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Strategic ignorance of health risk: its causes and policy consequences

JONAS NORDSTRÖM*

Department of Food and Resource Economics, University of Copenhagen, Copenhagen, Denmark and School of Economics and Management, Lund University, Lund, Sweden

LINDA THUNSTRÖM

Department of Economics, University of Wyoming, Laramie, WY, USA

KLAAS VAN 'T VELD

Department of Economics, University of Wyoming, Laramie, WY, USA

JASON F. SHOGREN

Department of Economics, University of Wyoming, Laramie, WY, USA

MARIAH EHMKE

Department of Agricultural and Applied Economics, University of Wyoming, Laramie, WY, USA

Abstract: We examine the causes and policy implications of strategic (willful) ignorance of risk as an excuse to over-engage in risky health behavior. In an experiment on Copenhagen adults, we allow subjects to choose whether to learn the calorie content of a meal before consuming it and then measure their subsequent calorie intake. Consistent with previous studies, we find strong evidence of strategic ignorance: 46% of subjects choose to ignore calorie information, and these subjects subsequently consume more calories on average than they would have had they been informed. While previous studies have focused on self-control as the motivating factor for strategic ignorance of calorie information, we find that ignorance in our study is instead motivated by optimal expectations – subjects choose ignorance so that they can downplay the probability of their preferred meal being high-calorie. We discuss how the motivation matters to policy. Further, we find that the prevalence of strategic ignorance largely negates the effects of calorie information provision: on average, subjects who have the option to ignore calorie information consume the same number of calories as subjects who are provided no information.

'Sometimes not seeing things can be a blessing.'

– August Strindberg

* Correspondence to: Department of Food and Resource Economics, University of Copenhagen, Rolighedsvej 25, DK-1958 Frederiksberg C, Copenhagen, Denmark. E-mail: jno@ifro.ku.dk

Introduction

The US Food and Drug Administration in 2018 implemented nationwide mandatory calorie labeling on restaurant menus.[1] The policy was prompted by the fact that eating out is on the rise: the amount Americans spend on food away from home has steadily increased since the 1980s and currently constitutes about half of the average household food budget (USDA, 2018). This trend is worrisome from a public health perspective, because restaurant meals typically have higher calorie contents than meals prepared at home, and people who eat out more often therefore generally consume more calories (Guthrie *et al.*, 2002; Mancino *et al.*, 2009; Lachat *et al.*, 2012). Given that currently 70% of the US population is obese or overweight (NCHS, 2018) and that obesity is a major risk factor for numerous serious diseases such as type 2 diabetes, cardiovascular disease, arthritis and several forms of cancer (Pi-Sunyer, 2009), reducing calorie consumption is vital in order to increase public health. The menu-labeling policy aims to encourage consumers to choose low-calorie meals when eating food away from home.

Menu labeling is effective, however, only if consumers pay attention to and use the information conveyed. Current evidence on this is not encouraging. Numerous field studies of local menu-labeling mandates that preceded the federal rule (e.g., at the city level in New York, Nashville and Philadelphia and at the state level in California, Maine, Massachusetts and Oregon) found little or no effect on calorie consumption (Borgmeier & Westenhoefer, 2009; Downs *et al.*, 2009; Elbel *et al.*, 2009, 2011; Bollinger *et al.*, 2011; Vadiveloo *et al.*, 2011; see also Long *et al.* 2015's meta-analysis of 19 studies).

This paper proposes that the limited effectiveness of menu labels may be driven by willful ignorance. Often, people are torn between immediate desires (eating chocolate cake, smoking cigarettes, engaging in risky sex, slacking off work) and the desire to sustain longer-term goals (staying slim and healthy, getting a promotion). Due to these conflicting preferences, engaging in risky consumption may cause emotional discomfort, such as anxiety, guilt or shame. However, there may be a (short-run) way of having your cake and eating it too: strategic ignorance of risks. By willfully ignoring the risks associated with immediate pleasurable activities, people may allow themselves to over-engage in risky consumption.

1 The original rule was issued in 2014 to implement the nutrition labeling provisions of the Patient Protection and Affordable Care Act of 2010, and the compliance date were eventually set to 7 May 2018. See https://www.fda.gov/food/food-labeling-nutrition/menu-and-vending-machine-labeling for details on the policy.

Consistent with this idea, in an experiment involving actual consumption of ready meals, Thunström *et al.* (2016) find that 58% of subjects choose not to learn the calorie content of their preferred meal. Subsequently, these subjects (who in the experiment stay uninformed) consume significantly more calories than either subjects who choose to become informed or subjects who are given the information exogenously. Woolley and Risen (2018) similarly find that 63% of subjects presented with a hypothetical restaurant setting choose not to learn the calorie content of a dessert. When subsequently told the calorie content, these subjects are more likely to order the dessert than are subjects who choose to be informed up front. Both studies propose that calorie information avoidance arises from a desire to give in to the immediate temptation of a tasty but high-calorie meal, suggesting that people with low self-control are more likely to willfully ignore calorie information. Indeed, Thunström (2019) finds that subjects with low self-control in the food realm[2] have a more negative emotional response to calorie information and a lower willingness to pay for a hypothetical meal that comes bundled with such information.

This paper presents the results of an economic laboratory experiment designed to add to the understanding of what motivates willful ignorance, and also to determine the extent to which willful ignorance impacts the effectiveness of mandatory calorie labeling.[3]

With respect to the question of what drives strategic ignorance, we propose that in addition to – and distinct from – low self-control, 'optimal expectations' may play a role. Brunnermeier and Parker's (2005) theory of optimal expectations suggests that people may ignore risk information in order to be able to downplay the probability of a bad future state. The benefits of doing so, in terms of reduced anticipatory anxiety, may outweigh the costs, in terms of reduced ability to plan for the future. Moreover, ignorance may be optimal even if people have no issues with self-control.

2 As measured by the eating self-control measure developed by Haws *et al.* (2016).

3 Our study relates to the body of literature that documents health status information avoidance (Melnyk & Shepperd, 2012; Emanuel *et al.*, 2015; Howell *et al.*, 2016) and the factors that might affect such avoidance (e.g., Howell & Shepperd, 2012, 2013; Lipsey & Shepperd, 2019). More broadly, our study relates to the literature on information avoidance in interpersonal settings, which finds that people may choose ignorance of the impact that their actions have on others as an excuse to be more self-serving (see, e.g., Dana *et al.*, 2007; Larson & Capra, 2009; Matthey & Regner, 2011; Conrads & Irlenbusch, 2013; Feiler, 2014; Grossman, 2014; Thunström *et al.*, 2014; Onwezen & van der Weele, 2016; and Grossman & van der Weele, 2017; see also Sweeny *et al.*, 2010; Hertwig & Engel, 2016; Golman *et al.*, 2017, for general reviews of the literature on information avoidance).

Oster *et al.* (2013) find support for this theory in their study of individuals at genetic risk for Huntington's disease, an incurable degenerative neurological disorder. They find that such individuals tend to avoid predictive testing for the disease and that untested individuals downplay their risk of having the disease, presumably to reduce anticipatory anxiety.

Learning the calorie content of a meal is far less consequential than learning whether one has Huntington's disease. Nevertheless, the same factors are at play: if ignorance of risk enables people to convince themselves that risk is low (the oversized pizza is probably low-calorie), then it may reduce any guilt or anxiety associated with risky behavior (feeling bad about eating the whole thing). People may judge this reduction in negative emotions to be sufficiently desirable in the short term to outweigh any detrimental effect of overconsumption to their long-term health.

To investigate this potential alternative motivation for strategic ignorance about calories, we apply Brunnermeier and Parker's model to a setting in which people receive immediate utility from consuming a meal, while anticipating negative future health consequences that depend on the meal's *ex ante* uncertain calorie content. In such a situation, people who care more about reducing immediate guilt or anxiety than about future health consequences may actively choose to ignore calorie information in order to downplay the meal's calorie content (i.e., they may form 'optimal expectations' of the calorie content). Moreover, if their willful ignorance is indeed caused by optimal expectations, two testable predictions emerge: in an experimental setting where randomly one group of subjects is given information and another group is not, those subjects in the former group who actively choose to ignore the information will on average: (1) consume more of the meal; and also (2) downplay the meal's calorie content to a greater extent than subjects in the latter group, who were not given information to begin with. Both predictions follow because the latter, exogenously uninformed group includes subjects who would want information were it made available. By definition, such subjects care more about the potential health costs of ignorance than about the anxiety-reducing benefits. If information is withheld from these subjects, they are more likely to keep both their optimism and consumption in check in order to avoid negative health consequences.

The data from our experiment confirm, first of all, that strategic ignorance of calorie information is a robust phenomenon: 46% of subjects choose to ignore the calorie content of ready meals and use their ignorance strategically, in the sense of consuming more calories on average than they would have had they been informed. This result aligns with evidence from previous laboratory experiments, as well as with evidence from the field on the effectiveness (or rather lack thereof) of menu-labeling mandates.

Further, we find empirical support for the two above-stated predictions, suggesting that optimal expectations indeed contribute to willful ignorance of calorie information. Moreover, and in contrast to previous studies, we do *not* find that subjects with present-biased preferences or low self-control are more likely to ignore information.

Finally, our experimental design allows us to quantify the extent to which willful ignorance impacts the effectiveness of information policies aimed at reducing risky consumption. We find that the impact is large: willful ignorance largely negates the effects of information provision. In other words, offering people information that is optional (i.e., information that they can choose to ignore) has about the same effect on risky consumption as giving them no information at all.

Theoretical model

Our model translates Brunnermeier and Parker's (2005) model of optimal expectations to our setting of an agent who receives immediate utility from consuming a meal, while anticipating negative future health consequences that depend on the meal's *ex ante* uncertain calorie content.

Let x denote the fraction of the meal that the agent consumes and $e(x)$ the 'enjoyment' that she gains from doing so in the current period 1. Assume $e(0) = 0$, $e'(0) > 0$ and $e''(x) < 0$. Also, let $-f(x)$ denote the negative health consequences from consuming the meal that she will incur in a future period 2 if and only if the meal is high-calorie. Assume $f(0) = 0$, $0 \leq f'(0) < e'(0)$ and $f''(x) \geq 0$. If the agent is uninformed about the meal's calorie content, then what Brunnermeier and Parker call her 'felicity' in period 1 is

$$\hat{E}\, U_1 = e(x) - \delta\, \hat{p} f(x),$$

where $\hat{E}$ is the subjective expectations operator associated with the subjective probability $\hat{p}$ that the meal is high- rather than low-calorie, δ is the agent's discount factor and $\delta \hat{p} f(x)$ is the agent's *anticipatory* disutility (in the form of anxiety) experienced during period 1 from considering the potential future health consequences if the meal is high-calorie.

The agent chooses x so as to maximize this felicity, with solution $x^n(\hat{p})$ (superscript 'n' for 'not informed') given by

$$e'(x^n) - \delta\, \hat{p} f'(x^n) = 0. \tag{1}$$

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Note that by the Implicit Function Theorem

$$\frac{dx^n}{d\hat{p}} = \frac{\overbrace{\delta f'(x^n)}^{(+)}}{\underbrace{e''(x^n) - \hat{p}\delta f''(x^n)}_{(-)}} < 0, \tag{2}$$

i.e., the higher the subjective probability that the agent places on the meal being high-calorie, the less she consumes.

Given her period-1 choice of x^n, the agent's felicity in period 2 if the meal turns out to be low-calorie is

$$\hat{E}U_2^{\ell} = e(x^n),$$

and if it turns out to be high-calorie, the agent's felicity in period 2 is

$$\hat{E}U_2^{h} = e(x^n) - \delta f(x^n).$$

In these expressions, $e(x^n)$ is what Brunnermeier and Parker refer to as the agent's 'memory utility' from period 1 and $f(x^n)$ is the agent's *realized* utility in period 2 if the meal is high-calorie.

Central to Brunnermeier and Parker's theory is the assumption that the agent chooses subjective probability $\hat{p}$ in period 1 so as to maximize her 'wellbeing', which is defined as the expected time average of her felicity. In our two-period setting, her wellbeing is

$$\mathcal{W}^n = E\left[\frac{1}{2}(\hat{E}U_1 + \hat{E}U_2)\right],$$

where E denotes what Brunnermeier and Parker refer to as the *objective* expectations operator, associated with the *objective* probability p that some state of the world obtains. In our setting, where the meal's calorie content is uncertain only in the sense of it being unknown to the agent, the relevant analog to that objective probability is the subjective prior probability p that the agent starts out with, before she engages in self-deception through choosing a value $\hat{p}$ different from p. Substituting from above yields

$$\begin{aligned} \mathcal{W}^n &= (1-p)\left[\frac{1}{2}(\{e(x^n) - \delta\hat{p}f(x^n)\} + \{e(x^n)\})\right] \\ &\quad + p\left[\frac{1}{2}(\{e(x^n) - \delta\hat{p}f(x^n)\} + \{e(x^n) - \delta f(x^n)\})\right] \\ &= e(x^n) - \delta\hat{p}f(x^n) + \frac{1}{2}(\hat{p} - p)\delta f(x^n). \end{aligned} \tag{3}$$

The agent's optimal $\hat{p}$ therefore solves

$$\max_{\hat{p}} \mathcal{W}^n = e(x^n) - \delta \hat{p} f(x^n) + \frac{1}{2}(\hat{p} - p)\delta f(x^n) \text{ subject to } \hat{p} \in [0, 1],$$

where $x^n = x^n(\hat{p})$. Using (1) and (2) yields that the solution is given by the first-order condition

$$\frac{\partial \mathcal{W}^n}{\partial \hat{p}} = -\frac{1}{2}\delta f(x^n) + \frac{1}{2}\delta(\hat{p} - p)f'(x^n)\frac{dx^n}{d\hat{p}} \leq 0, \text{ if } <, \text{ then } \hat{p} = 0. \quad (4)$$

Note that the condition can hold with equality only if $\hat{p} < p$. If the agent chooses not to become informed about the meal's calorie content, she will therefore optimally reduce her subjective probability $\hat{p}$ that the meal is high-calorie, possibly all the way to zero. The benefit of doing so, captured by the first term of the condition, is that it reduces the agent's subjective, anticipatory disutility in period 1. The cost, however, captured by the second term, is that it increases her future *objective* disutility through increasing her consumption x^n and thereby worsening expected future health consequences.

Now suppose that the agent has the option of learning the meal's calorie content before choosing x. The benefit of doing so is that she can then optimally tailor her consumption level to the calorie level. The cost, however, is that she can no longer choose subjective probability $\hat{p}$ so as to modify her anticipatory disutility.

More specifically, when considering the option to become informed, the agent will realize that, if she learns that the meal is low-calorie, her period-1 felicity will just equal her enjoyment of the meal

$$U_1 = e(x).$$

Her optimal choice x^{ih} (superscript '*ih*' for 'informed that the meal is healthy') will therefore be given by

$$e'(x^{ih}) = 0. \quad (5)$$

As a result, her period-2 felicity will be the memory utility from that enjoyment

$$U_2 = e(x^{ih}).$$

If, in contrast, she learns that the meal is high-calorie, her period-1 felicity will be

$$U_1 = e(x) - \delta f(x),$$

since she will anticipate the negative health consequences of her consumption.

Her optimal choice x^{iu} (superscript '*iu*' for 'informed that the meal is unhealthy') will be given by

$$e'(x^{iu}) - \delta f'(x^{iu}) = 0, \tag{6}$$

and her period-2 felicity will equal the memory utility from her enjoyment less the realized health consequences

$$U_2 = e(x^{iu}) - \delta f(x^{iu}).$$

Combining the two possible outcomes, we have that the agent's *ex ante* well-being if she becomes informed is

$$\mathcal{W}^i = E\left[\frac{1}{2}(U_1 + U_2)\right] = (1-p)e(x^{ih}) + p[e(x^{iu}) - \delta f(x^{iu})]. \tag{7}$$

The agent's decision of whether to stay ignorant or become informed depends on the comparison between $\mathcal{W}^n$ and $\mathcal{W}^i$. Which of the two is larger, and hence whether the agent chooses to become informed when given the opportunity, will depend on parameters. Specifically, if we make the simplifying assumption that both consumption benefits $e(x)$ and costs $f(x)$ are close to quadratic (so third-order effects can be ignored), we obtain the following results[4]:

Proposition. *If agents are heterogeneous in terms of the weight* δ *that they place on future consequences of calorie consumption and some choose to become informed while others choose to remain ignorant, it is agents with low* δ *who will choose ignorance.*

Corollary. *Agents who self-select into ignorance will have more optimistic expectations (i.e., lower* $\hat{p}$*) and higher consumption levels than agents who are forced to be uninformed.*

The proof of both results is relegated to the Appendix. The underlying intuition is straightforward, however. Agents who place a high weight on δ on the future care relatively less about the immediate benefit of ignorance in terms of reducing anticipatory disutility and care relatively more about the future cost in terms of potentially worse health outcomes; they are therefore more likely to choose to become informed. Moreover, if becoming informed is not an option, agents with high δ are more likely to keep their optimism and consumption in check in order to avoid negative health consequences.

4 The proposition is analogous to proposition 3 of Oster *et al.* (2013), which shows that testing for Huntington's disease is optimal only for individuals who place low weight on anticipated utility.

In our experimental setting, where randomly one group of subjects is given optional information and another group is not, we should therefore expect subjects in the former group who actively choose to ignore the information to on average: (1) consume more of the meal; and also (2) downplay the meal's calorie content to a greater extent than subjects in the latter group, who were not given such information to begin with.[5]

Experimental design

We recruited 201 subjects from the general population in the Copenhagen area to participate in an hour-long experiment session during lunchtime (starting at noon). Participants were paid DKK 300 (around USD 50). When recruited to the experiment, the subjects were told that they should not eat lunch before the experimental session.

Our experimental design builds on that in Thunström *et al.* (2016). The experiment uses ready meals as the risky good. Ready meals are ideal for our purposes, since they are fairly transparent in immediate pleasure (taste), but non-transparent in future harm (calories).[6] Ready meals thus provide scope for ignoring information about the harm from consumption.

All subjects were offered a choice between two meals: chicken with salad and pasta (500 calories) or roast beef with salad and quinoa (890 calories). Subjects were informed that one of the meals was high-calorie and that the other meal was low-calorie, and they were told the specific calorie numbers, but not initially which meal was which.[7] The two meals were placed on the desk in

5 Oster *et al.* (2013) end up examining – and finding evidence in support of – different implications of their theory. One is that subjects with a lower objective probability of having Huntington's disease (based on independent investigators' assessments of symptoms) should be more likely to avoid testing. The other is that, when it comes to major life decisions whose future consequences differ by Huntington's disease status – decisions such as whether to get married, have children or retire early – untested individuals should behave more similarly to subjects who have tested negative for the Huntington's disease mutation than to subjects who have tested positive. Our setting is different and therefore does not allow us to test analogs of either implication. We cannot elicit subjects' priors on which meal is high-calorie – the analog of the objective probability of having Huntington's disease – because doing so would contaminate our results. In addition, the closest analog in our setting to testing negative for the Huntington's disease mutation (respectively positive) would be for a subject who prefers the chicken (beef) meal to find out that it is low-calorie (high-calorie); behavioral responses to either outcome would clearly be confounded with taste preferences.

6 Most people find it difficult to guess the calorie contents of ready meals; see Burton *et al.* (2006).

7 Telling subjects the specific calorie numbers is an important design feature of the experiment, because people tend to underestimate the amount of calories in ready meals, even if they do not anticipate consuming those meals (Burton *et al.*, 2006). Our design preempts this tendency, while still leaving scope for 'optimal expectations' behavior: subjects who choose not to find out which meal is which can downplay the probability of their preferred meal being high-calorie.

front of each subject together with a pitcher of water. The desks had dividers, so that subjects were unable to see each other's meal choices or how much of the meals others consumed.

The experiment was conducted in the following eight steps.

Step 1

Subjects rated the expected taste of both meals (1 = very bad, 5 = very good).

Step 2

Subjects chose their preferred meal.

Step 3

Subjects in the treatment and control informed groups were informed that they had the opportunity to revise their meal choice. The 96 subjects in the treatment group were given the opportunity to learn the meals' calorie contents by choosing to open an envelope containing that information. If they did not want to know the calorie contents of the meals, they opened another envelope that contained an empty sheet of paper. The 53 subjects in the control informed group were told the meals' calorie contents both verbally and on paper. The 52 subjects in the control uninformed group were told nothing about the specific meals' calorie contents.

Step 4

Subjects in the treatment and control informed groups were offered the opportunity to revise their meal choice.

Step 5

Subjects in the control informed and control uninformed groups were asked if they would have avoided/taken calorie information had they had the opportunity to do so.

Step 6

The meal not chosen by the subject was removed from the subject's desk, and subjects finished their meal while answering survey questions pertaining to self-control, risk preferences, health concerns, exercise and sociodemographics.

Step 7

After finishing their meal, subjects were asked how many calories they thought were contained in the meal they had consumed and how many calories they thought they had consumed.

Step 8

Subjects were weighed and measured, and their leftover food was weighed in order to determine their calorie consumption.[8]

For descriptive statistics on the variables collected from the experiment, see Tables 1 and 2. To assess self-control, we used the brief self-control scale in Tangney *et al.* (2004). Items coded negatively (so that a high score indicates low self-control) on that scale were recoded positively, so that the final measure ranges from 13 (very low self-control) to 91 (very high self-control). To assess risk preferences, we used the incentivized measure developed by Eckel and Grossman (2008) to estimate subjects' coefficient of relative risk aversion. Health concern was measured on a Likert scale indicating agreement with the statement 'I care a lot how healthy food is' (1 = totally disagree, 7 = totally agree). The last two columns of Table 2 show that in terms of demographics or other characteristics, treatment group subjects did not differ significantly from control group subjects.

Empirical results

Evidence of ignorance being strategic

As shown in Table 3, 46% of the subjects in the treatment group chose to ignore the calorie information. In the standard expected utility model, without optimal expectations, agents would choose to ignore costless information only if they anticipate that learning the information would not change their behavior, making them exactly indifferent about learning it or not. The implication is that, if information were given to these agents exogenously, their behavior would not change. The most straightforward way to determine whether the treatment group subjects' voluntary ignorance is consistent with standard expected utility theory is therefore to compare their consumption

8 The experiment was carried out from April to June in 2015. Each experimental session contained 10 participants. Sessions were conducted at the same time of day throughout the experimental period. Further, sessions from the three treatment groups were evenly distributed over the period in order to minimize any possible seasonal effects.

Table 1. Descriptive statistics, full sample.

	Mean	SD	Minimum	Maximum
Self-control	57.71	9.97	35.0	88.2
Coefficient of relative risk aversion	0.900	1.100	0.025	3.900
Health concern	4.09	1.38	1	7
Sports (hours/week)	2.02	2.85	0	21
Female	0.50	0.50	0	1
Age	45.46	13.42	19	66
Above-average income	0.52	0.50	0	1
Some college education	0.68	0.47	0	1

Table 2. Descriptive statistics by group.

	Treatment		Control informed		Control uninformed		T-Ci	T-Cu
	Mean	SD	Mean	SD	Mean	SD	t-test	t-test
Self-control	58.17	10.32	59.45	10.14	55.17	8.75	–0.72	1.78*
Coefficient of relative risk aversion	0.89	1.10	0.75	1.01	1.07	1.20	0.79	–0.90
Health concern	4.06	1.41	4.13	1.46	4.12	1.28	–0.30	–0.26
Sports (hours/week)	2.29	3.36	2.24	2.59	1.31	1.83	0.09	1.92*
Female	0.47	0.50	0.57	0.50	0.50	0.50	–1.13	–0.36
Age	45.38	13.66	44.87	14.10	46.21	12.43	0.21	–0.37
Above-average income	0.50	0.50	0.55	0.50	0.51	0.51	–0.59	–0.12
Some college education	0.62	0.49	0.72	0.45	0.73	0.45	–1.13	–1.30

*$p < 0.10$.
T-Ci = treatment – control informed; T-Cu = treatment – control uninformed.

to that of control informed subjects who, had they been given the option, would have chosen ignorance as well.

If we use the answers provided in Step 5 of the experiment to perform this analysis, we find strong evidence that voluntary ignorance results not from indifference, but is strategic: subjects who chose to ignore calorie information in the treatment group (44 subjects) consumed on average 501 calories, while subjects in the control informed group who claimed they would have ignored information (10 subjects) consumed on average 301 calories. A two-tailed t-test rejects equality of these values ($p = 0.018$). However, the share of control informed subjects who claimed they would have chosen ignorance

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Table 3. Average calorie consumption by group.

	n	Calories
All	201	480
Treatment	96	495
– Chose information	52 (54%)	491
– Chose no information	44 (46%)	501
Control informed	53	400
– Would have chosen information	43 (81%)	423
– Would have chosen no information	10 (19%)	301
Control uninformed	52	532
Beef lovers	121	565
Treatment	59	585
– Chose information	34 (58%)	544
– Chose no information	25 (42%)	642
Control informed	26	458
Control uninformed	36	608
Chicken lovers	80	351
Treatment	37	352
– Chose information	18 (49%)	390
– Chose no information	19 (51%)	315
Control informed	27	345
Control uninformed	16	360

(10/53; i.e., 19%) is substantially lower than that of treatment subjects who actually chose ignorance (44/96; i.e., 46%). We therefore perform an additional analysis, using the same approach as Thunström *et al.* (2016). We focus thereby on 'beef lovers' – subjects who initially, in Step 2 of the experiment, chose the beef meal over the chicken meal. Because the beef meal was the higher-calorie one, it is these subjects who were most likely to respond to information revealing calorie content by either reducing their consumption of the beef meal or switching to the lower-calorie chicken meal.

Figure 1a shows kernel density estimates of ultimate calorie consumption by beef lovers in all three experimental groups. The figure indicates a clear shift towards higher consumption when beef-loving subjects are allowed to ignore calorie information (because they are in the treatment group) compared to when they are given the information exogenously (because they are in the control informed group). This shift is confirmed by a Kolmogorov–Smirnov (KS) test for equality of the treatment and control informed distributions, which strongly rejects the null of equality ($p = 0.011$). Similarly, a two-tailed t-test comparing average calorie consumption across the two groups – 585 for treatment group beef lovers versus 458 for control informed ones – strongly rejects the null of equal means ($p = 0.022$).

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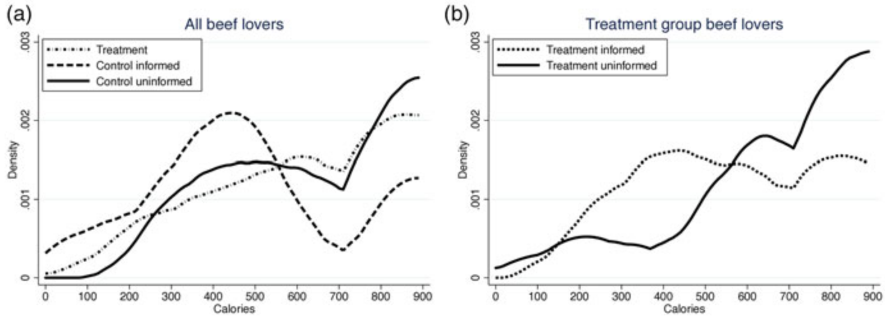

Figure 1. Calorie consumption of (a) all beef lovers and (b) treatment group beef lovers.

Figure 1b indicates, moreover, that the overall higher consumption by treatment group beef lovers is driven by subjects in that group who chose ignorance; those who chose to learn the calorie information consume about the same as subjects given information exogenously (i.e., the control informed subjects in Figure 1a). This is confirmed by a KS test, which fails to reject equality of the treatment informed and control informed subjects' calorie consumption distributions ($p = 0.183$). Similarly, a two-tailed t-test comparing the two groups' average calorie consumption levels – 544 for treatment informed beef lovers versus 458 for control informed ones – fails to rejects the null of equal means ($p = 0.143$).[9]

These results provide support for the prevalence of strategic ignorance, confirming the previous findings of Thunström *et al.* (2016), Woolley and Risen (2018) and Thunström (2019).

Evidence on ignorance being motivated by 'optimal expectations'

To investigate whether the observed voluntary ignorance of treatment group subjects might be motivated by the ability to then form optimal expectations about risk (future health costs), subjects were asked how many calories they thought were contained in the meal they had consumed. Responses to this question were not incentivized. Although incentives generally reduce noise in the data, incentivizing responses to this particular question might bias our results. We are specifically interested in people's ability to 'fool themselves',

9 Admittedly, because the two groups are small, significant differences are hard to detect: for a power level of 0.80 and a significance level of 0.05 (0.10), the minimum detectable effect size (i.e., the smallest true difference between the groups' average consumption levels that the t-test would detect as significantly different from zero at least 80% of the time) is 166 (147) calories.

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Table 4. Subjects' estimates of calories in their chosen meals.

	Treatment uninformed			Control uninformed			Tu-Cu	
	n	Mean	SD	*n*	Mean	SD	t-test	WMW test
All subjects	35	550	234	50	650	198	–2.13**	–2.361***
Beef lovers	20	540	212	36	635	187	–1.73**	–2.220**
Chicken lovers	15	563	268	14	689	227	–1.36*	–1.259

*p < 0.10, **p < 0.05, ***p < 0.01.
Tu-Cu = treatment uninformed – control uninformed; WMW = Wilcoxon–Mann–Whitney.

and incentives to accurately guess calorie intake might, by adding a cost to fooling oneself, provide an inaccurate picture of people's behavior when no such incentives are present. Further, under the null hypothesis that subjects do *not* form optimal expectations about calorie intake, there is no reason to believe that any noise in non-incentivized responses would tend to skew in any direction.

As shown in Table 4, the average estimate of subjects in the treatment uninformed group was 550 calories, while that for subjects in the control uninformed group was 650 calories. We also break down the data by beef lovers and chicken lovers (i.e., subjects who chose the beef salad or the chicken salad in Step 2 of the experiment).[10] Estimates by beef lovers and chicken lovers considered separately were similar. Importantly, the finding that these estimates are below the average $(0.5 \times (500 + 890) = 695)$ calorie content of the two meals need in itself not imply that these subjects engaged in optimal expectations. Rather, it may reflect some heterogeneity in the prior probability that subjects placed on which meal was high-calorie, combined with a general tendency to prefer low-calorie meals.

Any significant difference between the treatment and control groups' estimates does provide evidence that optimal expectations were at play, however. The reason for this is that, absent optimal expectations, the prior probability that treatment group subjects place on which meal was high-calorie would be immaterial to their decision whether to become informed or not.[11] As a result, one would expect both the treatment uninformed and

10 The subsample sizes shown differ slightly from those in Table 3 because not all subjects answered the question.

11 Since information is completely costless in the setting of our experiment, subjects would choose to become informed if their priors placed any weight at all on a state of the world in which information might change their optimal behavior; the magnitude of that weight would be irrelevant.

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control uninformed groups to have the same distribution of priors and thereby the same average estimate of their chosen meal's calorie content.

In contrast, if optimal expectations do play a role, then one should expect calorie estimates to differ across the two groups. More specifically, if subjects are heterogeneous in terms of the weight they place on future health consequences, then subjects in the treatment group who self-select into ignorance should on average downplay the future health costs by more than subjects in the control uninformed group. This is because the control uninformed group includes subjects who, if given the opportunity, would have self-selected into being informed, and these are subjects whose tendency to downplay future health costs is comparatively low.

As shown in the next-to-last column of Table 4, a one-tailed t-test rejects the null of equal means in favor of the alternative hypothesis suggested by our model, namely that the mean estimate of treatment uninformed subjects will be lower than that of control uninformed ones (the p-values for the three rows are 0.018, 0.044 and 0.092).

A caveat to this finding is that some subjects gave estimates that differed from either 500 or 890 calories. As mentioned in the description of the experimental design above, all subjects were told up front that those were the calorie contents of the two meals on offer, whereby uninformed subjects never learned which meal was which. Subjects who gave different estimates must therefore have not paid careful attention to the exact calorie numbers or have forgotten those numbers by the time they were asked for their estimate (towards the end of the experiment).

Figure 2 shows the distribution of estimates given by the treatment uninformed and control uninformed subgroups, both as histograms and as kernel density estimates. In all six panels, there is a tendency for the treatment uninformed subjects' distribution to be shifted leftwards relative to that of control uniformed subjects. This impression is confirmed by one-tailed Wilcoxon–Mann–Whitney tests. As shown in the last column of Table 4, both for the full sample and for the subsample of beef lovers, these tests reject the null of equal distributions in favor of the alternative hypothesis that the distribution for control informed subjects stochastically dominates that of treatment uninformed ones (the p-values for the three rows are 0.009, 0.013 and 0.104).

Conversely, subjects would be indifferent about information, and thus might choose to remain ignorant, if learning the state of the world would not change their behavior anyway, but then their priors would be irrelevant also. Mathematically, if optimal expectations play no role, so $\hat{p}$ equals p, then expression (3) for wellbeing under ignorance reduces to $\mathcal{W}^n = e(x^n) - p\delta f(x^n)$. If information does not change behavior, so $x^{ib} = x^{iu} = x^n$, then this exactly equals expression (7) for wellbeing under information, $\mathcal{W}^i$, regardless of the value of p. If information does change behavior, so $x^{ib} \neq x^n$ and/or $x^{iu} \neq x^n$, then by revealed preference $\mathcal{W}^i > \mathcal{W}^n$, again regardless of the value of p.

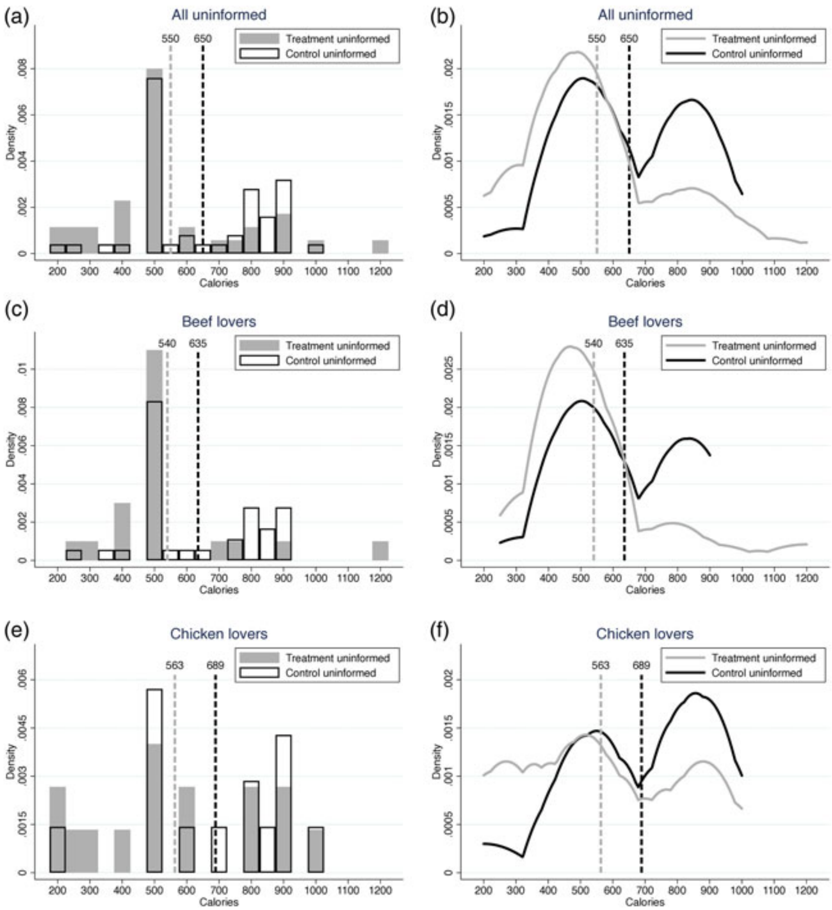

Figure 2. Comparison of the distributions of treatment uninformed and control uninformed subjects' estimates of calories in their chosen meal, using histograms in (a), (c) and (e) and kernel density estimates in (b), (d) and (f). (a) and (b) compare the distributions for all uninformed subjects, (c) and (d) for uninformed beef lovers only and (e) and (f) for uninformed chicken lovers only.

Evidence on ignorance negating the impact of health risk information

We next turn to the important question of how the prevalence of strategic ignorance might impact the effectiveness of information policies designed to reduce risky (here, calorie) consumption. To answer this question, we compare calorie consumption when subjects have no access to information (i.e., control uninformed subjects) to calorie consumption when subjects are provided information, but can choose either to take it or ignore it (i.e., treatment group subjects).

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Figure 1a shows the distribution of calorie consumption for beef lovers in these two groups (as well as in the control informed group). Providing risk information that subjects can choose to ignore seems to have no impact on risk behavior: a KS test fails to reject the null of equal distributions for the control uninformed and treatment groups ($p = 0.862$), and a two-tailed t-test comparing average calorie consumption across the two groups – 608 for control uninformed beef lovers versus 585 for treatment group ones – fails to reject the null of equal means ($p = 0.619$).

The same finding also applies when comparing the consumption of all subjects (i.e., beef and chicken lovers combined). A KS test fails to reject the null of equal distributions of calorie consumption for the control uninformed group as a whole and the treatment group as a whole ($p = 0.614$), and a two-tailed t-test comparing their average calorie consumption – 532 for all control uninformed subjects versus 495 for all treatment group ones – fails to reject the null of equal means ($p = 0.327$).

In contrast, our findings indicate that if all subjects were forced to take the risk information provided, the policy *would* have a strong and significant impact on calorie consumption. A KS test rejects the null of equal distributions of calorie consumption for control informed and control uninformed beef lovers ($p = 0.030$), and a two-tailed t-test comparing average calorie consumption for the two groups (458 and 608) strongly rejects equality ($p = 0.012$). For the two groups taken as a whole, the rejections are even stronger ($p = 0.010$ and $p = 0.001$, respectively). These results suggest that the prevalence of strategic ignorance may entirely negate the impact on risky consumption from a policy that entails risk information provision.

Possible alternative explanations for our findings

Could theories other than Brunnermeier and Parker's model of 'optimal expectations' provide an explanation for our findings? A number of other theories have been developed to explain the phenomenon of voluntary ignorance. Kőszegi's (2003) model of 'information aversion', which builds on Caplin and Leahy's (2001) model of psychological expected utility, assumes that anticipatory utility can be concave in expected health outcomes. Kőszegi shows that this can lead to voluntary ignorance, unless the benefits of learning one's true health status (in terms of ability to then make adjustments) are large enough. Mayraz's (2011) model of 'wishful thinking' assumes that agents skew probability beliefs towards outcomes that yield higher utility. Oster *et al.* (2013) show that this can lead to voluntary ignorance if it reduces the perceived benefits of learning the truth below the costs of acquiring information. In Thunström *et al.*'s (2016) model of 'guilt aversion', ignorance reduces guilt from overconsuming calories due to limited self-control. In turn, lack of self-control comes from present bias, as captured by a low β in the standard Laibson (1997) (β, δ) model of self-control. For agents with higher present bias (lower β) and therefore higher overconsumption, the guilt-reducing benefits of ignorance are more likely to outweigh the opportunity costs (in terms of forgone ability to adjust to the true state of the world). In Woolley and Risen's (2018) informal story of 'following one's heart over one's head', ignorance 'protects' a present-biased decision from being overridden by a more rational, unbiased self that would kick in if information were acquired. A formal model of this story would presumably deliver a greater incentive for ignorance for more present-biased agents, as in Thunström *et al.*'s model. Lastly, in Grossman and van der Weele's (2017) model of 'self-signaling', ignorance protects an agent's self-image of virtuousness by weakening the signal to their internal critic that a subsequent, non-virtuous decision sends. Although the focus of their model is on social behavior and on the virtue of altruism, it can easily be reinterpreted to focus on health-related behavior and on the virtue of health consciousness.

Importantly, with the exception of Mayraz's model, all of these models assume that agents take the distribution of risky outcomes as given. As a result, none of these models can accommodate our findings, or those in Oster *et al.*, of downward-biased beliefs about risk. Mayraz's model *can* accommodate such beliefs; however, because the perceived benefits of information, even with downward-biased beliefs, are always positive in his model, voluntary ignorance can arise only if the direct costs of acquiring information are positive as well (and outweigh the benefits). In our setting, acquiring information is costless, and yet we observe voluntary ignorance.[12]

We conclude therefore that only Brunnermeier and Parker's model of optimal expectations can fully explain our findings. As noted in the introduction, however, we do not suggest that optimal expectations are necessarily the *sole* mechanism underlying voluntary ignorance. The findings of Thunström *et al.* (2016) and Woolley and Risen (2018) suggest that in settings such as ours, involving health risks from calorie overconsumption, voluntary ignorance may also be driven by low self-control, as measured by time-inconsistent preferences. To test this, we elicited our subjects' time preferences using the approach of Andersen *et al.* (2008) and measured self-control more directly as well, using the scale developed by Tangney *et al.* (2004). Neither of these self-control measures robustly explains the observed strategic ignorance in

12 Oster *et al.*, whose setting has positive direct costs of testing, show that Mayraz's model has difficulty accommodating a different key finding of their study, namely that individuals who avoid testing for Huntington's disease when they do not yet have clear symptoms often get a 'confirmatory' test once their symptoms have become obvious.

this study, however. In fact, their estimated effects are so sensitive to model specification that we see no point in reporting them.

This negative finding is surprising because our study is very similar in setup to that of Thunström *et al.*, even involving similar subject pools: Thunström *et al.* recruited their subjects from the general Stockholm population, and we recruited ours from the general population in Copenhagen. Minor differences in how we elicited present bias might play a role. Thunström *et al.* used hypothetical money payments at different time horizons, including 'now', whereas we used actual payments, involving (for budgetary reasons) significantly smaller amounts of money and (to avoid the transaction cost issues discussed by Coller & Williams, 1999) a minimum time horizon of one week. Minor cultural differences between Swedes and Danes (the latter reputedly being more laidback) might conceivably also play a role – in different populations, different mechanisms underlying voluntary ignorance may dominate.

It is worth noting also that, although models of voluntary ignorance tend to focus on a single mechanism in isolation, some of the mechanisms may actually interact. In our own model, imperfect self-control can make wishful thinking more likely, because present-biased agents would, all else equal, place a lower weight on future consequences of calorie consumption – $\beta\delta$ instead of δ. Our Proposition implies that this would make them more prone to choosing ignorance. Unlike in Thunström *et al.*'s model, however, present bias is in our model not *necessary* for voluntary ignorance to arise.

More generally, all of the above-described models of voluntary ignorance, including our own, involve a trade-off between benefits and costs of ignorance. This trade-off in turn depends on the relative weight agents place on various emotional consequences of risky decisions, such as *ex ante* anxiety, *ex post* guilt and *ex post* self-image, as well as on direct consequences, such as harm to health. Since plausibly a host of factors other than present bias could help determine these weights, we collected data from our subjects pertaining to risk preferences, health concern, exercise and sociodemographics. We only find robustly, however, that women and subjects who are more concerned about their health are less likely to choose ignorance.

Conclusion

In addition to confirming that strategic ignorance of calorie information is a robust phenomenon, two key findings emerge from this study.

First, whereas previous studies point to low self-control as a motivation for strategic ignorance, our results indicate that it may also emerge through a different, 'optimal expectations' channel: staying ignorant allows people to form optimistic beliefs about the calorie contents of their favorite meals.

Second, our results indicate that in settings where people can choose to ignore calorie information, menu labeling may completely fail to affect calorie consumption. Restaurants and coffee shops appear to be such settings. Elbel *et al.* (2009), for instance, found that four weeks after the introduction of mandatory labeling in fast-food restaurants in New York City, only 54% of customers had noticed the menu labels. Similarly, Krieger *et al.* (2013) found that 18 months after menu label introduction in King County, Washington, only 62% of food-chain customers and 30% of coffee-chain customers reported seeing the calorie information.

What should policy-makers conclude from our findings? It depends on the policy objective. If – as is likely true for public health officials – the goal is purely to change risk outcomes, such as the negative health consequences of excessive calorie consumption, then strategic ignorance is undesirable, regardless of what mechanism underlies it. The apparent widespread prevalence of strategic ignorance may then call for measures that make calorie information harder to ignore. For instance, Ellison *et al.* (2013, 2014) show that symbolic traffic light labels enhance the effectiveness of numeric calorie information on menus, and Dallas *et al.* (2019) show that people respond more to calorie information displayed to the left (rather than the usual right) of menu items. Public information campaigns could also be used to make negative health consequences of calorie overconsumption more salient, and thereby increase the perceived cost of ignorance. However, the message of such campaigns could also be ignored. Alternatively, policy-makers might consider 'hard' paternalistic measures such as taxes or reduced choice sets of risky consumption (e.g., mandatory product reformulations), instead of relying on information as a means to encourage low-calorie food consumption.

If the policy goal is to maximize welfare, however, then matters are more complex, because then the mechanism underlying strategic ignorance *does* matter. Brunnermeier and Parker's (2005) theory of optimal expectations does not imply that strategic ignorance is harmful. On the contrary, choosing ignorance may maximize utility by optimally balancing reduced immediate anxiety against increased future health risks. Moreover, ignorance may be privately optimal not just *ex ante*, but also *ex post* (i.e., without giving rise to regret). It follows that if optimal expectations are the main drivers of strategic ignorance, and, importantly, if negative spillover effects of ignorance (e.g., future health care costs imposed on others) are not so large as to outweigh its private benefits, then the socially optimal policy response may paradoxically be to *accommodate* ignorance through providing information that is easy to tune out. Counteracting strategic ignorance, such as by making calorie information nearly impossible to tune out, may end up only reducing welfare by taking away consumers' ability to engage in optimal self-deception. In contrast, if the main driver of strategic ignorance is low self-control, then choosing ignorance may be suboptimal even privately. Forcing calorie information on consumers could then increase both private and social welfare if it induces appropriate behavioral adjustments (Thunström, 2019).

Most likely, both mechanisms play a role, but to varying degrees for different consumers. As noted by Sunstein (2018), there is a great deal of heterogeneity in how information affects consumers in terms of behavioral adjustments and welfare. We encourage future research to further explore how the welfare effects of information provision may depend on the distribution of the mechanisms underlying strategic ignorance.

Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/bpp.2019.52.

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Appendix

Proof of the Proposition

The proof proceeds by establishing the following two results:

i. At $\delta = 0$, $\mathcal{W}^n = \mathcal{W}^i$ and $\partial\mathcal{W}^n/\partial\delta > \partial\mathcal{W}^i/\partial\delta$.
ii. For quadratic $e(x)$ and $f(x)$, at any $\delta^* > 0$ where $\mathcal{W}^n = \mathcal{W}^i$, $\partial\mathcal{W}^i/\partial\delta > \partial\mathcal{W}^n/\partial\delta$.

Result (i) implies, by continuity, that at positive but sufficiently small values of δ, $\mathcal{W}^i$ lies strictly below $\mathcal{W}^n$. Result (ii) implies that if $\mathcal{W}^i$ ever climbs above $\mathcal{W}^n$ at a higher value of δ – which is easily shown by example to be possible – then it will stay above $\mathcal{W}^n$ up to $\delta = 1$. The two results combined imply the Proposition.

Result (i)

To establish that at $\delta = 0$, $\mathcal{W}^n = \mathcal{W}^i$, note that at $\delta = 0$, conditions (1), (5) and (6) imply that $x^n = x^{ih} = x^{iu}$, and expressions (3) and (7) as a result reduce to $\mathcal{W}^n = \mathcal{W}^i = e(x^{ih})$.

To establish that at $\delta = 0$, $\partial\mathcal{W}^n/\partial\delta > \partial\mathcal{W}^i/\partial\delta$, note from first-order condition (4) for $\hat{p}$ that the corner solution $\hat{p} = 0$ arises at values of δ such that

$$-\frac{1}{2}\delta f(x^n) - \frac{1}{2}p\delta f'(x^n)\frac{dx^n}{d\hat{p}} < 0,$$

or, solving for δ and using that $x^n = x^{ih}$ at $\hat{p} = 0$, at

$$\delta < \frac{-e''(x^{ih})f(x^{ih})}{p[f'(x^{ih})]^2} \equiv \delta^c.$$

At these values of δ, $\mathcal{W}^n$ reduces to

$$\mathcal{W}^n = e(x^{ih}) - \frac{1}{2}p\delta f(x^{ih}),$$

so:

$$\frac{\partial \mathcal{W}^n}{\partial \delta} = -\frac{1}{2} pf(x^{ih}).$$

Meanwhile, differentiating $\mathcal{W}^i$ with respect to δ and using the envelope theorem yields

$$\frac{\partial \mathcal{W}^i}{\partial \delta} = -pf(x^{iu}).$$

Using again that $x^{ih} = x^{iu}$ at $\delta = 0$, it follows that

$$\left.\frac{\partial \mathcal{W}^n}{\partial \delta}\right|_{\delta=0} = -\frac{1}{2} pf(x^{ih}) > -pf(x^{ih}) = \left.\frac{\partial \mathcal{W}^i}{\partial \delta}\right|_{\delta=0}.$$

Before turning to the implications of $e(x)$ and $f(x)$ being quadratic, it is useful to show that when $\delta > \delta^c$, so that $\hat{p} > 0$, differentiating $\mathcal{W}^n$ with respect to δ and using the envelope theorem yields

$$\begin{aligned}
\frac{\partial \mathcal{W}^n}{\partial \delta} &= -\hat{p}f(x^n) - \frac{1}{2}(p - \hat{p})\left\{ f(x^n) + \delta f'(x^n) \cdot \frac{dx^n}{d\delta} \right\} \\
&= -\hat{p}f(x^n) - \frac{1}{2}(p - \hat{p})\left\{ f(x^n) + \delta f'(x^n) \cdot \frac{\hat{p}}{\delta}\frac{dx^n}{d\hat{p}} \right\} \\
&= -\frac{1}{2} pf(x^n) - \frac{1}{2}\hat{p}\left[\underbrace{f(x^n) + (p - \hat{p})f'(x^n) \cdot \frac{dx^n}{d\hat{p}}}_{=0} \right] \\
&= -\frac{1}{2} pf(x^n).
\end{aligned}$$

The second step of this derivation uses that, from (1) and (2)

$$\frac{dx^n}{d\delta} = \frac{\hat{p}f'(x^n)}{e''(x^n) - \hat{p}\delta f''(x^n)} = \frac{\hat{p}}{\delta}\frac{dx^n}{d\hat{p}},$$

and the final step uses first-order condition (4). Since we showed above that when $\delta \leq \delta^c$, $x^n = x^{ih}$ and $\partial \mathcal{W}^n / \partial \delta = -\frac{1}{2} pf(x^{ih})$, it follows that for all δ

$$\frac{\partial \mathcal{W}^n}{\partial \delta} = -\frac{1}{2} pf(x^n). \tag{8}$$

If now $e(x)$ is quadratic, of the form $Ax - \frac{1}{2}Bx^2$, then our assumptions about $e(x)$ require that $A > 0$ and $B > 0$. Similarly, if $f(x)$ is quadratic, of the form

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$Cx + \frac{1}{2}Dx^2$, our assumptions require that $C \geq 0$ and $D \geq 0$, with C and D not both zero. To simplify notation, define $a \equiv A/B$, $b \equiv B/(\delta D)$ and $c \equiv C/D$, and also define $x \equiv x^{iu}$, $y \equiv x^n$ and $z \equiv x^{ih}$.

Preliminaries

With this notation, condition (6)

$$e'(x^{iu}) - \delta f'(x^{iu}) = 0,$$

becomes

$$A - Bx - \delta[C + Dx] = 0,$$

so that

$$x \equiv x^{iu} = \frac{A - \delta C}{B + \delta D} = \frac{\frac{A}{B}\frac{B}{\delta D} - \frac{C}{D}}{\frac{B}{\delta D} + 1} = \frac{ab - c}{b + 1},$$

$$c + x = \frac{b(a + c)}{b + 1}, \tag{9}$$

and

$$a - x = \frac{a + c}{b + 1} = \frac{1}{b}(c + x). \tag{10}$$

Similarly, condition (1)

$$e'(x^n) - \hat{p}\delta f'(x^n) = 0,$$

becomes

$$A - By - \hat{p}\delta[C + Dy] = 0,$$

so that

$$y \equiv x^n = \frac{A - \hat{p}\delta C}{B + \hat{p}\delta D} = \frac{\frac{A}{B}\frac{B}{\delta D} - \hat{p}\frac{C}{D}}{\frac{B}{\delta D} + \hat{p}} = \frac{ab - \hat{p}c}{b + \hat{p}},$$

and therefore

$$c + y = \frac{b(a + c)}{b + \hat{p}}. \tag{11}$$

Combining (9) and (11) gives

$$\frac{c+x}{c+y} = \frac{b+\hat{p}}{b+1}. \tag{12}$$

Lastly, condition (5)

$$e'(x^{ih}) = 0,$$

becomes

$$A - Bz = 0,$$

so that

$$z \equiv x^{ih} = \frac{A}{B} = a.$$

Using these preliminaries, we are to show that if at some $\delta^* > 0$

$$\mathcal{W}^i = \mathcal{W}^n,$$

then at that δ^*, the following 'slope inequality' holds:

$$\frac{\partial \mathcal{W}^i}{\partial \delta} > \frac{\partial \mathcal{W}^n}{\partial \delta}.$$

Note first that, using result (8) above, the slope inequality can be rewritten as follows:

$$\begin{aligned}
& -pf(x^{iu}) > -\frac{1}{2}pf(x^n) \\
& \Leftrightarrow\ 2f(x^{iu}) < f(x^n) \\
& \Leftrightarrow\ 2Cx^{iu} + D(x^{iu})^2 < Cx^n + \frac{1}{2}D(x^n)^2 \\
& \Leftrightarrow\ 2\frac{C}{D}x^{iu} + (x^{iu})^2 < \frac{C}{D}x^n + \frac{1}{2}(x^n)^2 \\
& \Leftrightarrow\ 2cx + x^2 < cy + \frac{1}{2}y^2 \\
& \Leftrightarrow\ c^2 + 2cx + x^2 < \frac{1}{2}c^2 + cy + \frac{1}{2}y^2 + \frac{1}{2}c^2 \\
& \Leftrightarrow\ (c+x)^2 < \frac{1}{2}(c+y)^2 + \frac{1}{2}c^2 \\
& \Leftrightarrow\ \left(\frac{c+x}{c+y}\right)^2 < \frac{1}{2} + \frac{1}{2}\left(\frac{c}{c+y}\right)^2 \\
& \Leftrightarrow\ \left(\frac{b+\hat{p}}{b+1}\right)^2 < \frac{1}{2}\left[1 + \left(\frac{c}{c+y}\right)^2\right],
\end{aligned}$$

where the final step uses (12).

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Consider now first values of $\delta \in (0, \delta^c]$, where $\hat{p} = 0$. At such values, we can rewrite $\mathcal{W}^n$ as

$$\begin{aligned}\mathcal{W}^n &= e(x^{ih}) - \frac{1}{2}p\delta f(x^{ih}) = \left[Ax^{ih} - \frac{1}{2}B(x^{ih})^2\right] - \frac{1}{2}p\delta\left[Cx^{ih} + \frac{1}{2}D(x^{ih})^2\right] \\ &= B\left\{\left[\frac{A}{B}x^{ih} - \frac{1}{2}(x^{ih})^2\right] - \frac{1}{2}p\frac{\delta D}{B}\left[\frac{C}{D}x^{ih} + \frac{1}{2}(x^{ih})^2\right]\right\} \\ &= B\left\{\left(az - \frac{1}{2}z^2\right) - \frac{p}{2b}\left(cz + \frac{1}{2}z^2\right)\right\}.\end{aligned}$$

We can also rewrite $\mathcal{W}^i$ as

$$\begin{aligned}\mathcal{W}^i &= (1-p)e(x^{ih}) + p[e(x^{iu}) - \delta f(x^{iu})] \\ &= (1-p)\left[Ax^{ih} - \frac{1}{2}B(x^{ih})^2\right] + p\left[Ax^{iu} - \frac{1}{2}B(x^{iu})^2\right] - p\delta\left[Cx^{iu} + \frac{1}{2}D(x^{iu})^2\right] \\ &= B\left\{(1-p)\left[\frac{A}{B}x^{ih} - \frac{1}{2}(x^{ih})^2\right] + p\left[\frac{A}{B}x^{iu} - \frac{1}{2}(x^{iu})^2\right] - p\frac{\delta D}{B}\left[\frac{C}{D}x^{iu} + \frac{1}{2}(x^{iu})^2\right]\right\} \\ &= B\left\{(1-p)\left(az - \frac{1}{2}z^2\right) + p\left(ax - \frac{1}{2}x^2\right) - \frac{p}{b}\left(cx + \frac{1}{2}x^2\right)\right\}.\end{aligned}$$

Equating the two expressions then gives

$$\begin{aligned}&\mathcal{W}^i = \mathcal{W}^n \\ &\Leftrightarrow (1-p)\left(az - \frac{1}{2}z^2\right) + p\left(ax - \frac{1}{2}x^2\right) \\ &-\frac{p}{b}\left(cx + \frac{1}{2}x^2\right) = \left(az - \frac{1}{2}z^2\right) - \frac{p}{2b}\left(cz + \frac{1}{2}z^2\right) \\ &\Leftrightarrow p\left(ax - \frac{1}{2}x^2\right) - \frac{p}{b}\left(cx + \frac{1}{2}x^2\right) = p\left(az - \frac{1}{2}z^2\right) - \frac{p}{2b}\left(cz + \frac{1}{2}z^2\right) \\ &\Leftrightarrow \left(ax - \frac{1}{2}x^2\right) - \frac{1}{b}\left(cx + \frac{1}{2}x^2\right) = \left(az - \frac{1}{2}z^2\right) - \frac{1}{2b}\left(cz + \frac{1}{2}z^2\right) \\ &\Leftrightarrow \left(-\frac{1}{2}a^2 + ax - \frac{1}{2}x^2\right) - \frac{1}{b}\left(\frac{1}{2}c^2 + cx + \frac{1}{2}x^2 - \frac{1}{2}c^2\right) = \left(-\frac{1}{2}a^2 + az - \frac{1}{2}z^2\right) \\ &\qquad - \frac{1}{2b}\left(\frac{1}{2}c^2 + cz + \frac{1}{2}z^2 - \frac{1}{2}c^2\right)\end{aligned}$$

$$\Leftrightarrow -\frac{1}{2}(a-x)^2 - \frac{1}{2b}[(c+x)^2 - c^2] = -\frac{1}{2}(a-z)^2 - \frac{1}{4b}[(c+z)^2 - c^2]$$
$$\Leftrightarrow b(a-x)^2 + [(c+x)^2 - c^2] = b(a-z)^2 + \frac{1}{2}[(c+z)^2 - c^2]$$
$$\Leftrightarrow b(a-x)^2 + (c+x)^2 = \frac{1}{2}[(c+a)^2 + c^2].$$

Using (10), this can be rewritten further as

$$\begin{aligned}
&\frac{1}{b}(c+x)^2 + (c+x)^2 = \frac{1}{2}[(c+a)^2 + c^2] \\
&\Leftrightarrow \frac{b+1}{b}(c+x)^2 = \frac{1}{2}[(c+a)^2 + c^2] \\
&\Leftrightarrow \frac{b+1}{b}\left(\frac{c+x}{c+a}\right)^2 = \frac{1}{2}\left[1 + \left(\frac{c}{c+a}\right)^2\right] \\
&\Leftrightarrow \frac{b+1}{b}\left(\frac{b}{b+1}\right)^2 = \frac{1}{2}\left[1 + \left(\frac{c}{c+a}\right)^2\right] \\
&\Leftrightarrow \frac{b}{b+1} = \frac{1}{2}\left[1 + \left(\frac{c}{c+a}\right)^2\right]
\end{aligned} \tag{14}$$

Meanwhile, at $\hat{p} = 0$ and thereby $y = x^n = a$, the rewritten slope inequality (13) reduces to

$$\left(\frac{b}{b+1}\right)^2 < \frac{1}{2}\left[1 + \left(\frac{c}{c+a}\right)^2\right]. \tag{15}$$

Clearly, (14) implies (15), since $b/(b+1)$ is a fraction. This establishes Result (ii) for $\delta \in (0, \delta^c]$.

Consider next values of $\delta \in (\delta^c, 1]$, where $\hat{p} > 0$. At these values, first-order condition (4) becomes:

$$f(x^n) + (p - \hat{p})f'(x^n)\frac{dx^n}{d\hat{p}} = 0,$$

which can be rewritten as

$$Cx^n + \frac{1}{2}D(x^n)^2 + (p - \hat{p})(C + Dx^n) \cdot -\delta\frac{C + Dx^n}{B + \hat{p}\delta D} = 0$$
$$\Leftrightarrow (B + \hat{p}\delta D)\left(Cx^n + \frac{1}{2}D(x^n)^2\right) - (p - \hat{p})\delta(C + Dx^n)^2 = 0$$

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$$\Leftrightarrow \left(\frac{B}{\delta D} + \hat{p}\right)\left(\frac{C}{D}x^n + \frac{1}{2}(x^n)^2\right) - (p - \hat{p})\left(\frac{C}{D} + x^n\right)^2 = 0$$

$$\Leftrightarrow (b + \hat{p})\left(cy + \frac{1}{2}y^2\right) - (p - \hat{p})(c + y)^2 = 0$$

$$\Leftrightarrow (b + \hat{p})\left[\frac{1}{2}(c + y)^2 - \frac{1}{2}c^2\right] - (p - \hat{p})(c + y)^2 = 0$$

$$\Leftrightarrow (b + \hat{p})\left[\frac{1}{2} - \frac{1}{2}\left(\frac{c}{c + y}\right)^2\right] - (p - \hat{p}) = 0$$

$$\Leftrightarrow (b + \hat{p})\left[\frac{1}{2} - \frac{1}{2}\left(\frac{c}{c + y}\right)^2\right] - [(b + p) - (b + \hat{p})] = 0$$

$$\Leftrightarrow (b + \hat{p})\left[3/2 - \frac{1}{2}\left(\frac{c}{c + y}\right)^2\right] - (b + p) = 0.$$

If we define

$$\alpha \equiv \left(\frac{c}{c + y}\right)^2 \in [0, 1),$$

the final expression can be rewritten as

$$\left(\frac{b + \hat{p}}{b + p}\right)^2 = \left(\frac{2}{3 - \alpha}\right)^2, \tag{16}$$

while the slope inequality (13) becomes

$$\left(\frac{b + \hat{p}}{b + p}\right)^2 < \frac{1}{2}(1 + \alpha). \tag{17}$$

But (16) implies (17), since it is straightforward to check that for all $\alpha \in [0, 1)$

$$\left(\frac{2}{3 - \alpha}\right)^2 < \frac{1}{2}(1 + \alpha).$$

In other words, at values of $\delta \in (\delta^c, 1]$, the slope inequality $\partial\mathcal{W}^i/\partial\delta > \partial\mathcal{W}^n/\partial\delta$ holds not just when $\mathcal{W}^i = \mathcal{W}^n$, but always. This again establishes Result (ii), and thereby the Proposition.

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Proof of the Corollary

For $\delta \leq \delta^c$, we showed above that $\hat{p} = 0$ and $x^n = x^{ih}$, implying that both optimism and consumption are independent of δ. It follows that in the extreme case where parameters are such that $\delta^c \geq 1$, all agents will place zero subjective probability $\hat{p}$ on future health consequences under ignorance, and all agents will consume the same amount.

If, however, $\delta^c < 1$, then we have for $\delta > \delta^c$ that $\hat{p}$ is interior and does depend on δ. Specifically, applying the Implicit Function Theorem to first-order condition (4) and using our result (8) above that $\partial \mathcal{W}^n / \partial \delta = -\frac{1}{2} p f(x^n)$ at $\hat{p} > 0$ yields that $\hat{p}'(\delta)$ is equal in sign to

$$\frac{\partial^2 \mathcal{W}^n}{\partial \hat{p} \partial \delta} = \frac{\partial}{\partial \hat{p}} \left[\frac{\partial \mathcal{W}^n}{\partial \delta} \right] = \frac{\partial}{\partial \hat{p}} \left[-\frac{1}{2} p f(x^n) \right] = -\frac{1}{2} p f'(x^n) \frac{dx^n}{d\hat{p}} > 0.$$

Moreover, substituting $\hat{p}(\delta)$ into (1) to obtain

$$e'(x^n) - \hat{p}(\delta)\delta f'(x^n) = 0$$

yields that

$$\frac{dx^n}{d\delta} = \frac{[\hat{p}'(\delta)\delta + \hat{p}(\delta)] f'(x^n)}{e''(x^n) - \hat{p}(\delta)\delta f''(x^n)},$$

which is equal in sign to

$$\hat{p}'(\delta)\delta + \hat{p}(\delta) > 0.$$

It follows that agents with $\delta < \delta^*$, who self-select into ignorance if given the opportunity, will on average have lower $\hat{p}$ and higher consumption x^n than agents with $\delta > \delta^*$ who are forced (contrary to their preference) to be uninformed.