Willingness-to-pay for Warnings: Some Tables

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Research Question

- How much do people value alerts (signals) about potential preventable threats?
- How do signal's probabilistic characteristics affect the willingness-to-pay for it and the welfare gains from using it?
- Applications:
  - Natural disaster warnings (tornados, floods, earthquakes)
  - Medical tests for treatable conditions
  - Investing in research on likelihood of catastrophic events (rogue AI, global warming, pandemics)
- Note: most real-life applications provide little practice with using the signal

Overview of the Experiment

- An insurance experiment:
  - Two states of the world: bad ($\omega = 1$) and good ($\omega = 0$)
  - Probability of a bad state is $P(\omega = 1) = \pi$
  - Bad state $\implies$ loss of $\$L$
  - A perfectly protective insurance can be purchased for $\$c$
- Subject can purchase a signal s before purchasing the insurance:
  - A signal is characterized by its true-positive $(P(s = 1|\omega = 1))$ and true-negative rates $(P(s = 0|\omega = 0))$

Research objective

How do signal characteristics affect the WTP?

- Theoretically, what should be the WTP for a signal?
- If bad states are a priori rare ($\pi L << c$) $\implies$ never protect without a signal
- The theoretical WTP b for an expected utility maximizer given a signal s is a solution b^* to the following:

$$P(s=1)u(Y_0 - b^* - c) + \pi P(s=0|\omega=1)u(Y_0 - b^* - L)+$$

$$+(1-\pi)P(s=0|\omega=0)u(Y_0 - b^*) = (1-\pi)u(Y_0) + \pi u(Y_0 - L)$$

- A risk-neutral agent then pays:

$$b^* = \pi(1 - P(s=0|\omega=1))L - P(s=1)c$$

- The formulas become more complicated if subjects can protect without a signal (bad state are not rare enough)
- The theoretical WTP b for an expected utility maximizer given a signal s is a solution b^* to the following:

$$P(s=1)u(Y_0-b^*-c)+\pi P(0|1)u(Y_0-b^*-L)+(1-\pi)P(0|0)u(Y_0-b^*) =$$

$$= \min[(1-\pi)u(Y_0)+\pi u(Y_0-L), u(Y_0-c)]$$

- A risk-neutral agent then pays:

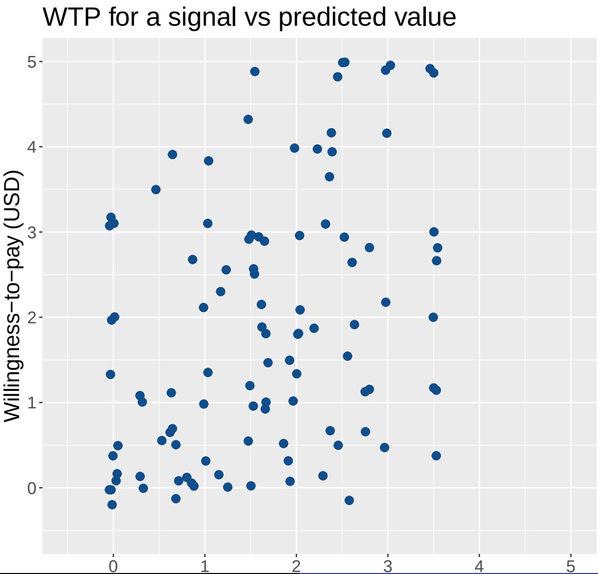
$$b^* = \min[\pi L, c] - \pi(1-P(s=0|\omega=1))L - P(s=1)c$$

Hypotheses

1. Conditional on the signal's value for risk-neutral subjects, false positive and false negative rates reduce the perceived value of the signal (WTP)
2. Conditional on the signal's value for risk-neutral subjects, false positive and false negative rates increase expected costs
3. Extra: how much of these disrepancies result from belief updating issues or risk aversion?

WTP for signals

- Higher average WTP for more valuable signals



WTP for the Signal

- Extra effect of false positive and false negative rates

Table: WTP for Information

	(1) OLS	(2) OLS	(3) OLS	(4) OLS
value	.475***	.24**	.119	.109
	(5.1)	(2.2)	(0.9)	(0.8)
Prior prob.		1.76***	1.85***	1.86***
		(2.7)	(2.8)	(2.8)
honest_treatment		.759***		.306
		(2.7)		(1.0)
False neg. rate			-2.13***	-1.64**
			(-2.8)	(-2.1)
False pos. rate			-2.34***	-1.83***
			(-3.5)	(-3.0)
Constant	.54***	.214	1.19***	.981**
	(3.6)	(0.9)	(3.1)	(2.4)
Observations	150	150	150	150
Adjusted R^2	0.14	0.21	0.22	0.22

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

WTP for the Signal (Risk Aversion)

- Does accounting for risk aversion based on blind protection choices helps to explain WTP?

Table: WTP for Information (Accounting for Risk Aversion)

	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS
value	.475***				
	(5.1)				
value_ra		.236**	.0615	.0615	-.112
		(2.1)	(0.4)	(0.4)	(-0.7)
honest_treatment			.734*	.734*	.132
			(1.7)	(1.7)	(0.3)
False neg. rate					-2.92**
					(-2.1)
False pos. rate					-2.13**
					(-2.3)
Constant	.54***	.793***	.886***	.886***	2.02***
	(3.6)	(3.6)	(3.8)	(3.8)	(3.5)
Observations	150	78	78	78	78
Adjusted R^2	0.14	0.04	0.07	0.07	0.09

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

WTP for the Signal (Uniform Risk Aversion)

- Risk aversion measurements are noisy. What if we assume the same risk aversion for everybody?

θ	R^2
0	.17
0.5	.15
1	.1
1.5	.07
Observations	150

Actual Costs vs Theoretical Costs

- Calculate actual costs based on decisions made in the Informed Protection treatment and actual posterior probabilities of losses.
- Each reported participant's strategy s is a tuple of numbers (r_w, r_b) representing protection responses correspondingly to white and black hints
- Then the expected cost of each decision are:

$$EC(s) = \pi(P(0|1)(1 - r_w) + P(1|1)(1 - r_b))L +$$

$$+(P(s = 0)r_w + P(s = 1)r_b)c$$

- Regress expected costs on minimal theoretical costs and other signal characteristics

Actual Costs vs Theoretical Costs

Table: Actual Exp. Costs vs Theoretical Costs

	(1) OLS	(2) OLS	(3) OLS	(4) FE	(5) FE	(6) FE
Optimal exp. costs	1.04***	.842***	.592	1.04***	.879***	1.13***
	(9.4)	(4.3)	(1.3)	(10.7)	(4.1)	(9.3)
Prior prob.		-2.19	-3.69		-2.07	
		(-1.1)	(-1.2)		(-1.1)	
False neg. rate			-2.68			-.696
			(-1.6)			(-0.6)
False pos. rate			.713			2.51
			(0.4)			(1.4)
Constant	-.888***	-.733**	-.662**	-.875***	-.684***	-.918***
	(-3.3)	(-2.6)	(-2.2)	(-4.0)	(-3.3)	(-4.3)
Observations	150	150	150	150	150	150
Adjusted R^2	0.34	0.35	0.36	0.41	0.42	0.43

t statistics in parentheses

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Additional Complementary Tables

- Factors affecting informed protection responses
- How well do participants update their beliefs?

Informed Protection: Correlation

Table: Informed Protection

	(1) All	(2) All	(3) Smart	(4) Smart
Posterior prob.	.663***	.114	.692***	.126
	(8.5)	(0.9)	(9.4)	(0.8)
Prior prob.		.467***		.519***
		(3.5)		(3.1)
Gremlin says Black		.497***		.506***
		(5.8)		(5.0)
Constant	.235***	.0872**	.233***	.0678
	(7.3)	(2.2)	(7.7)	(1.6)
Observations	300	300	228	228
Adjusted R^2	0.35	0.41	0.36	0.42

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Informed Protection: Determinants

Table: Informed Protection: Response to Reported Beliefs

	(1)	(2)	(3)
	All	All	Smart
Belief	.746***	.358**	.462**
	(7.8)	(2.4)	(2.5)
Posterior prob.		.424***	.367**
		(3.5)	(2.6)
Constant	.206***	.189***	.178***
	(5.3)	(4.8)	(4.6)
Observations	300	300	228
Adjusted R^2	0.32	0.38	0.40

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Informed Protection: Do Subject's Beliefs Matter?

Table: Informed Protection: Response to Reported Beliefs

	(1)	(2)	(3)
	All	All	Smart
Belief	.746***	.358**	.462**
	(7.8)	(2.4)	(2.5)
Posterior prob.		.424***	.367**
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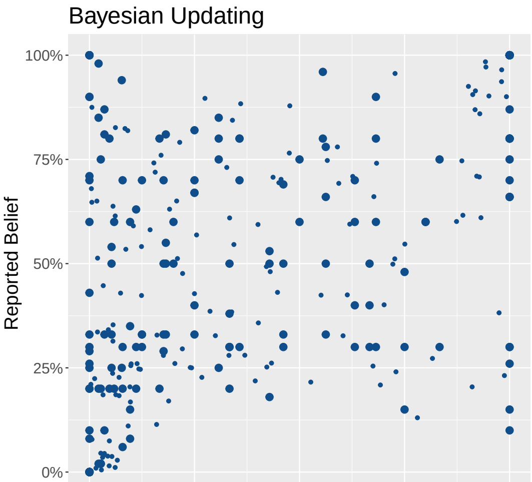
Belief Updating

- A bit more correlation with actual posterior probabilities!
- Even more if we exclude everybody scoring less than 7 out of 9 quiz questions



Belief Updating: Correlation

Table: Belief Elicitation: Belief vs Posterior

	(1)	(2)	(3)
	All	Not_honest	Good quiz
Posterior prob.	.649***	.68***	.477***
	(16.6)	(15.6)	(8.5)
Constant	.138***	.128***	.212***
	(9.7)	(7.9)	(10.5)
Observations	300	228	200
Adjusted R^2	0.55	0.57	0.34

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

What Affects Beliefs?

Table: Belief Elicitation: Determinants

	(1) OLS	(2) FE	(3) Smart, FE
Posterior prob.	.0528	.114	.126
	(0.4)	(0.9)	(0.8)
Prior prob.	.347**	.467***	.519***
	(2.0)	(3.5)	(3.1)
Gremlin says Black	.542***	.497***	.506***
	(5.3)	(5.8)	(5.0)
Constant	.123**	.0872**	.0678
	(2.3)	(2.2)	(1.6)
Observations	300	300	228
Adjusted R^2	0.34	0.41	0.42

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- Posterior probability $\mu = P(B|S = x)$ that the ball is black conditional on a hint $S = x$ can be written as:

$$\ln\left(\frac{\mu}{1-\mu}\right) = \lambda_0 + S_B + S_W$$

- With $\lambda_0 \equiv \ln(p/(1-p))$ representing (transformed) prior beliefs
- And S_B, S_W describing the effect of new evidence:

$$S_B \equiv I(S = B)\ln(P(s = B|B)/P(s = B|W))$$

$$S_W \equiv I(S = W)\ln((1 - P(s = B|B))/(1 - P(s = B|W))$$

Table: Belief Elicitation: Decomposition

	(1) OLS	(2) FE	(3) Smart, FE
lt_prior	.178	.205**	.231**
	(1.4)	(2.5)	(2.2)
signalB	-.0835	.735**	.988**
	(-0.2)	(2.5)	(2.5)
signalW	.818***	0	0
	(2.8)	(.)	(.)
Constant	.332	-.471**	-.577**
	(0.9)	(-2.7)	(-2.6)
Observations	68	68	52
Adjusted R^2	0.16	0.20	0.25

t statistics in parentheses

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