends surgery for patients with asymptomatic AAA of 5.5 cm or larger (Brewster et al., 2003). But with significant variance in outcomes around the 5.5 cm size and the uncertainty of other relevant predictors, surgeons are often left to make a judgment call; it is not clear that surgeons optimally select which patients should choose surgery and when they should receive it. Previous research has shown that surgeons cannot reliably estimate patients' risk of surgical complications in lung resection (Ferguson et al., 2010).

Furthermore, a systematic review of the surgical literature showed substantial divergence from risk guidelines (Tubbs et al., 2006). Our findings from experiments using more abstract and less detailed versions of the AAA problem suggest that previous patient outcome systematically impacts subsequent treatment decisions (Dale et al., 2006; Hemmerich et al., 2007). Without strict adherence to guidelines, AAA treatment decisions are still a question of the appropriate timing of surgery for an individual patient, so the room for physician judgment opens the door for Risk as Feelings, in addition to Risk as Analysis. The key research question is: “if physicians who are provided with the statistically specified risks associated with their options do not strictly follow these guidelines, then do Risk as Feelings factors influence their decisions?”

Surgical Decisions

We hypothesize that negative patient outcomes, like an AAA rupture during watchful waiting, cause physicians regret and anxiety, which can impact their subsequent AAA treatment decisions. The physicians' anxiety might influence them to choose surgery earlier to avoid rupture with the next patient. The impact of bad patient outcomes has been observed among surgical physicians queried after an operative mortality. These physicians expressed a desire for guidance and consultation before returning to the operating room for the next patient (Goldstone et al., 2004). The above findings, along with the Risk as Feelings Hypothesis, motivate our hypothesis that deciding when to stop surveillance of an expanding AAA and proceed with surgery is influenced by physicians' anxiety about future bad outcomes. Because physicians make repeated decisions for many different patients during AAA surveillance, there are many opportunities for previous treatment outcomes to influence their decisions. However, no data are available that illuminate whether previous bad patient outcomes, regret, and anxiety impact physicians' treatment decisions about surgical treatment.

We have gleaned some support for our hypothesis about this decision process. Our previous experiments utilized the abstract statistical structure of the expanding AAA problem that is used in the current studies, but the previous experiments did not implement extensive realistic detail and only measured effects on decision making, not emotion. Using an abstracted version of the AAA decision simulation, in which the same statistical risks regarding rupture and surgical mortality were utilized, we found that older adults making decisions about a computer simulated balloon and vascular surgeons making the same decisions with a similar abstract version of the AAA, chose to end the expansion of a balloon/AAA significantly earlier when their randomly assigned experimental condition administered during their practice trial ended with a rupture than when it did not (Dale et al., 2006; Hemmerich et al., 2007). Vascular surgeons were more than 3.3 times more likely to select surgery to stop the AAA from expanding, and older adults, who represented an at-risk population for AAA, showed a significant but smaller effect, being 1.98 times more likely to halt a balloon growing at the rate reported in the literature. Findings from both of these computer game-like simulation experiments demonstrated that the experimental condition, which represented a previous AAA patient's outcome, influenced the decision to stop AAA/balloon expansion earlier when the previous AAA/balloon ruptured than when it had not. These findings were striking because participants in both experiments were provided with the statistical risks associated with intervention and the AAA/balloon's current size on the computer screen so that Risk as Analysis could guide their decisions, and still the participants' previous experience influenced their decisions. However, it was unclear if this effect would persist for a more realistic AAA simulation with clinical details of the simulated patient and graphical representation of a Computed Tomography (CT) scan of the AAA. Furthermore, in these previous studies no data were collected on regret or anxiety, or on whether the simulation was viewed as negative and arousing. Addressing these issues is the purpose of the two experiments reported here. The following description details the enhancements made to the AAA simulation used in both experiments.

Enhancement of AAA Computer Simulation

Clinical AAA Scenario

The AAA simulation was adapted from the Balloon Analog Risk Task (BART), a laboratory test of risk-taking with good reliability and well documented external validity (Hopko et al., 2006; Lejuez et al., 2002; White et al., 2008). The recipient of the reward for good performance (participant vs. others) does not impact participants' decision-making in the task (Benjamin & Robbins, 2007). For the current experiments we increased the AAA simulation's realism by prefacing it with a vignette of an hypothetical older, asymptomatic, male patient with 15 years remaining life expectancy (See Appendix A [insert link to online file]). We also made the visual display more like a CT scan of an AAA by using gray-scale and eliminating the video game-like characteristics of the previous versions. A sentence reminded participants of the constant 5% risk of a perioperative death (Appendix A [insert link to online file]). Two buttons were available to mouse click, one labeled "continue watchful waiting," which advanced the AAA another 6 months updating the screen's graphic and information, and the other button labeled "go to surgery," which drew a surgical result from a distribution of 95% "successful surgery" and 5% "patient death". Each click of the "continue watchful waiting" button updated the AAA so that the simulation task represented a series of repeated AAA patient clinic visits. Each decision to continue watchful waiting updated the screen with details of the patient presenting for another assessment 6 months later. As long as watchful waiting was continued, the AAA continued expanding at the same rate indicated by published expansion and rupture data. The computer simulation display included a section of a CT of the AAA, as well as its size, its risk of rupture in the next 6 months, and the accrued donation reward (explained below) (Lederle et al., 2002). The task was complete when either the physician chose surgery or the AAA ruptured. The updated rupture odds and the static 5% likelihood of surgical mortality provided all the necessary information to pursue the recommended guideline strategy of the Society for Vascular Surgery for the timing of surgical repair, to allow the AAA to expand until it reached 5.5 cm and then to select surgery (Brewster et al., 2003).

The experimental paradigm included two patient trials. The first being a practice trial to familiarize the participant with the simulation and the second being the actual performance trial. Unbeknown to participants, the practice trial also presented the randomization to one of three experimental conditions and is referred to from this point on as the experimental manipulation. Both experiments implemented double-blind, randomized computer-generated assignment to one of three experimental conditions: 1) Watchful Waiting Death (WWD) in which the AAA ruptures early after 5 visits, 2) Perioperative Death (PD) in which the patient dies perioperatively when the subject decides to send them for surgery, or 3) Successful Operation (SO) in which the surgery succeeds, the AAA is repaired and the patient is cured. This experimental manipulation was designed to provide the participants with different experiences with previous patient outcomes before they were to make a treatment decision for the next patient.

Experiment 1: laboratory evaluation of emotional impact

The purpose of Experiment 1 was to test the emotional effects of the AAA simulation's randomly assigned experimental conditions. This two-part experiment first tested the hypothesis that the AAA rupture simulation causes anxiety. The effects on participants' state anxiety and associated negative arousal related to the AAA rupture were the dependent variables of interest. We hypothesized that under the WWD experimental condition, participants' state anxiety would increase in response to the simulation. Further, under the PD experimental condition, participants would experience a smaller increase in anxiety, while the SO condition would experience no anxiety change. Additionally, we hypothesized that participants would rate the AAA as negative and arousing relative to other images. We tested these hypotheses using a validated survey instrument for state anxiety (STAI-S), and by eliciting ratings of the simulated AAA rupture's emotional valence and arousal and comparison along with a wide variety of experimental picture stimuli from the International Affective Picture System (IAPS) (Lang et al., 2005).

Methods

From December 2007 through April 2008, walk-in research volunteers at the Booth Business School's Decision Research Laboratory (The University of Chicago) volunteered 15-25 minutes of their time in exchange for \$5.00 and the chance to earn additional money based on their performance. The obtained sample was made up of university graduate and undergraduate students. The University of Chicago's Social and Behavioral Sciences Institutional Review Board approved the research protocol and procedure. Participants were randomized by double-blinded computer assignment to one of the three conditions of WWD, PD, or SO, dictating the patient outcome they would experience during their practice trial. Participants were paid \$5.00 for participating and an extra \$0.25 with every decision to continue watchful waiting not resulting in an AAA rupture. The additional money was lost if the AAA ruptured or there was a surgical mortality (5% random outcome) after choosing surgery.

The experiment was self-administered by participants on a laptop computer in a small plain white decision laboratory room under the supervision of a research assistant. The computer-based AAA simulation task was bookended by some important questionnaire items. Part 1 of the questionnaire consisted of socio-demographic questions, the STAI-Trait subscale (Spielberger, 1977), and the STAI-State Short Form (STAI-SSF) (Marteau & Bekker, 1992). Part 2 consisted of a repeated administration of the STAI-SSF and a separate task in which participants used images from the IAPS (images # 1675, 1931, 2130, 2190, 7237, 3170, 3210, 6312, 8030, 8186, 8485, 7054, 7211, 7238, 2480, 7506, 8330, 8501, 8162, 3250) and the iconographic Self-Assessment Mannequin (SAM) to report their affect caused by the IAPS pictures and the AAA computer simulation on two dimensions, valence (positive vs. negative) and arousal (exciting vs. boring) (Lang et al., 2005). These images, with normative ratings available, covered four quadrants (valence by arousal) and included some with normative ratings that were negative and arousing (e.g. infant with a very large eye-tumor, a racecar and driver on fire, and a man aggressively forcing a girl into the back of a van), some positive and high-arousal (e.g. sky-diver, ski-jumper), some negative and low-arousal

(e.g. lonely man looking out window), while others were positive and low-arousal (e.g. a brightly-colored abstract picture). These materials and procedures were tested by the IAPS developers and are described in detail with normative ratings reported (Lang et al., 2005).

AAA Simulation Procedure and Questionnaire

After informed consent was obtained, participants completed part 1 of the questionnaire. Participants were told to imagine that they were physicians in charge of an AAA patient's care. They then received instructions on the performance-linked incentive structure and were told that the practice trial would familiarize them with the simulation controls for the performance trial that would count for determining the donation reward. They were not told that the practice trial would also entail random assignment to one of three patient outcomes. Using double-blind random assignment, the computer program presented each subject with one of three experimental conditions which portrayed patient outcomes, WWD, PD, or SO. Participants immediately learned of the simulated patient's outcome via a message on the screen indicating that the AAA ruptured and patient died, the patient died perioperatively, or the surgery was successful, and then answered part 2 of the questionnaire that included the STAI-SSF for a second time to measure state anxiety. This second STAI-SSF measure allowed a pre to post- manipulation comparison of anxiety change. Participants then took part in the performance trial that counted for determining their money reward. The performance trial decisions were not of interest due to the interference caused by the anxiety measurement and the decision data are not presented here. When participants completed the performance trial, they performed the IAPS ratings.

IAPS Ratings Module Procedure

Participants were asked to rate 21 IAPS pictures and the AAA rupture simulation, an approximately 5 second animation of the AAA incrementally expanding and then rupturing. Participants used the 9 point iconographic SAM to rate these 22 stimuli on the dimensions of valence and arousal. Each dimension is scored on a 9-point Likert-type scale between endpoints of negative versus positive and high arousal versus low arousal. Participants briefly viewed the full-screen image and then advanced to a screen to make the SAM rating.

Statistical Analysis

Our hypothesis that the experimental simulation increased anxiety was analyzed using a 3×2 (experimental condition by time) ANCOVA to test the hypothesis that anxiety changed most for participants in the WWD group. The variables of trait anxiety (STAI-T), age and gender were entered as covariates. For the ratings of the AAA rupture animation and IAPS images, we plotted the ratings on a two dimensional graph (valence by arousal) to see how the simulation compared to the image ratings.

2.2 Results – Experiment 1

The basic demographics of the obtained sample are presented in the top portion of Table 1. There were no significant differences in age, gender, ethnicity, or trait anxiety between the three randomly assigned groups. Participants had low state anxiety at entry into the experiment that did not differ between experimental groups (Table 1).

Emotion Effects

The results of a 3×2 (demonstration condition by time) ANCOVA design with trait anxiety (STAI-T), age and gender were entered as covariates, supported our hypothesis that the WWD group would exhibit a significant increase in post manipulation state anxiety compared to the SO group (See Figure 1).

A significant interaction $F(2,68) = 3.44, p < .04$, indicated that STAI-SSF change from the beginning of the experiment to after the practice trial differed by experimental condition, with the WWD showing the greatest rise in state anxiety ($M = 10.9, SD = 2.4$ to $M = 13.5, SD = 3.9, p < 0.001, d = .71$), the PD group showing a weaker but significant increase ($M = 10.6, SD = 2.9$ to $M = 12.3, SD = 2.9, p = 0.011, d = .56$), and the SO group showing no change from time one to time two on state anxiety ($M = 10.3, SD = 3.4$ to $M = 10.8, SD = 3.0, p = 0.40$) (Figure 1). The STAI-SSF pre-manipulation and post-manipulation scores correlated significantly, $r_{sp}(n=77) = .50, p < .01$, with each other, as well as individually with the STAI-T measure, $r_{sp}(n=76) = .59, p < .01$, and $r_{sp}(n=77) = .45, p < .01$, respectively. There was no relationship between the participants' trait anxiety (STAI-T) and the changes in pre-manipulation to post manipulation state anxiety (STAI-SSF). This pattern of results demonstrated that when accounting for trait anxiety, the experimental manipulation affected the participants' state anxiety in the predicted fashion so that the WWD experimental group experienced a significant and sizeable increase in state anxiety, the PD group experienced a significant but smaller increase, and the SO group stayed the same post manipulation.

IAPS Evaluation of AAA Stimuli

Our second hypothesis was supported by plotting the aggregate mean of the participants' ratings of the AAA rupture simulation, like that presented in the WWD experimental group, with their ratings of 21 pictures taken from the IAPS library. This comparison demonstrated that the AAA rupture simulation fell into the negative valence and high arousal quadrant (Figure 2), and was similar to the images that were rated as being extreme on both dimensions. Using paired t-tests, the only image within the quadrant rated more negatively than the AAA rupture was the IAPS #3170 “baby eye tumor” $t(76) = 4.6, p < 0.001$. However, the AAA was rated as significantly more arousing $t(76) = 3.0, p < .01$. The AAA rupture simulation was rated most similar to the #8485 “race car fire” and #6312 “van abduction”.

Conclusions – Experiment 1

As hypothesized, the WWD experimental condition caused a significant and sizeable increase in state anxiety and the AAA rupture computer animation displayed in this condition was rated as negative and arousing. Furthermore, the ratings of the AAA rupture animation and IAPS images indicate that participants perceived the AAA as negative and arousing, and rated it similarly to negative and arousing IAPS images. These results demonstrate causal effects of a negative and arousing experimental manipulation on participants' state anxiety.

Experiment 2: Field Experiment with Physicians

With Experiment 1 providing evidence that the enhanced realism AAA simulation is anxiety inducing and viewed as negative and arousing, we then tested the simulation's influence on the decision making of physicians who often encounter AAA patients in their practices, specifically surgeons and geriatricians. Corresponding to the anxiety effects observed in Experiment 1, we hypothesized the following directional effects: 1) participants who experience a patient's AAA rupture will choose surgery for the next patient earlier (at a smaller size) than those who experience a simulated patient's successful surgery; 2) participants who experience a simulated patient's perioperative death will delay surgery longer than the successful surgery group in their subsequent treatment decision, and 3) participants who experience a negative outcome in their performance trial, particularly an AAA rupture, will experience more regret about their decision.

Methods

Participants in this field experiment were physicians (N=132) from two specialties that care for AAA patients: surgeons (N=63) and geriatricians (N=69) attending either a geriatric or surgical professional society meeting which were held in Washington D.C. in May of 2008 and in Chicago in October of 2009 respectively. Recruitment took place at an experiment table outside the exhibit hall. Physicians were offered candy and a bottle of drinking water, as well as a \$1.00 minimum donation to a health-related charity to be made by the research team on their behalf. The Social & Behavioral Sciences Institutional Review Board at The University of Chicago approved this study.

Participation/Performance Incentive

Incentives were tied to good simulation performance to motivate participants towards good decision-making in the same fashion as Experiment 1, with the only differences being that the rate was a guaranteed \$1.00 donation to participate, and another \$1.00 for each decision to continue WW not resulting in an AAA rupture, and the “winnings” going to charity (Doctors Without Borders or the American Geriatrics Society Foundation for Health in Aging). The accrued donation was lost if the AAA ruptured or the patient died from surgery, again making the statistically optimal decision to be following the guidelines of choosing surgery at 5.5 cm.

Materials

Participants were given a two-part questionnaire. Part 1 was completed before the computer AAA simulation task, and Part 2 was completed after both the practice and performance trials of the simulation task. Part 1 included the psychometrically-validated scales: the “state” portion of the State-Trait Anxiety Inventory (STAI-S) (Spielberger, 1977), the Intolerance of Uncertainty Scale (IUS) (Buhr & Dugas, 2002) assessing attitudes towards uncertainty; and three items from the Domain specific Risk attitude Scale (DOSPERT) assessing risk, benefit, and likelihood for betting a day's income (Blais & Weber, 2006). Questions were also included about demographics, clinical training, AAA experience, experience of unexpected “bad” patient outcomes (death or return to the OR) in the past 6 months, and perceived accuracy of the simulation. Part 2 of the questionnaire included

several questions to be answered after participants completed the AAA simulation task. A few questions assessed the participants' self-reported strategy by asking which of the following factors had influenced their decisions about when to choose surgery: AAA appearance, donation amount, rupture risk, practice simulation, patient characteristics, and reported size in centimeters. Additionally, the five item Decision Regret Scale was included (Brehaut et al., 2003).

Procedure

The same procedure that was implemented in Experiment 1, was utilized in Experiment 2 with the following differences. Just as in Experiment 1, the computer implemented double-blind random assignment to one of the same experimental conditions in the practice trial. However, in Experiment 2, participants were not surveyed on their state anxiety, but instead immediately went on to complete the performance trial under the same conditions as described above, with the number of decisions to continue watchful waiting before deciding to go to surgery being the principle dependent variable.

Statistical Analysis

The effect of the intervention on physician decision behavior was assessed using Cox proportional hazards regression modeling. The “event” was making the decision to go to surgery, and time was defined as the number of decisions to continue watchful waiting. The primary independent variable of interest was again the experimental condition presented in the practice trial to which the subject was randomly assigned. If the performance trial was ended by an AAA rupture it was treated to be censored because it is not known how much longer the subject would have continued watchful waiting. T-tests, Chi-squares and Fisher's exact tests were used to compare surgeons and geriatricians on socio-demographics, professional characteristics, and psychological variables. Statistical analyses were conducted using STATA.SE 11. (Stata Corp., College Station, TX)

Results

Pre-simulation Questionnaire: Clinical Experience and Knowledge—There were no statistically-significant differences between the three experimental conditions at baseline, and state anxiety was generally low (Table 2). Over two thirds of surgeons and almost 80% of geriatricians reported having direct experience treating at least some AAA patients, and 16% indicated that they had experienced a “bad outcome” with an AAA patient in the past 6 months.

Cox Regression: The hypothesized effect of a preceding AAA rupture on subsequent behavior was found (See Table 3). After controlling for the covariates, the WWD condition demonstrated the hypothesized effect (Hazard Ratio=1.87, $p=.01$) indicating that participants in this condition were 87% more likely to choose surgery at any decision point than the control group. The WWD group chose surgery after a watchful waiting decision time (median=6) that corresponded to an AAA diameter of 4.7cm and corresponding reported rupture rate of 1.0%. The SO group's (median=9) and PD group's (median=10) decision times until surgery corresponded to a 5.1cm diameter (1.6% rupture risk) and 5.3cm diameter (2.0% rupture risk), respectively. The PD group's watchful waiting time was not

statistically significantly different from the SO group, but they trended in the expected direction and were approximately 19% less likely to choose surgery at any decision point (Figure 3). It is worth noting that surgeons and geriatricians did not differ significantly in their decision making, although a trend was observed in which surgeons chose surgery earlier than geriatricians ($HR=1.33, p=.19$). These results support our hypothesis that a bad treatment outcome will push the physicians' decisions away from experiencing the same bad outcome again, particularly when the bad outcome is the patient's AAA rupturing during WW. The global test of proportional hazards was performed using Schoenfeld's residuals and was found to be non-significant, $\chi^2 (16, N=132) = 14.5, p=.56$.

Additionally, we found that a higher baseline state anxiety score on the STAI-SSF ($HR=0.97, p=.025$), and the physicians reporting that patient characteristics influenced their decision ($HR=0.42, p=.01$), were predictive of longer WW times. These effects were not anticipated, but they do not contradict any of the hypotheses tested. Collapsing across conditions, the physicians chose surgery three time points earlier (representing 18 months less surveillance time) when the AAA was 4.9cm with an associated rupture risk of 1.4%, smaller than statistical guidelines recommend to intervene surgically (curve not shown).

Post-Simulation Questionnaire

Self-Reported Decision Strategy: Participants were asked what factors influenced their decisions about when to recommend the patient for surgery, distinct from the test of the experimental condition. The most important finding is that participants who indicated that the practice trial influenced their decision-making trended towards shorter WW time ($HR=1.76, p=0.06$). The practice trial was reported to be influential at a higher rate by the WWD experimental condition (31%) and the PD experimental condition (26%) more than the SO (7%). The nature of this effect was further clarified by stratifying the experimental groups, which revealed that was an interaction between condition and reporting that the practice trial influenced performance trial decision making (See Table 4). Participants in the WWD experimental condition who indicated that their practice trial was influential chose surgery significantly earlier than those who did not indicate the practice trial was influential, $m=4.1$ versus $m=6.6, \chi^2=10.2, p<.01$. Although the trend was not significant, it is noteworthy that WWD condition participants who indicated that the practice trial did not influence their decisions also went to surgery earlier than the other two condition's participants, suggesting that the impact of having a patient with an AAA rupture is not reliant on conscious awareness of its impact. As hypothesized, the PD condition showed a decision trend in the opposite direction from the SO control group and waited the longest to recommend surgery regardless of whether they indicated the practice trial was influential.

Oddly, only 38% of all participants indicated that the updating AAA rupture odds displayed on the simulation screen influenced their decision. The updating was not a significant predictor in the cox-regression analysis described above. The practice trial simulation was the second most commonly cited influence (20%), and the physical appearance of the aneurysm was the third (17%). Only a small minority of participants indicated that patient characteristics (8%) were influential, and importantly, the amount of donation (2%) was seldom reported to be influential.

Effects on Regret: While scores on the Decision Regret Scale (See Table 5) did not differ significantly between the three experimental conditions, significant differences were found between participants who had AAA ruptures during their performance trial ($m=63.4\pm19.5$) and those who had successful surgical outcomes $m=32.8\pm11.2$, $F(2,126)=22.7$, $p<0.001$. Only 4 participants out of 144 who chose surgery experienced surgical mortalities in their performance trial condition.

Conclusions from Experiment 2

As hypothesized, a WWD significantly expedited physicians' decisions to recommend surgery and a PD trended towards delaying surgery for a subsequent AAA patient. Even when statistical AAA rupture risk information is available and updated with each WW decision, the randomized manipulation led to an earlier decision to go to surgery. Those who experienced the AAA rupture were 87% more likely to go to surgery at any point in time.

While controlling for the self-reported influence of the practice trial in the Cox-regression, the experimental manipulation still significantly impacted decisions. Furthermore, looking at the pattern of results stratified by experimental condition, even in participants reporting no influence of the practice trial, the WWD still caused physicians to choose surgery earlier, suggesting that participants are not fully aware of the previous patient outcome's influence on their decision making.

Lastly, feelings of regret after the participant learned of the outcome of their performance trial, may be an important driver of the *Risk as Feelings* effect in subsequent decision-making. Regret was significantly higher for participants who had an AAA rupture during their performance trial and is associated with the desire to have made different treatment decisions.

Limitations

There are several limitations to these experiments. Although significant effort was made to represent the characteristics of a typical AAA patient, physicians were aware that they were not making decisions for an actual patient, and thus they were not as engaged as they would be with a real patient. However, a randomized experiment like this one is impossible in actual clinical practice. While the sample consisted of physicians who are familiar with AAA in their real clinical practices, it is possible that the incentive-laden choices they made in the experiment were not the ones they would make in practice. A related issue is that patients could play a major role in decisions about AAA treatment. It is likely that deciding when to have an elective repair for AAA is a decision in which patients impact physicians' decision making and the process is probably shared. With a greater premium being placed on patient autonomy and participation in their own treatment, treatment decisions are certain to also be influenced by patients' Risk as Analyses and Risk as Feelings. Further research is needed to properly account for the role that patients play in these decisions, and it is appropriate to frame the findings presented in this paper as representative of physicians' decisions regarding the recommendation to bring to the patient physician decision dyad.

Additionally, Experiment 2 utilized participants from two different medical specialties. Although we did not find a statistically significant difference between surgeons and geriatricians, we believe that it is likely that they differ in their decision making in some important ways, especially considering their different roles in the patient's care. It is necessary to better account for the effects of experience making such decisions in future studies.

Regarding Experiment 1, as with any laboratory-based simulation study, the external validity of the findings can be questioned based on the participants enrolled. Experiment 1 utilized a sample of laboratory volunteers consisting primarily of students who were required to play the role of a physician. Perhaps the anxiety and negative emotions experienced by the students are not the same as those experienced by physicians. While the purpose of Experiment 1 was to determine whether the AAA simulation was perceived as negative and arousing, and thus non-clinicians were deemed acceptable participants, it is possible that physicians' training or clinical experience might diminish their affective reactions to patient outcomes in this context. However, the influences on affect we observed in Experiment 1 were consistent with the decision making of physicians in Experiment 2 in the predicted pattern. They also resonated with survey data from physicians who have recently lost a patient perioperatively and seek psycho-emotional support (Goldstone et al., 2004).

Overall Conclusions

If taken in combination, the results of these experiments provide evidence for the Risk as Feeling Hypothesis and provide evidence of a link between regret, anxiety and decision-making in physicians' thinking about AAA treatment. The decision making result found in our earlier work was replicated with a more realistic simulation, more complete patient information, and explicit guidelines – representing significant improvement in the realism of our simulation used in our previous experiments (Dale et al., 2006; Hemmerich et al., 2007). Experiment 1 demonstrated that when the simulated AAA patient experienced an early rupture, participants experienced a large increase in anxiety at the critical time when they were about to make treatment decisions for a subsequent patient; they rated the AAA rupture simulation as negative and arousing commensurate with images previously validated and concurrently rated. The decision to operate on an AAA patient is based on the changing risk of rupture versus the risk of surgical repair. Risk of rupture is still primarily based on the maximum AAA diameter. These size-based statistical assessments of rupture risk are inaccurate for up to 25% of patients with any size AAA. Current statistically-based guidelines provide some direction, but do not thoroughly guide clinicians' decision making about the timing for surgery. These findings support the relevance of Risk as Feelings to AAA treatment decision making through a significant influence of an “experiential system” or “somatic marker” that can subconsciously, and sometimes consciously, warn that a particular loss is looming ever closer (Damasio, 1994; Damasio et al., 1991; Slovic et al., 2004).

Importantly, in our previous research, both vascular surgeons and older adults continued WW for longer than guidelines recommend (Dale et al., 2006; Hemmerich et al., 2007).

Experiment 2, utilizing a more realistic AAA simulation, found participants choosing surgery earlier than guidelines recommend. The WWD experimental condition, nevertheless, led to significantly earlier surgery, compared to the other two experimental conditions.

These findings provide evidence for the influence of bad patient outcomes, particularly AAA rupture, on physician regret and anxiety in a subsequent risky medical treatment decision. They support the Risk as Feelings Hypothesis by illustrating another instance in which physicians' "experiential", or "Risk as Feelings", system operates differently than the "analytic" system in making a decision (Loewenstein, 1996; Loewenstein et al., 2001; Slovic et al., 2004; Slovic et al., 2005). Furthermore, the type of bad outcome that the subject experiences appears to impact the direction that subsequent decisions are adjusted (i.e. if surgery is chosen earlier or later), because decision makers' regrets, anxieties and subsequent decision making are specific to the type of bad outcome. These experiments are the first to provide data on the causal link, through emotions, between preceding treatment outcomes and subsequent physicians' treatment decisions.

Our results suggest an anticipatory feeling of anxiety caused by a previous treatment outcome affects future physician treatment decisions. Medical professionals deciding about when to recommend surgery for patients with asymptomatic AAA, or other threatening health conditions and treatments presenting competing risks, need to be aware both of the impact that their previous patient outcomes might have on their decision making and of the need to receive the appropriate decisional and psycho-emotional support for performing at optimal level. Historically, the role of affect in physician decisions has been under-appreciated. Previous work suggests that physicians, like others, are not fully aware of the nature and extent of these experiential influences on their choices (Loewenstein, 1996; Loewenstein et al., 2001; Slovic et al., 2004; Slovic et al., 2005). It should not surprise psychologists that our findings here likewise suggest that physicians are not fully aware of how their previous experience is affects their subsequent decision making.

This study represents only a first step towards demonstrating an experiential or Risk as Feelings effect on physician decision making, and further research is needed to better understand the role of Risk as Feelings in this context and others. It is also necessary to explore other medical and surgical treatment decisions that involve risk. By testing the ability to generalize these findings to other treatment decisions, we will begin to develop a theory of the relationship between physicians' previous experience and their treatment decision making.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Experiment 1 Pre to Post-Manipulation State Anxiety (STAI-SSF) by Experimental Group

Figure 2. Experiment 1; IAPS Image and AAA Ratings Valence by Arousal

Figure 3. Experiment 2: Kaplan Meier Survival Functions by Experimental Group

Table 1

Experiment 1; N = 76 Laboratory Manipulation Validation

Characteristics	Observed Mean (SD) or Percent%			P-value
	Watchful Waiting Death "WWD" (n = 26)	Perioperative Death "PD" (n = 24)	Successful Operation "SO" (n = 26)	
Age	21 ± 3.9	20 ± 1.3	20 ± 3.2	0.22
Female	58	54	62	0.87
Ethnicity	African-American	13	19	0.63
	White	50	54	
	Asian	4	15	
	More than One/Other	23	12	
Education	HS Grad	4	12	0.20
	Some College	81	85	
	College Grad	15	4	
Emotion Variables				
STAI-T	40.0 (9.3)	38.2 (8.5)	38.1 (8.8)	0.69
DRM	positive	3.1 (1.4)	3.3 (1.3)	0.15
	negative	1.2 (0.9)	1.0 (1.0)	0.21
	fatigue	2.0 (1.3)	2.0 (1.4)	0.91
STAI-SSF	Pre-manipulation	10.9 (2.4)	10.3 (3.4)	0.75
	Post-manipulation	13.5 (3.9)	10.8 (3.0)	0.02*
IAPS Ratings	AAA rupture valence	2.4 (1.3)	2.0 (1.2)	0.03*
	AAA rupture	6.6 (1.4)	5.9 (2.5)	0.15

Form: IAPS: International Affective Picture System

Table 2
Experiment 2: Descriptive Variables by Randomly-Assigned Experimental Condition

Sample Characteristics	Watchful-Waiting Death "WWD" (n=43)	Perioperative Death "PD" (n=44)	Successful Operation "SO" (n=45)	P-value*
Age	43.9(12.7)	43.9(12.7)	43.2(12.9)	44.4(12.3) 0.91
Years of Experience	13.2(12.9)	13.2(12.9)	12.0 (12.0)	11.9(12.3) 0.86
Female	33	33	36	40 0.77
Ethnicity				
African-American	5	2	7	0.79
White	57	54	64	
Asian	24	26	16	
More than One/Other	14	19	13	
Place of Practice [†]				
private	23	40	40	0.17
academic	70	60	58	0.46
government	9	10	16	0.58
other	11	11	11	0.99
Have AAA Patient Experience?	74	77	71	0.83
Poor AAA Outcomes last 6 months	13	25	17	0.39
Risk and Anxiety Measures				
Baseline State Anxiety (STAI-SSF)	31.8(8.0)	31.7(9.3)	30.1(7.0)	0.55
Intolerance for Uncertainty (IUS)	23.5 (7.5)	23.3(6.2)	21.7(7.5)	0.41
Domain Specific Risk Taking (DOSPRT)				
Betting day's income:				
How risky is	4.3(0.9)	4.0(1.1)	4.3(1.0)	0.29
How likely is it that you would	1.2(.5)	1.5 (1.0)	1.4(0.7)	0.14
How beneficial is	1.5 (0.8)	1.6(0.9)	1.3(0.6)	0.18

[†] Some participants reported more than one

* ANOVA or Chi-squared statistic

DOSPRT = Domain Specific Risk Taking

STAI-SSF = State Trait Anxiety Inventory - State Short Form

IUS = Intolerance of Uncertainty

Table 3
Experiment 2: Cox Proportional Hazards Regression Analysis of Number of Watchful
Waiting Decisions Before Recommending AAA Surgery

Predictor	HR	P > z	[95% Conf. Interval]	
Age	1.00	0.57	0.99	1.02
Male gender	1.41	0.13	0.90	2.22
Surgeon (specialty)	1.33	0.19	0.87	2.03
DOSPERT				
betting risk	0.98	0.87	0.78	1.23
betting likely	0.87	0.47	0.61	1.25
betting benefit	1.09	0.61	0.79	1.50
STAI-SSF	0.97	0.03	0.94	1.00
IUS	1.00	0.93	0.97	1.03
Bad AAA outcome in past 6 mo.	1.14	0.64	0.66	1.97
EXPERIMENTAL CONDITION				
Successful Operation (SO)	Ref	Ref	Ref	
AAA rupture (WWD)	1.87	0.01	1.15	3.02
Perioperative death (PD)	0.81	0.41	0.49	1.34
PARTICIPANT INDICATED INFLUENCE				
Physical appearance	0.82	0.48	0.47	1.43
Donation	0.25	0.06	0.06	1.08
Practice simulation	1.76	0.06	0.97	3.20
Burst rate	0.80	0.37	0.50	1.30
Patient characteristics	0.42	0.04	0.18	0.95

Ref = reference category

DOSPERT = Domain Specific Risk Taking

STAI-SSF = State Trait Anxiety Inventory - State Short Form

IUS = Intolerance of Uncertainty

Table 4
Experiment 2: Number of Uncensored Decisions to Continue Watchful Waiting by
Experimental Condition

	Uncensored Mean(SD) and Medians			Comparison btwn Conditions
	AAA Rupture "WWD"	Surgical Death "PD"	Control "SO"	
Practice Simulation Influenced				
Yes	4.0(1.4) median=4	7.1(3.3) median=8	6.7(1.5) median=7	$X^2=12.1$, $p<.01$
No	6.6(3.2) median=7	8.2(2.7) median=9	7.5(2.8) median=9	$X^2=3.1$, $p=.21$
Comparison Yes vs. No	$X^2=10.2$, $p<.01$	$X^2=0.7$, $p=.12$	$X^2=4.7$, $p=.03$	

Table 5
Experiment 2: Subject Test Trial Regret by Outcome

	Test Trial Outcome		
	AAA Rupture n=8	Perioperative Death n=2	Successful Operation n=122
Regret Scale	63.4±19.5	40.0±11.3	32.8±19.5
% Participants would have:			
Performed surgery earlier	5 (62.5)	0 (0)	9 (7.6)
Waited longer for surgery	0 (0.0)	0 (0)	5 (4.2)
Not acted differently	3 (37.5)	2 (100.0)	105 (88.2)