How Many Economists does it take to Change a Light Bulb? A Natural Field Experiment on Technology Adoption

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Overview

- Question and Motivation
- Large Scale Natural Field Experiment
  - Door to door in suburbs of Chicago
- Reduced Form Treatment Results:

  Price and social norms matter
- Steps forward

Questions

- Superior technologies are not always adopted
- Economics:
  - Cost-Benefit tradeoff
    - Discounting
    - Sunk Costs (Status Quo Bias)
- How to increase adoption?
- What discipline (economics, psychology or sociology) provides the most effective means of motivating adoption?
- What is the effect of a price change?
- What is the effect of a frame change involving social norms?

Motivation for CFL Adoption

- 80% reduction below 1990 levels by 2050
    - President Obama's Climate Goals
- 70% of residential households have 1 CFL *but* only 11% of potential sockets have CFLs
    - DOE: "CFL Market Profile"
- Replacing 1 incandescent light bulb in every American household would:
    - Prevent the equivalent annual greenhouse gas emissions from 420,000 cars
    - Save $806 million in annual energy cost (60 Watt =>13 Watt)
    - Cost: ~$1 a bulb (flood lights around $10/bulb)

Economics, Psychology and Sociology on Technology Adoption

Economics - price matters (cost-benefit tradeoff)

Jaffe, Newell and Stavins (2003)

Psychology – impact of social norms

Cialdini Influence: The Psychology of Persuasion

Goldstein, Cialdini and Griskevicius (2008)

Sociology – impact of “change agents”

Rogers Diffusion of Innovations

Moore Crossing the Chasm

One path to motivate adoption is through isolating key "types" of people in society.

Experimental Design

Script:	*Neutral Frame (NF)*
Full Price	
Low Price	

"I am here today to talk to you about reducing your energy usage by using compact fluorescent light bulbs or "CFLs" and to provide you with an opportunity to purchase one."

$1: "May I tell you more about them before offering you up to 2 sets of 4 bulbs for $1.00 each, 80% off their normal price of $5.00 each?"

$5: "May I tell you more about them before offering you up to 2 sets of 4 bulbs at their normal price of $5.00 each?"

"The most important difference between incandescent and fluorescent light bulbs is that fluorescent lights use about 75% less energy than conventional light bulbs and last about 10 times as long, they can save you a substantial amount of money through the reduction in energy consumption – even given their slightly higher cost."

Experimental Design

Script:	*Neutral Frame (NF)*	*Social Norm Low (SNL)*	*Social Norm Med. (SNM)*
Full Price			
Low Price			

Before stating price:

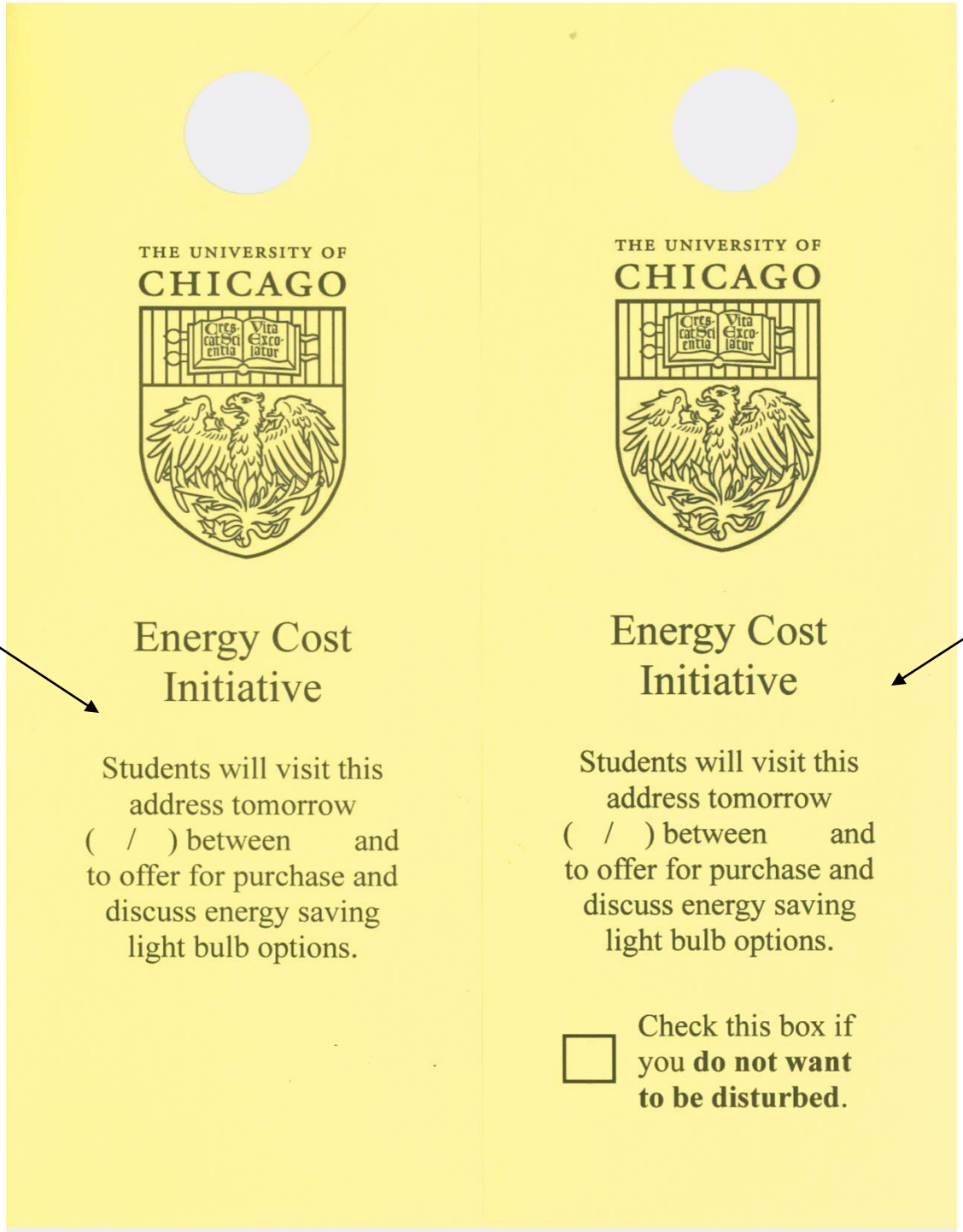
SNL: "For instance, did you know that 70% of U.S. households own at least one CFL?"

SNM: "For instance, did you know that 70% of the people we surveyed in this area owned at least one CFL?"

Experiment Implementation

- Door-to-door field experiment
  - Suburbs of Chicago (Libertyville, Lemont, Roselle and Arlington Heights)
  - Map neighborhoods into treatment groups by street
  - Hire students to approach households on weekends
    - Students approach approx. 25 households per hour
    - Typically change to new treatment after each hour
    - 4 hours of work: 10am-11am, 11am-noon, 1pm-2pm and 2pm-3pm
  - Our team approaches households the day prior to students and hang flyers on doors announcing arrival the following day
  - Currently knocked on 5,305 with a door answer rate of 31% and a purchase rate of 9.8% conditional on answering the door

Warning (W)



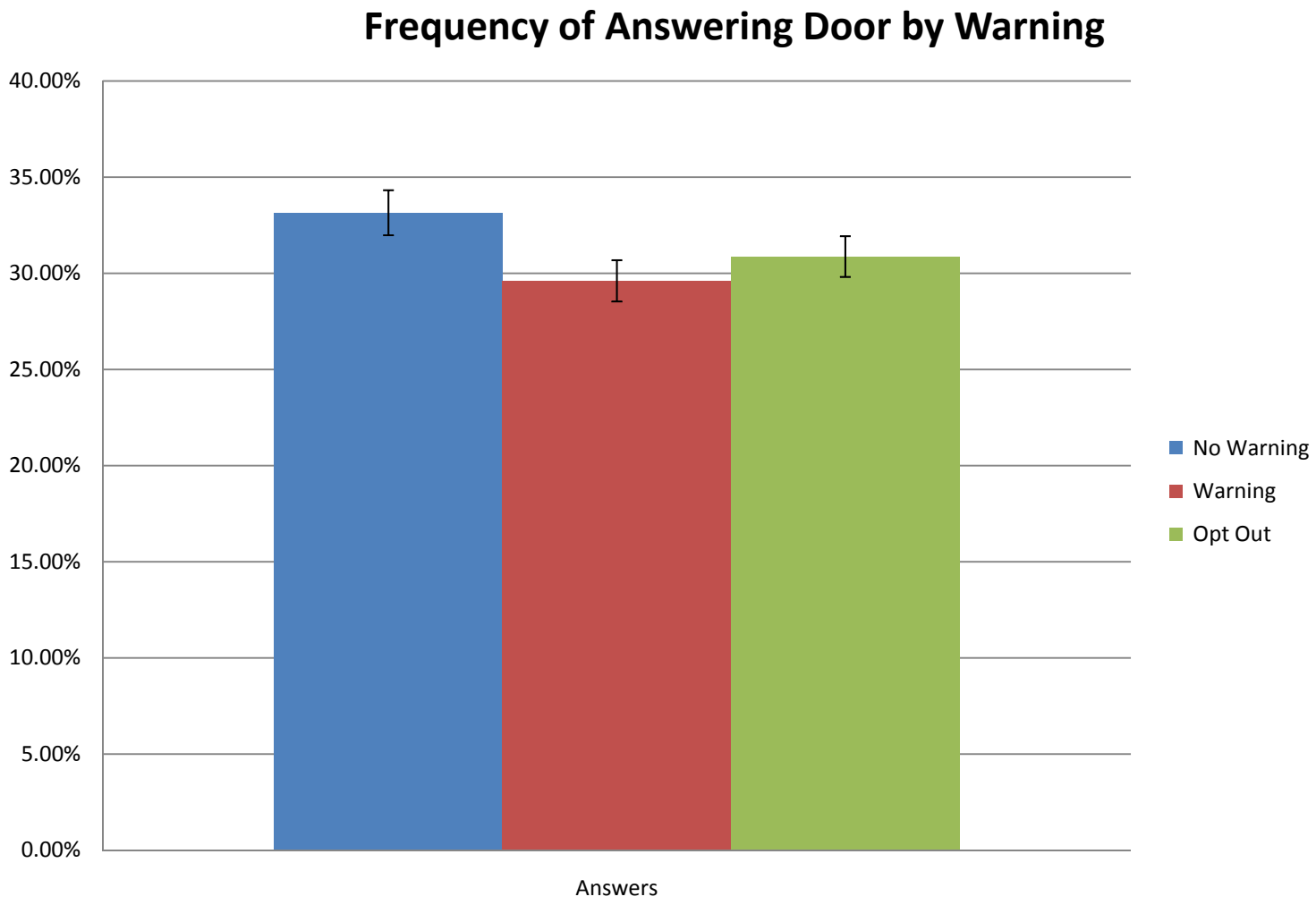
Opt Out (OO)

Experimental Implementation

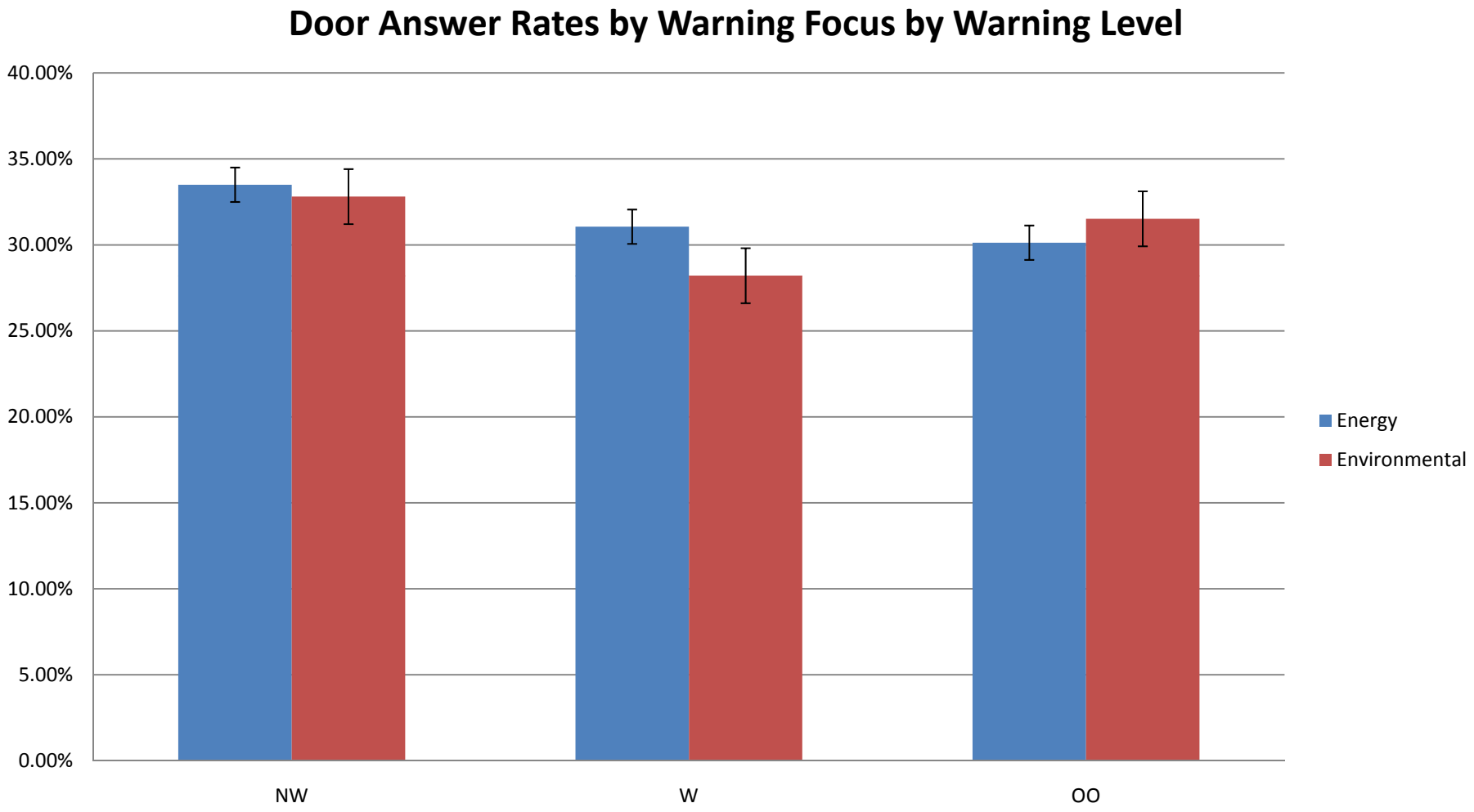
Table 1b: Technology Adoption: Treatment Balance Statistics: Number Knocked Doors

Pressure Level	Payment	No Warning	Warning	Opt Out
Neutral Frame	$1	417	318	338
	$5	334	372	309
Social Norm: Low	$1	149	222	269
	$5	83	293	220
Social Norm: Medium	$1	318	320	345
	$5	313	329	356

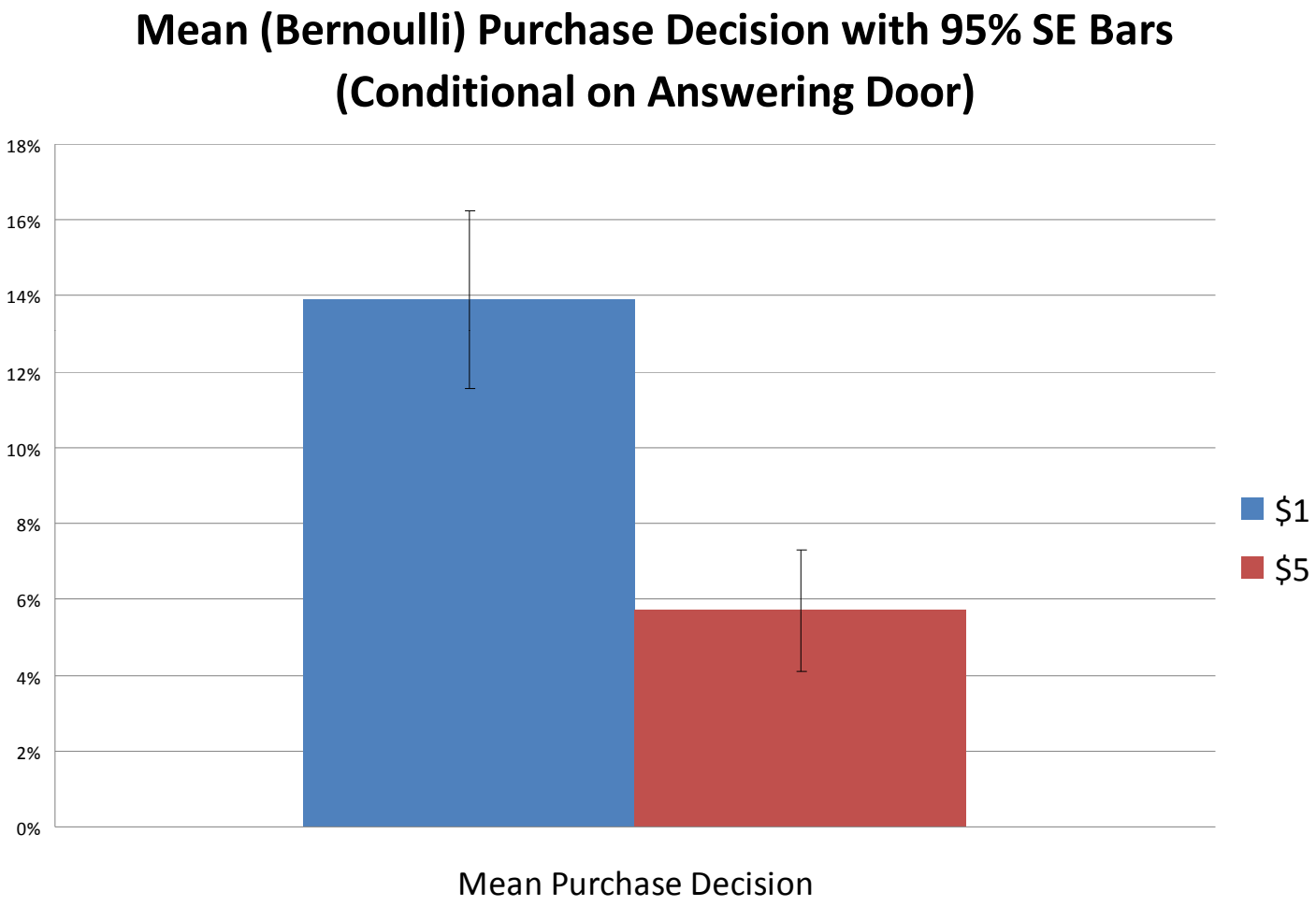
Results


Frequency of Answering Door by Warning
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Answers
No Warning
Warning
Opt Out

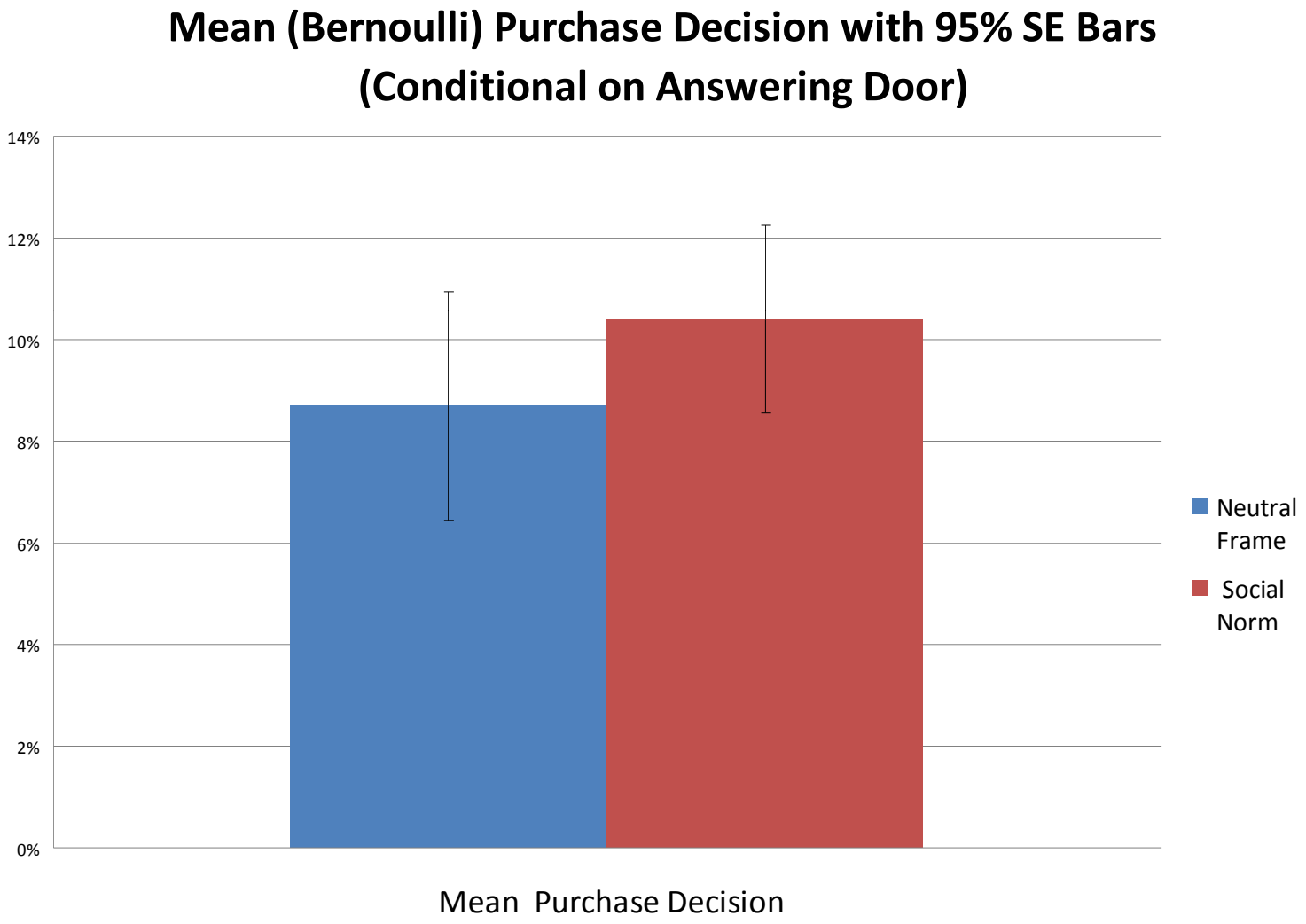
Results


Door Answer Rates by Warning Focus by Warning Level
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
NW
W
OO
Energy
Environmental

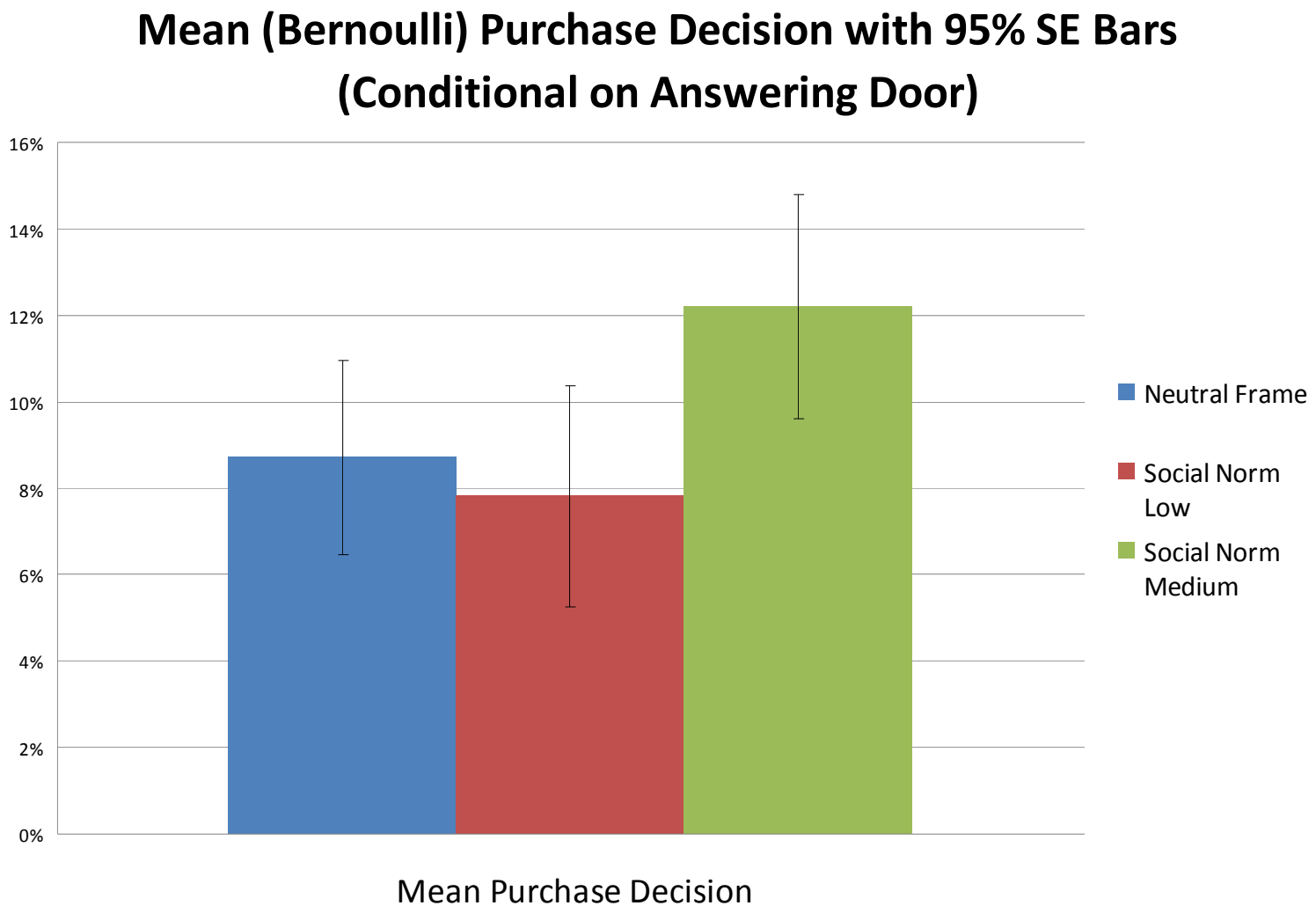
Results


Mean (Bernoulli) Purchase Decision with 95% SE Bars
(Conditional on Answering Door)
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
$1
$5
Mean Purchase Decision

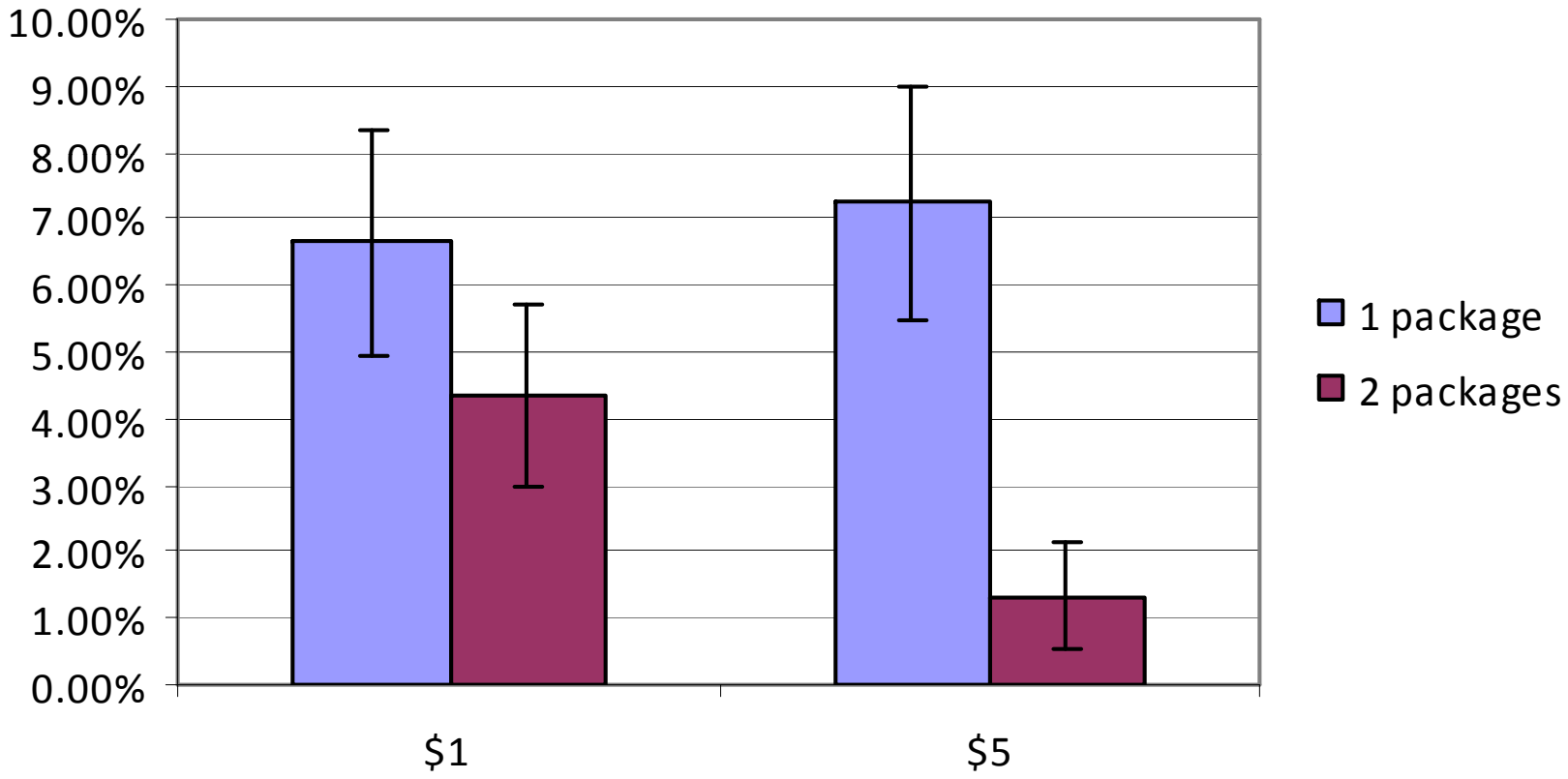
Results


Mean (Bernoulli) Purchase Decision with 95% SE Bars
(Conditional on Answering Door)
14%
12%
10%
8%
6%
4%
2%
0%
Neutral Frame
Social Norm
Mean Purchase Decision

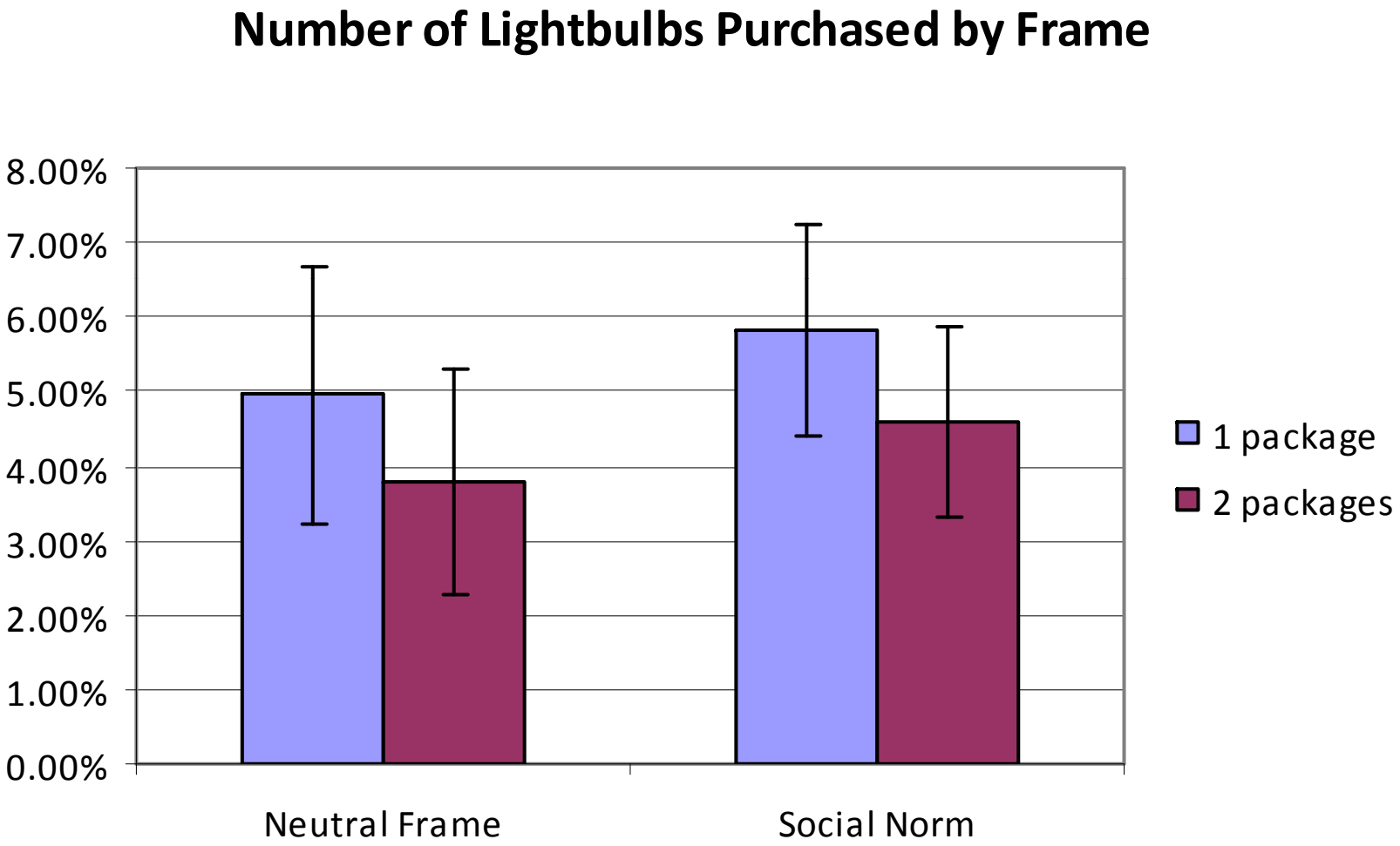
Results


Mean (Bernoulli) Purchase Decision with 95% SE Bars
(Conditional on Answering Door)
16%
14%
12%
10%
8%
6%
4%
2%
0%
Neutral Frame
Social Norm Low
Social Norm Medium
Mean Purchase Decision

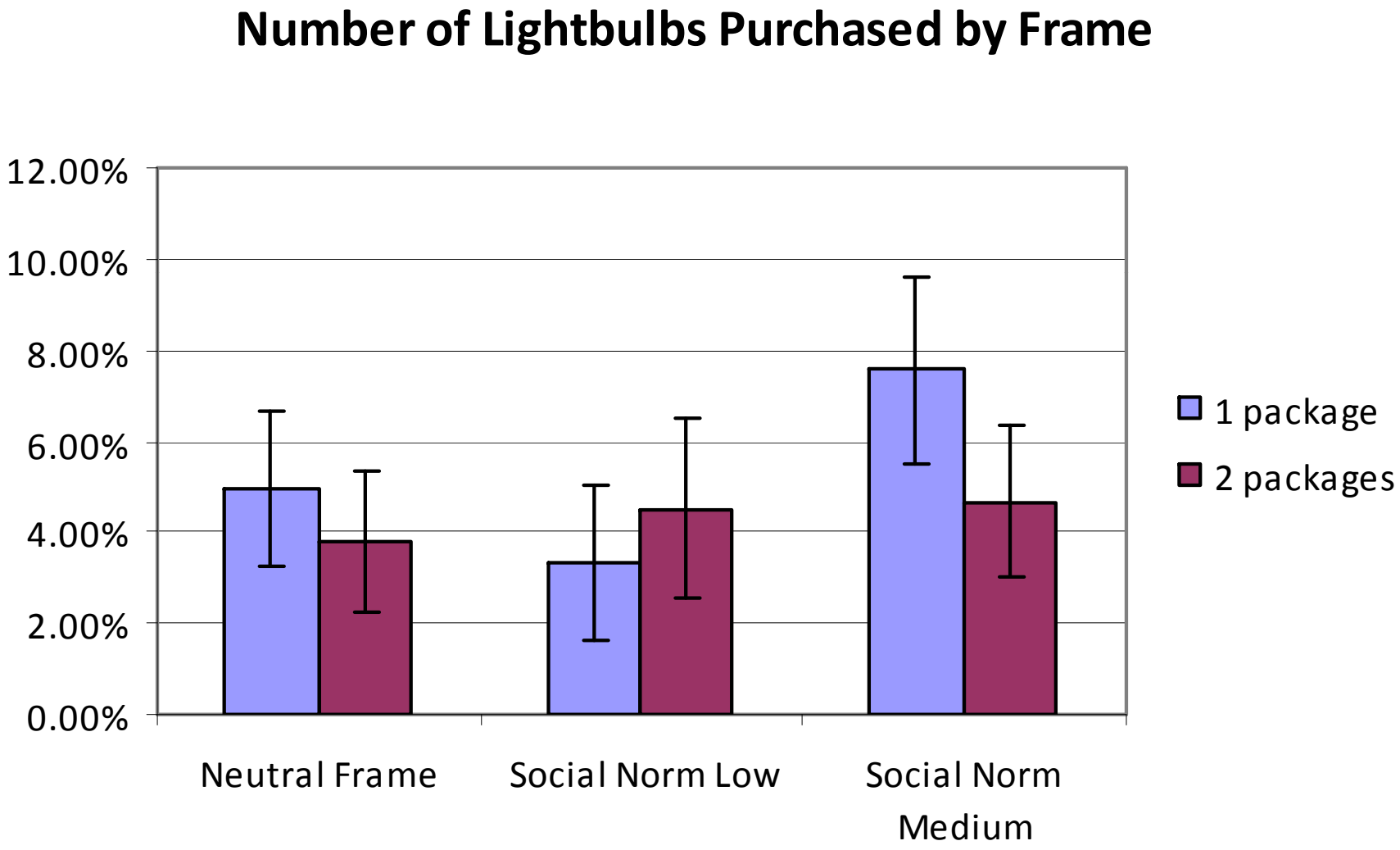
Results


Number of Lightbulbs Purchased by Payment
10.00%
9.00%
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
$1
$5
1 package
2 packages

Results


Number of Lightbulbs Purchased by Frame
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Neutral Frame
Social Norm
1 package
2 packages

Results


Number of Lightbulbs Purchased by Frame
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Neutral Frame
Social Norm Low
Social Norm Medium
1 package
2 packages

Results

	NF	SNL	SNM
Elasticity	-2.53	-4.75	-1.95

	NF->SNL		NF->SNM	
	%ΔQ	*Eqv %ΔP*	%ΔQ	*Eqv %ΔP*
$5	-29.58%	*11.71%*	61.34%	*-24.29%*
$1	11.91%	*-4.72%*	36.82%	*-14.58%*

Work in Progress

- Structural estimation
- Sociology treatment
- Third stage of model: Installation
  - Follow up surveys
  - Offer free installation
  - Work with energy companies

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Results

Table 4a: Technology Adoption: Purchase Decision Given Payment (Conditional on Door Answer)

Payment	Number of Observations	Mean	Standard Deviation
$1	828	.139	.346
$5	823	.057	.232

The two-tailed t-test gives a p-value of $\leq .001$.

Table 4b: Technology Adoption: Purchase Decision Given Pressure (Conditional on Door Answer)

Payment	Number of observations	Mean	Standard Deviation
Neutral Frame	606	.087	.283
Social Norm	1045	.104	.306

The two-tailed t-test gives a p-value of .267.

Table 4c: Technology Adoption: Purchase Decision Given Pressure & Level (Conditional on Door Answer)

Payment	Number of observations	Mean	Standard Deviation
Neutral Frame	606	.087	.283
Social Norm Low	423	.078	.268
Social Norm Medium	622	.122	.328

The two-tailed (binomial) t-test between NP and SNL yields a p-value of .59.
The two-tailed (binomial) t-test between NP and SNM yields a p-value of .046.
The two-tailed (binomial) t-test between SNL and SNM yields a p-value of .

Model

Model follows on Della Vigna, List and Malmendier (2009)

2nd Stage: Purchase decision

$$U(y) = u(m\text{-}p_y y, y) + v(y, G(y)) - s(y)$$

$$G(y) = \sum_{\forall j \neq i} g_j + g_i(y)$$

$$s(y) = s_0 + I_{y=0} \cdot S(\rho, \kappa); \quad S_{\rho/\kappa}(\cdot) > 0$$

$$U'(y) = \begin{cases} -s_0 - S(\rho, \kappa) & \text{if } y = 0 \\ -p_y u_x(\cdot) + u_y(\cdot) + v_y(\cdot) + g_y v_G(\cdot) - s_0 & \text{if } y > 0 \end{cases}$$

Purchase decision is tradeoff:

Social pressure $S(\rho,\kappa)$

vs.

Marginal personal (u_x and u_y) and
Social benefits (v_y and v_G)

Model

1st Stage: Avoidance decision

$$U = \begin{cases} U_0 & \text{not home} \\ \max[U_0 + R, U_0 + A(y)] & \text{home} \end{cases}$$

$$R = -s_0$$

$$A(y) = -p_y u_x(\cdot) + u_y(\cdot) + v_y(\cdot) + g_y v_G(\cdot) - s_0$$

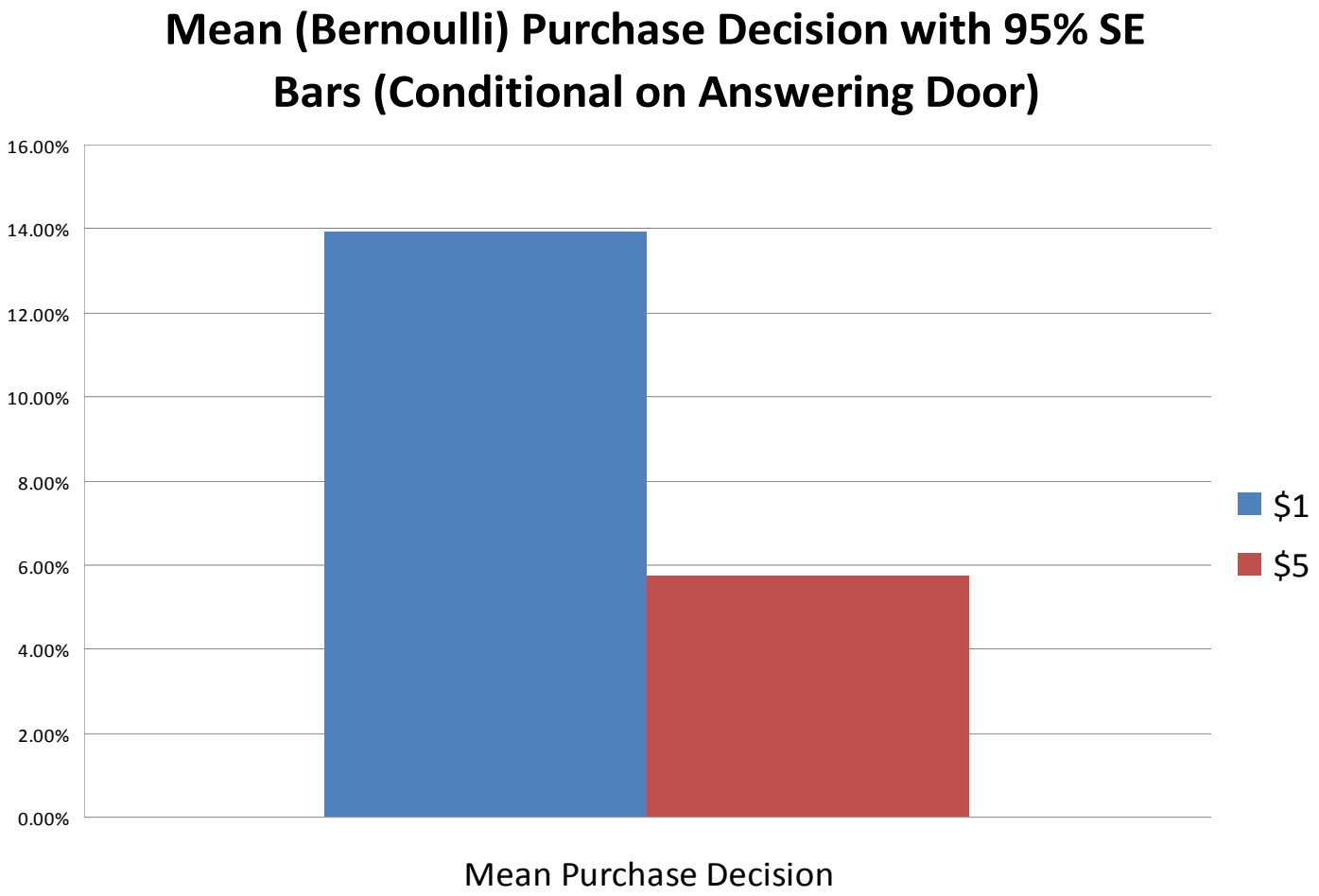
$$\max_h h \cdot \max[U_0 + R, U_0 + A(y)] + (1-h)U_0 - c(h)$$

$$\text{F.O.C}: \ \max[R, A(y)] = c'(h)$$

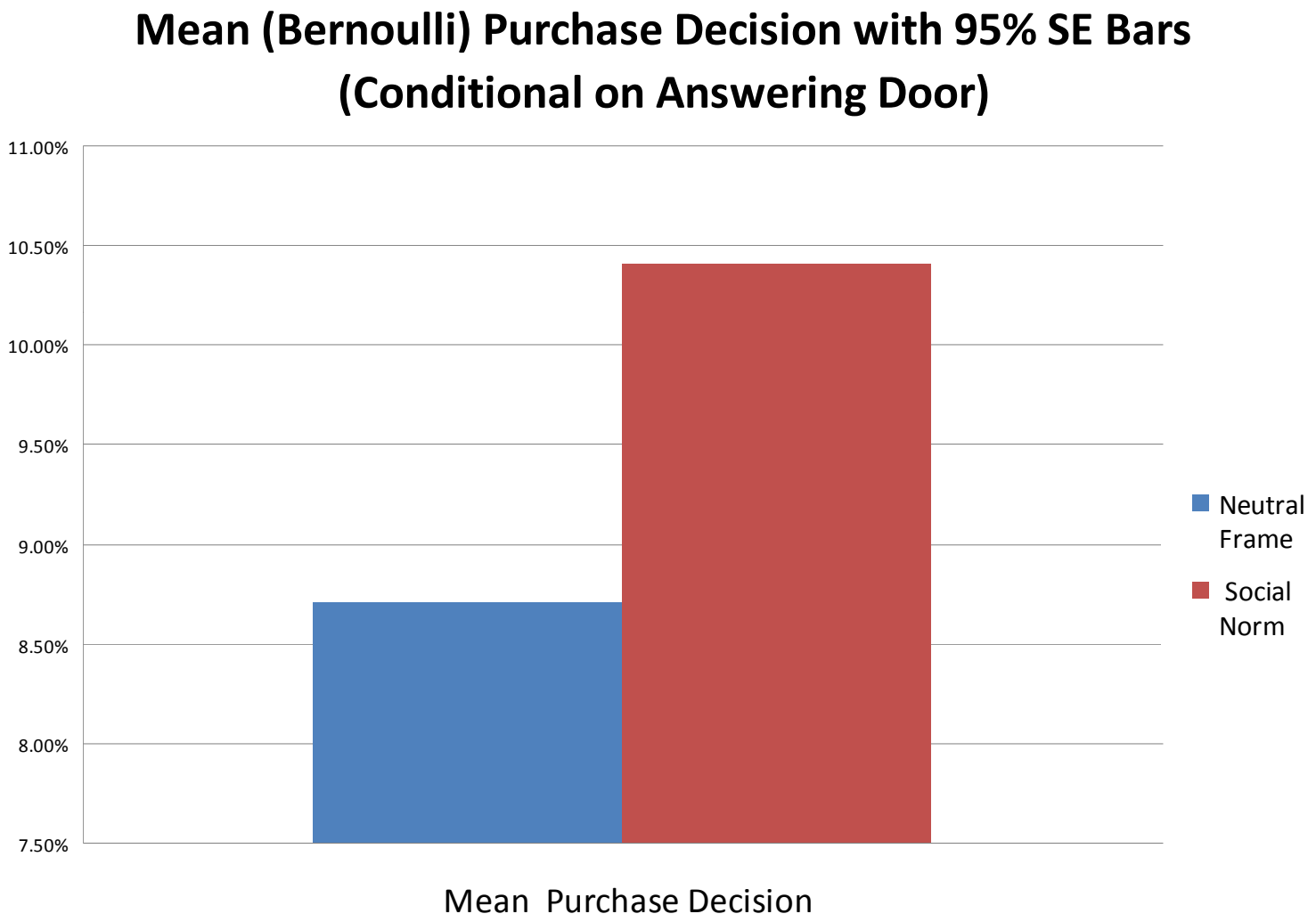
h*is a function of

- Expected disutility of door to door salesperson (s_0)
- Marginal personal benefits (u_x and u_y)
- Marginal social benefits (v_y and v_G)

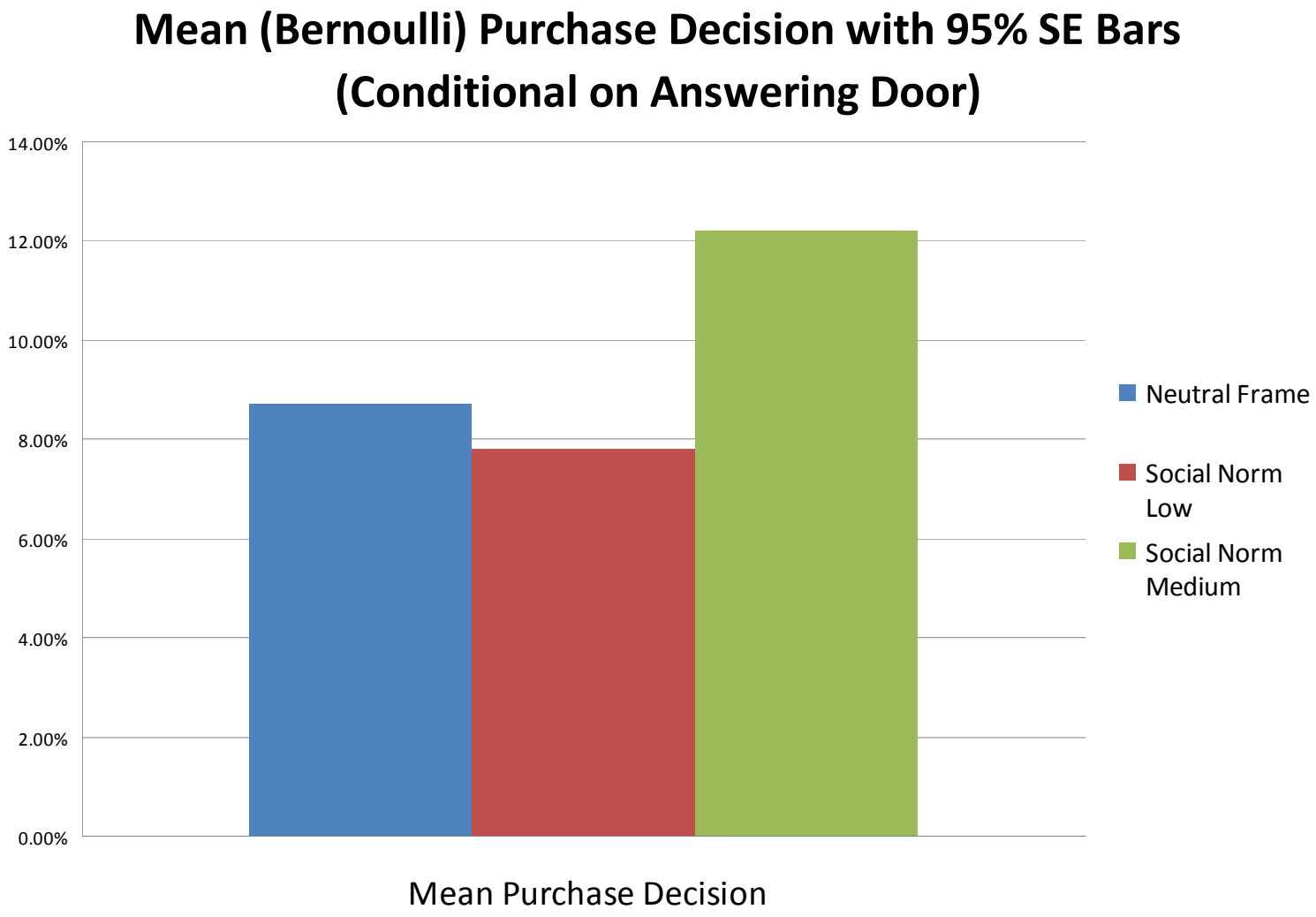
Results


Mean (Bernoulli) Purchase Decision with 95% SE Bars (Conditional on Answering Door)
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
$1
$5
Mean Purchase Decision

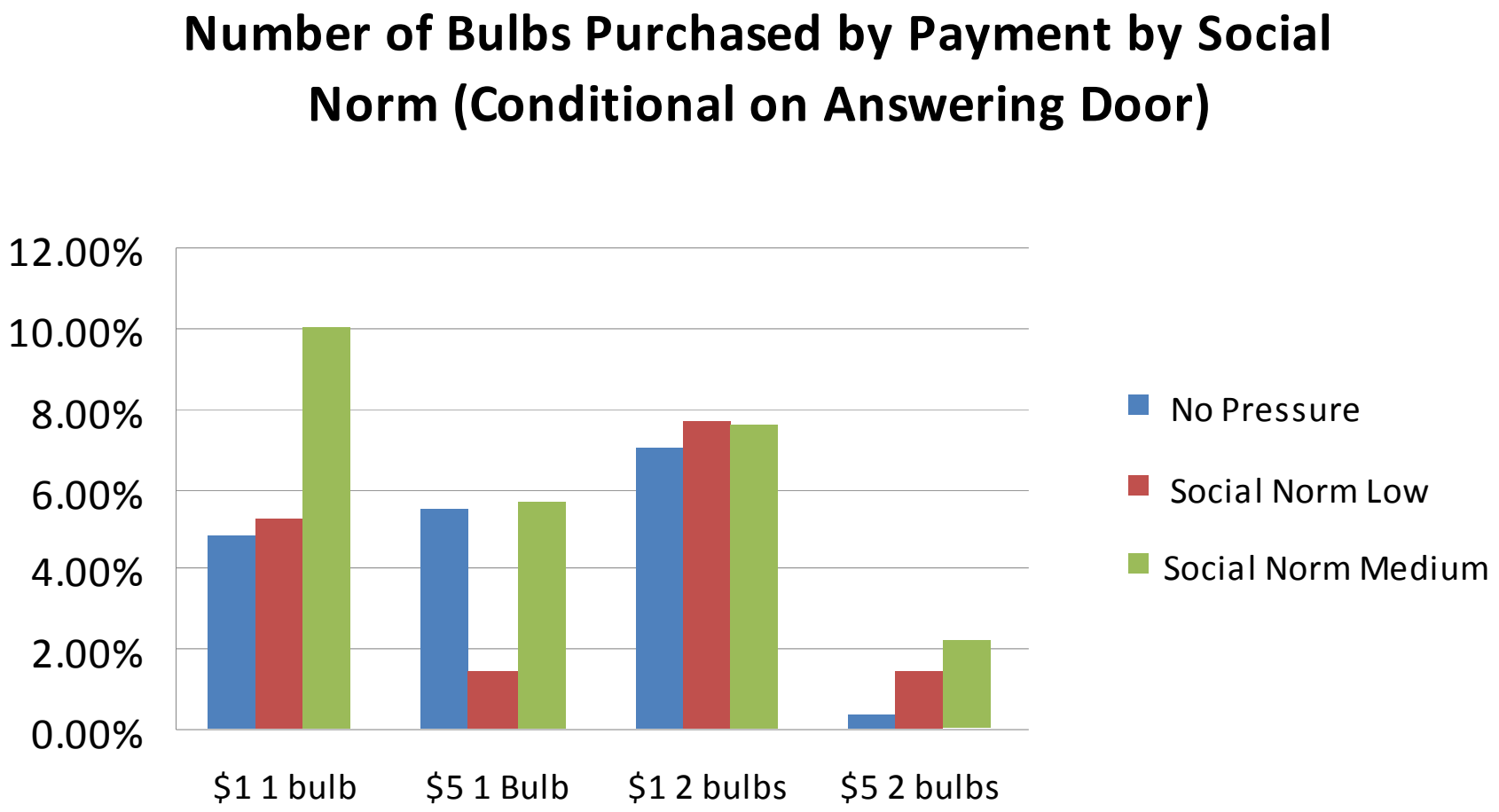
Results


Mean (Bernoulli) Purchase Decision with 95% SE Bars
(Conditional on Answering Door)
11.00%
10.50%
10.00%
9.50%
9.00%
8.50%
8.00%
7.50%
Neutral Frame
Social Norm
Mean Purchase Decision

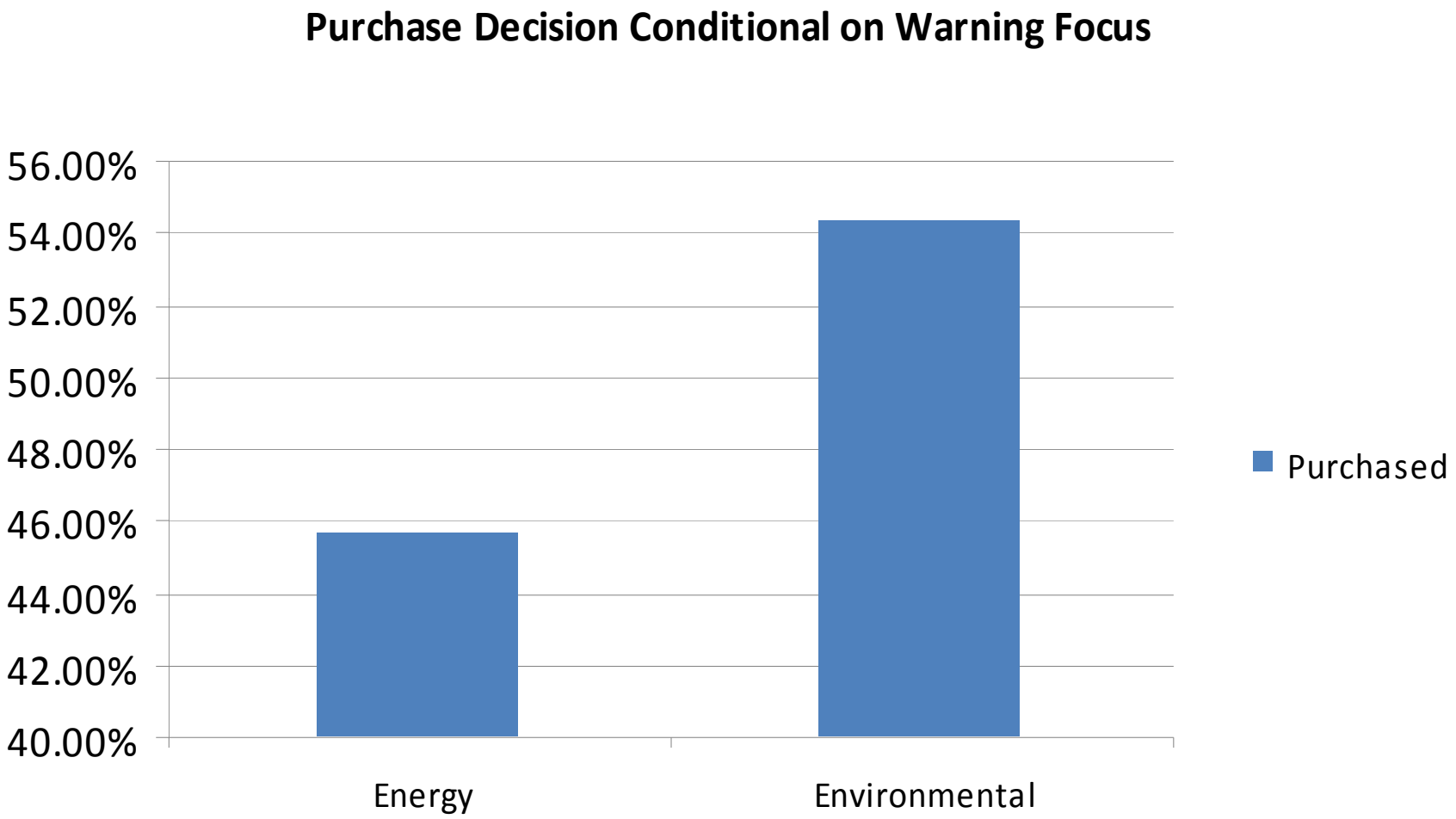
Results


Mean (Bernoulli) Purchase Decision with 95% SE Bars
(Conditional on Answering Door)
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Neutral Frame
Social Norm Low
Social Norm Medium
Mean Purchase Decision

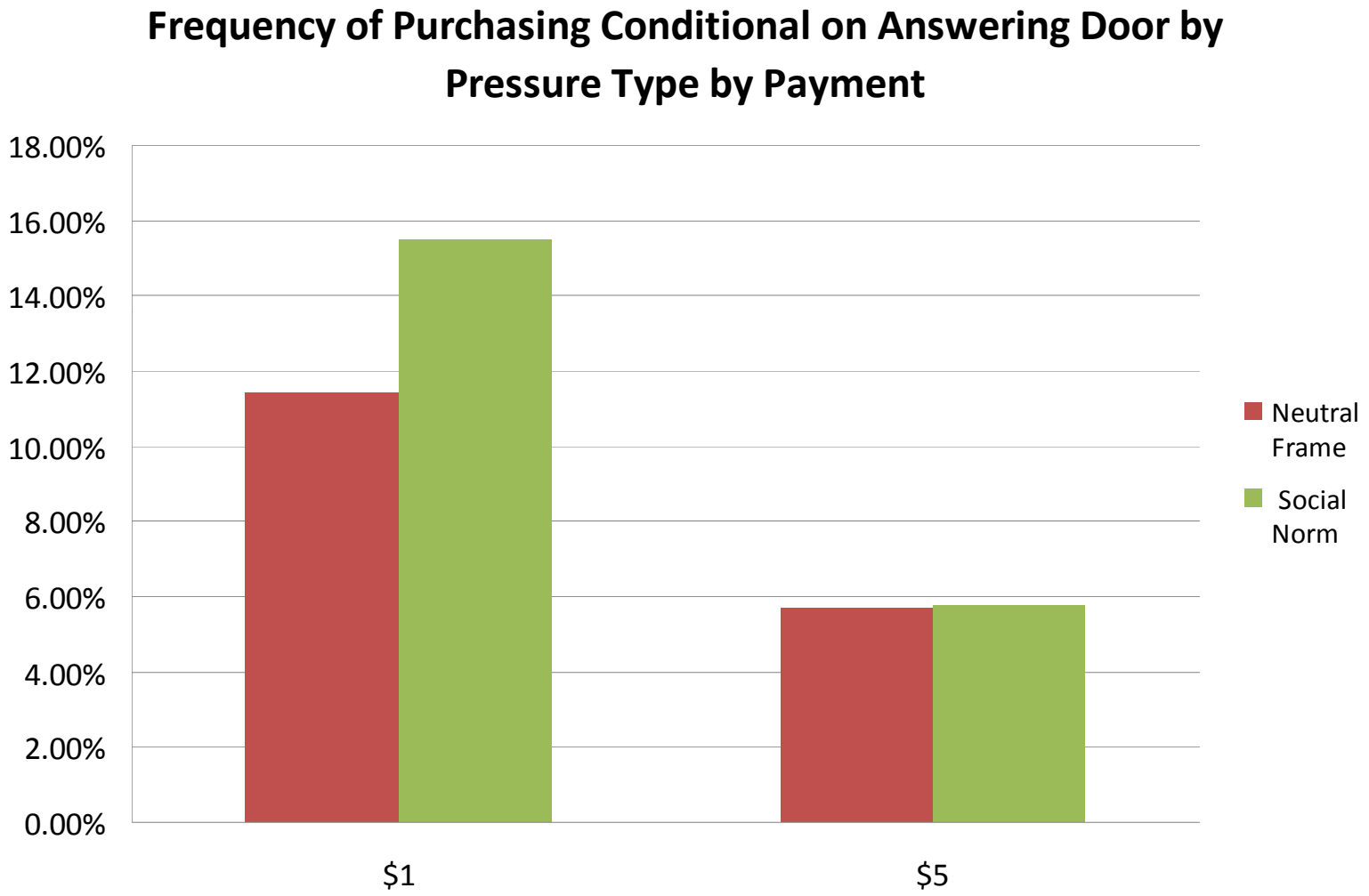
Results


Number of Bulbs Purchased by Payment by Social Norm (Conditional on Answering Door)
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
$1 1 bulb
$5 1 Bulb
$1 2 bulbs
$5 2 bulbs
No Pressure
Social Norm Low
Social Norm Medium

Results


Purchase Decision Conditional on Warning Focus
56.00%
54.00%
52.00%
50.00%
48.00%
46.00%
44.00%
42.00%
40.00%
Energy
Environmental
Purchased

Results


Frequency of Purchasing Conditional on Answering Door by Pressure Type by Payment
18.00%
16.00%
14.00%
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
$1
$5
Neutral Frame
Social Norm

Results

Table 4a: Technology Adoption: Purchase Decision Given Payment

Payment	Number of Observations	Mean	Standard Deviation
$1	2696	.043	.202
$5	2609	.018	.133

The two-tailed t-test gives a p-value of $\leq .001$.

Table 4b: Technology Adoption: Purchase Decision Given Pressure

Payment	Number of observations	Mean	Standard Deviation
No Pressure	2088	.025	.157
Social Norm	3217	.034	.181

The two-tailed t-test gives a p-value of .079.

Table 4c: Technology Adoption: Purchase Decision Given Pressure & Level

Payment	Number of observations	Mean	Standard Deviation
No Pressure	2088	.025	.157
Social Norm Low	1236	.027	.161
Social Norm Medium	1981	.038	.192

The two-tailed t-test between NP and SNL yields a p-value of .817.
The two-tailed t-test between NP and SNM yields a p-value of .018.
The two-tailed t-test between SNL and SNM yields a p-value of .093.

Results

Table 5a: Number Purchased (given 1 or 2) by Payment Status

	0 lightbulbs (3651/3362)	1 lightbulb (55/36)	2 lightbulbs (60/11)
1	96.95%	1.46%	1.59%
5	98.62%	1.06%	.32%

Table 5b: Social Norms & Purchase Number

	0 lightbulbs (2762/4251)	1 lightbulb (30/61)	2 lightbulbs (23/48)
No Pressure	98.12%	1.07%	.8200%
Social Norm	97.50%	1.4%	1.1%

Results

Table 7a: Frequency of Purchasing (unconditional) by Warning by Payment

	$1	$5
No Warning (29/11)	3.28%	1.51%
Warning (51/15)	5.930%	1.51%
Opt Out (35/21)	3.68%	2.37%

Table 7b: Frequency of Purchasing (conditional on answering door) by Warning by Payment

	$1	$5
No Warning [inc oo & athome] (29/11)	9.860% [8.120%]	4.560% [3.700%]
Warning [inc oo & athome] (51/15)	20.73% [16.09%]	4.95% [4.2%]
Opt Out [inc oo & athome] (35/21)	12.15% [9.109%]	7.53% [6.23%]

Table 7c(i): Frequency of Purchasing (unconditional) by Pressure Type

	$1	$5
No Pressure(37/16)	3.45%	1.58%
Social Norm (78/31)	4.810%	1.94%

Table 7c(ii): Frequency of Purchasing (unconditional) by Pressure Type

	$1	$5
No Pressure 1 bulb (15/15)	1.44%	1.49%
Social Norm 1 bulb (40/21)	2.54%	1.34%
No Pressure 2 bulbs (22/1)	2.11%	.1%
Social Norm 2 bulbs (38/10)	2.41%	.64%

Results

Table 7d(i): Frequency of Purchasing conditional on answering door by Pressure Type

	$1	$5
No Pressure (37/16)	11.42%	5.67%
Social Norm (78/31)	15.48%	5.73%

Table 7d(ii): Frequency of Purchasing (unconditional) by Pressure Type

	$1	$5
No Pressure 1 bulb (15/15)	5.12%	5.43%
Social Norm 1 bulb (40/21)	8.66%	4.05%
No Pressure 2 bulbs (22/1)	7.51%	.36%
Social Norm 2 bulbs (38/10)	8.23%	1.93%

Table 7e: Frequency of Purchasing (unconditional) by Warning Type by Social Norm

	No Warning	Warning	Opt Out
No Pressure(17/18/18)	2.26%	2.61%	2.78%
Social Pressure(23/48/38)	2.67%	4.12%	3.19%

Table 7f: Frequency of Purchasing conditional on answering door by Warning Type by Social Norm

	No Warning	Warning	Opt Out
No Pressure(17/18/18)	7.109%	9.140%	10.59%
Social Pressure(23/48/38)	7.770%	13.64%	9.57%

$$U(x,y) = u(x,y \mid q, \bar{y}) + bv(y, G(y)) - s(y)$$

s.t. $m = p_x x + p_y y \rightarrow x = m / p_x - (p_y / p_x) y$

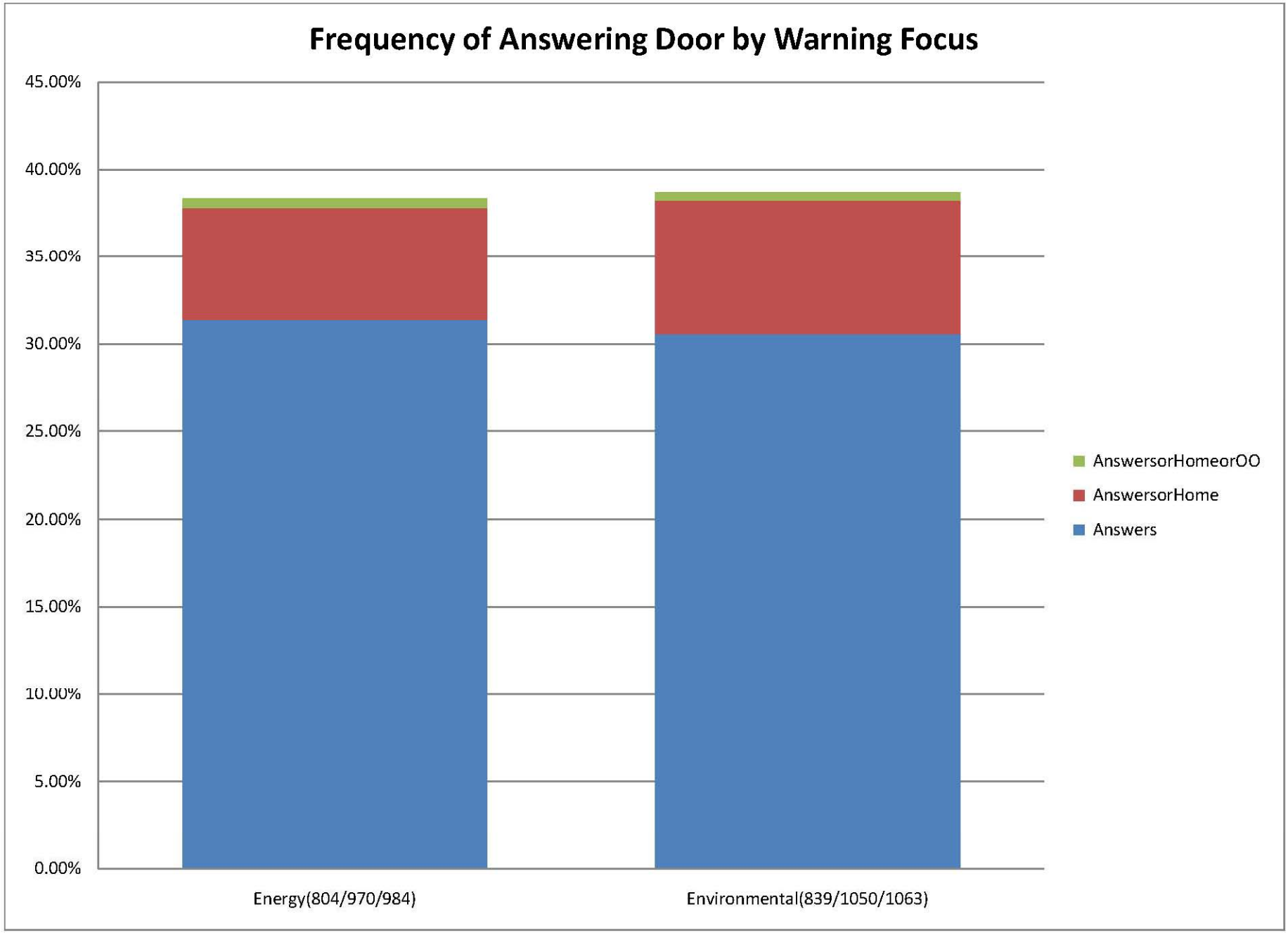

Frequency of Answering Door by Warning Focus
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Energy(804/970/984)
Environmental(839/1050/1063)
AnswersorHomeorOO
AnswersorHome
Answers

Table 3a: Technology Adoption: Treatment Balance Statistics: Pressure Level

No Pressure	2088
Social Norm: Low	1236
Social Norm: Medium	1981

Table 3b: Technology Adoption: Treatment Balance Statistics: Warning Level

No Warning	1614
Warning	1854
Opt Out	1837

Table 3c: Technology Adoption: Treatment Balance Statistics: Warning Focus

Environmental	2562
Energy	2743

Table 3d: Technology Adoption: Treatment Balance Statistics: Payment

$1	2696
$5	2609

Experimental Design

- I am here today to talk to you about reducing your energy usage by using compact fluorescent light bulbs or “CFLs” and to provide you with an opportunity to purchase one.

- May I tell you more about them before offering you up to 2 sets of 4 bulbs for $1.00 each, 80% off their normal price of $5.00?
- May I tell you more about them before offering you up to 2 sets of 4 bulbs at their normal price of $5.00?

- The most important difference between incandescent and fluorescent light bulbs is that fluorescent lights use about 75% less energy than conventional light bulbs and last about 10 times as long, they can save you a substantial amount of money through the reduction in energy consumption – even given their slightly higher cost.