Centre for Household, Income, Labour and Demographic economics

Working Papers

A Rationale for Searching (Imprecise) Health Information

Francesca Barigozzi and Rosella Levaggi

ChilD n. 07/2006

e-mail: de-child@unito.it
Web site: http://www.child-centre.it

A Rationale for Searching (Imprecise) Health Information

Francesca Barigozzi* and Rosella Levaggi†

This version: January 2006

Abstract

We analyse a model of patient decision-making where anxiety about the future characterizes the patient's utility function. Anxiety corresponds to fear of bad news and results in the patient being averse to information. First, the patient chooses the accuracy of a signal which discloses information on his health status. Then he up-dates his beliefs according to Bayes's rule and chooses an action. We show that the choice of imprecise information can be optimal because it allows the patient to trade off the damage deriving from complete ignorance with the anxiety raised by the news about his health level.

JEL Classification: D81; D83; I19.

Key Words: Information learning, Psychological expected utility, Bayesian up-dating.

1. Introduction

The attitude of patients towards health care and the search for health information has dramatically changed in the past few years. This phenomenon is the result of several factors, perhaps the most important being the fact that patients have now easy access to information. A spectacular example is the Internet where a huge amount of health information is available at negligible cost.[1] More generally, the media are increasingly aware of health related matters and specific

*Department of Economics, University of Bologna, Strada Maggiore 45, 40125 Bologna (Italy). E-mail: barigozz@spbo.unibo.it

†Department of Economics, University of Brescia, Via S. Faustino, 74b, 25122 Brescia (Italy). E-mail: levaggi@eco.unibs.it

[1] Interesting issues that a decision-maker faces when searching for information on the Internet are that of "information overload" and "information processing". These issues are not addressed in this paper.

magazines and programmes are devoted to explain how to preserve our "health stock" and how the most popular diseases can be cured.[2] Thus, when dealing with the problem of acquiring health information, patients must first decide which *source* of information to address to. In particular they choose whether asking for information to a physician, searching for alternative sources (as the Internet, magazines, friends and relatives) or both.[3]

Obviously different sources of health information provide information characterized by different level of precision. In particular even when truthful and correct, health information obtained from sources other than a physician is necessarily less targeted to patient's needs than the information a physician is able to transmit.

While the dissemination of *general* (not targeted) health information can obviously be useful in the case of preventive behaviors[4] or not serious illness, we should be concerned about the way not-targeted messages about diseases affect individuals. In particular, since individuals are generally ignorant on health matters, the dissemination of information on *specific and serious* health problems or illness does not necessarily allow the patient to form a precise diagnosis or to give a correct interpretation to his symptoms. As mentioned before, a physician, on the contrary, is more efficient in this process so that his diagnosis is always more accurate.

In this environment, some interesting questions naturally arise. What is the rationale for a patient to search for information from sources other than the physician? Does health information disseminated in the different media really increase patient's utility?

The topic of information acquisition by a decision maker is certainly not a new one and a vast literature exists (among the others, see Moscarini and Smith, 2001). The most common issue in this case refers to the optimal stopping rule in information acquisition by comparing the cost of searching for information and processing it, against the benefits of information in terms of more accurate decisions. With this respect, the dissemination of general information, or the reduction of the costs in procuring it, is clearly a desirable process. However, when health matters are considered, fear about future health becomes relevant and information can lead to anxiety. With this respect a new issue then arises: as medical evidence indicates, fear deeply

[2] In all that cases the relevant cost for the decision-maker is in term of opportunity cost of time devoted to in searching for and processing information.

[3] Evidence on the access to sources of health information other than a physician (books, magazines, the Internet, TV programs, friends or relatives) in the US can be found in Tu and Hargraves (2003). Specific data on the use of the Internet to search for health information in the US are provided in Fox and Rainie (2002).

[4] Some empirical studies show that the dissemination of health information about appropriate life-style is welfare improving. See, for example, Wagner, Hu and Hibbard (2001) and references within.

influences patients' behavior when searching for information.

Caplin and Leahy (2001) (C-L henceforth) extend expected utility theory to situations in which agents experience feelings of anticipation prior to the resolution of uncertainty. They show how these anticipatory feelings may influence decision makers. In particular they provide an example from portfolio theory to illustrate the potential impact of anticipation on portfolio decisions and asset prices. Recently, their framework has been used by Kozsegi (2003) to study the problem of anxiety related to future health and health behavior. According to such a framework, the standard model of choice under uncertainty must be enriched by adding beliefs to the description of consequences, in order to capture anticipatory feelings such as anxiety or hopefulness.

The aim of our analysis is to investigate how anxiety influences patients' attitude towards information search. Using the extended expected-utility model of C-L (2001) we consider a Bayesian consumer searching for health information and show that anxiety costs might induce the patient to choose information sources less precise than a physician advise or a medical test. In fact, by deliberately choosing an imprecise signal (i.e. an imprecise source of information), the patient is able to decrease the level of anxiety induced by information.[5]

Patients can be averse or not to information. When they are information averse they suffer from anxiety if information is disclosed. In other words information averse patients dislike bad news more than they like good news. Modelling anxiety as utility derived from the patient's expectations about future physical condition, the patients' utility function is not defined over physical outcomes as in standard analysis, but instead over *beliefs about physical outcomes.*

In our model, if the patient stays ignorant he pays the cost of selecting an inefficient action. In fact, the level of consumer's health depends on nature and on a specific health maintenance action that, in order to be most effective, has to be state-contingent. In addition, since the patient derives utility directly from his beliefs, he must also consider how the information he gathers will affect those beliefs. Furthermore, we assume that the decision-maker is able to indirectly influence his beliefs through the choice of signals. In our model signals can be interpreted as health information sources characterized by different content precision. The patient can decide

[5] In a different setup, Caplin and Eliaz (2003) incidentally reach a similar conclusion as for the test for AIDS: "while there are strong health-based incentives to test for AIDS, fear may override these incentives. Our resolution of the problem is to decrease the informativeness of a bad test result, mitigating the fear of bad news, and thereby allowing the health-based incentives to reassert their primacy."

to stay ignorant or he can decide to make a medical test or to go to the physician such that information is fully disclosed. Importantly, a third alternative is possible: the patient can search for health information from sources other than the physician. For example, by searching for information disseminated on the Internet the patient is able to choose different accuracy of information.

With this setup, we can address the analysis of the trade-off between the physical benefits and emotional costs of information for patients who are information averse. We show that the choice of imprecise information can be optimal because it allows the patient to trade off the damage deriving from complete ignorance with the anxiety raised by the news about his health level. The peculiarity of our model is in *the patient choosing the precision of a signal.* The signal provides information on the patient's health status. In particular, the timing of the model is the following: first the patient chooses the precision of the signal, then he observes the signal realized and accordingly up-dates beliefs on his health status; finally he chooses the preferred action.

As it was specified before, the choice of complete information learning (corresponding to a perfectly informative signal) is interpreted here as the decision to see a physician or to make a medical test. Whereas, the choice of incomplete information learning (an imperfectly informative signal) is interpreted as the decision to search for information from the media and/or the Internet. In the latter case, the patient's action is taken without consulting the physician. This implies that, in our model, the physician and the other sources of health information are substitutes for the patient.[6] The latter bases his choice either on the physician's advise or on the partial information obtained from the Internet (or on his prior, if he decides to stay ignorant). From an empirical point of view, the substitutability between non-physician information and information from a physician is documented by Wagner *et al.* (2001) and by Bundorf *et al.* (2004). Both papers show that health information obtained from sources other than a physician (i) affects patient's behavior and (ii) decreases the demand for health information from health professionals. We propose an explanation of this phenomenon based on patient's anxiety.[7]

Our work is closely related to and borrows from two recent papers by Kozsegi (2003) and

[6] See the last section of the paper for a discussion on the complementary case.

[7] Note that, even if, in general, the price of information alternatives affects information seeking behavior, the difference in the price of information from health professional and from the Internet cannot explain alone the search of information on the Internet. In fact, as Bundorf *et al.* (2004) find: "Among individuals without chronic conditions, the uninsured were *less likely* to seek health information on the Internet".

Eliaz and Spiegler (2004) (respectively K and E-S, henceforth), which our analysis complements in several directions.

Similarly to K, in our model ignorance is costly in terms of inefficient actions. However, since he derives utility directly from his belief, if the patient is information averse, he might refuse useful information that is very cheap because of fear of bad news.

As in E-S, we allow the patient to update beliefs on health status by acquiring information. Closely related to our analysis and in a richer setup with respect to the one we study, E-S investigate whether an enriched expected utility model, in which a Bayesian decision-maker's belief is an argument in his vNM utility function, can be used to explain anomalous choices of information sources that the usual expected utility model is not able to explain.

In the previous discussion we have analyzed the information acquisition process by an 'anxious patient. However, it should be noticed that, as already pointed out by several authors (see for example C-L, 2001), a similar problem may be relevant in other contexts with uncertainty where an unskilled decision maker may decide to rely on personally acquired information or, alternatively, on experts' advice, such as, for example, in the case of the decision process concerning households' financial plans.

The paper is organized as follows. In Section 2 we present the model setup introducing and formally stating the concept of anxiety. In Section 3 we discuss the patient's decision process and, in sections 4 we discuss the main results. Section 5 provides some numerical examples and section 6 the concluding remarks.

2. The model

Following the methodology of C-L (2001, 2004) and in the same vein than K, the patient's utility is a function of physical outcomes and beliefs-based emotions, with anticipatory emotions responding to information. As C-L write: "Anxiety is an anticipatory emotion experienced prior to the resolution of uncertainty. It is related to the feeling of living with uncertainty" (C-L 2001, page 69).

There are two periods, 1 and 2, and total utility is the sum of future utility from physical outcomes, and current anticipatory emotions, which depend on rationally formed beliefs about the exact same outcomes. Both terms are in expected-utility form. The patient's physical utility in period 2 is $h(w_i, a)$, where $w_i = \{w_1, w_2\}$ is the health status realized in period 1 and a is an action taken in the same period; $w_i, a \in \Re$. The action a has no effects on period 1, it only affects utility in period 2. We assume that w_1 is the preferred health status: $w_1 > w_2$. Moreover, each status has the same probability to occur: $p_1 = p_2 = 1/2$, where p_i =prob(w_i).

Since in the first period the patient derives utility from the anticipation of period-2 physical outcomes, anticipatory utility depends on expected physical utility in period 2 conditional on patient's beliefs in period 1:

$$\text{emotional utility} = u\left(E\left[h\left(w_i, a\right)|\text{patient' information}\right]\right) \tag{2.1}$$

The function $u(\cdot)$ is increasing in the expectation of physical health. The shape of $u(\cdot)$ determines the patient's preferences for information. For a given a, when $u(\cdot)$ is concave the patient is averse to information: he prefers late resolution of uncertainty about his health condition. In other words, since he dislikes bad news more than he likes good news, he prefers to stay ignorant.[8] If $u(\cdot)$ is convex, on the contrary, the patient is 'information-loving'. Finally, when $u(\cdot)$ is linear the patient is 'information -neutral'.

Utility in period 2 corresponds to physical utility $h\left(w_i, a\right)$. To calculate total patient' utility from the perspective of period 1, we add to emotional utility (2.1) the expectation of period-2 physical utility:

$$\text{total utility} = u\left(E\left[h\left(w_i, a\right)|\text{patient' information}\right]\right) + E\left[h\left(w_i, a\right)|\text{patient' information}\right] \tag{2.2}$$

As will be shown in section 4.1, a model where utility is as in (2.2) generates results that are qualitatively equivalent to results obtained with emotional utility only. For that reason, in the main body of the paper we follows K by assuming that the patient's utility is given exclusively by (2.1). That also allows the direct comparison of our results to K's.

Let us assume that physical utility is $h(w_i, a) = w_i - (w_i - a)^2$. Thus, given the health status w_i, w_i also corresponds to the maximum level of physical health that can be reached if the appropriate action ($a = w_i$) is chosen. If the taken action a is not appropriate, the patient will be worse off: the loss function $(w_i - a)^2$ measures the damage from an inaccurate action.

By observing a signal the patient learns information on his health status. As in E-S, a signal is a random variable which can take two values, s_1 and s_2. A signal is characterized by a pair

[8] As E-S observe, in a dynamic model, information aversion translates in preference for late resolution of uncertainty.

of conditional probabilities (q_1, q_2), where $q_i \in \left[\frac{1}{2}, 1\right]$ $i = 1, 2$, is the probability of observing the realization s_i conditional on the state being w_i : q_i =prob$(s_i|w_i)$. Thus, when $q_1 = q_2 = 1$ the signal is fully informative, while when $q_1 = q_2 = \frac{1}{2}$ the signal is fully uninformative. For the sake of tractability we also assume that $q_1 = q_2 = q$, that is a signal is simply characterized by *one* conditional probability q.

By selecting the sources of health information the patient is able to influence directly the precision of the information he learns. This is equivalent to say that the patient chooses the precision of the signal q. In particular, the decision to see a physician or to undertake a medical test is equivalent to the choice of $q = 1$, the fully informative signal. Whereas, the decision to stay ignorant is equivalent to the choice of $q = \frac{1}{2}$. Finally, the decision to seek for sources of health information other than a physician corresponds to the choice of an intermediate value for q. The patient's choice of the precision of the signals, given the prior $p = 1/2$, is rational.[9] When choosing q, the patient anticipates both that he will update his beliefs upon observing the signal's realization and that he will choose the action a according to such beliefs. In particular, he knows that either the optimal action (if the signal is fully informative, $q = 1$) or a non-optimal one (if the signal is partially or non informative, $q < 1$) will be taken. Finally we assume that information is completely costless.

To summarize, the patient maximizes his emotional utility (2.1). First he chooses the signal precision q and observes the realization of the signal, then he updates his priors according to Bayes' rule, and finally he chooses the optimal action a given updated beliefs. All the actions take place in period 1.

Some empirical studies show that, in many situations, information aversion correctly describes patients' attitude towards information on their health status (see for example Lerman *et al.* 1998 and the references cited in K). Thus, we assume that the function $u(\cdot)$ is concave. Since there exists no trade-off between the physical benefits and emotional costs of information for patients who are not information averse, this also represents the most interesting case.

To see that, let us consider patient's anticipatory utility without the loss function: $u(E[w_i|\text{patient's information}])$. When no information has been learnt, anticipatory utility is $u(\frac{1}{2}w_1 + \frac{1}{2}w_2)$. Whereas, with full information learning, posterior beliefs are either one or zero and the patient obtains either utility $u(w_1)$ or utility $u(w_2)$. In this latter case anticipatory utility is equiv-

[9] In K, as in our model, anomalous attitute twards information are explained *at a given prior concerning* patient's health status. On the contrary, the analysis by E-S is developped for *all possible prior beliefs.*

alent to expected utility $\frac{1}{2}u(w_1) + \frac{1}{2}u(w_2)$. Thus, when the patient is prone to information ($u(\cdot)$ convex), he will always choose full information learning since, for Jensen's inequality, $u(\frac{1}{2}w_1 + \frac{1}{2}w_2) < \frac{1}{2}u(w_1) + \frac{1}{2}u(w_2)$. If we add to the previous picture the loss function, it is clear that the cost due to an inefficient action will reinforce the result: an information loving patient always chooses to be perfectly informed. On the contrary, when the patient is information averse ($u(\cdot)$ concave) and no loss function exists, the previous inequality holds in the opposite sense and the patient always chooses to stay ignorant. In words: the loss in anticipatory utility due to the bad news w_2 is higher than the gain due to the good news w_1. The patient is information averse because he fears bad news. By reintroducing the loss function with an information averse patient, we observe that the trade off between the physical benefits of information disclosure (in terms of efficient action) and its psychological costs (in terms of anxiety) arise.[10]

The previous discussion shows that, when an information averse patient can not actively react to the news on his health status, he prefers to stay ignorant. In other words, if there is noting to do, according to intuition, no information learning represents the best choice.[11]

Let us calculate posterior beliefs in our simple model. Given priors $p = \frac{1}{2}$ and conditional probabilities $q = \text{prob}(s_i|w_i), i = 1, 2$, both the probability of each signal s_i and posterior beliefs are indicated in the following table:

s_i	prob(s_i)	prob$(w_1|s_i)$
s_1	1/2	q
s_2	1/2	$1-q$

(T1)

We define $z_i = \text{prob}(w_1|s_i)$. Thus, z_i represents the posterior probability of the preferred health status, given the signal s_i has been observed: $z_1 = \text{prob}(w_1|s_1) = q$ and $z_2 = \text{prob}(w_1|s_2) = 1-q$. Note that, in this simple setting, the conditional probability q corresponds to the up-dated belief that the true state is w_1, given the signal s_1. In other words, in our model, by choosing the precision of the signal q, the patient directly chooses his posterior beliefs.

[10] This is the issue K investigates. In his paper the choice is between a signal which is fully informative ($q = 1$) and a signal which is fully uninformative $\left(q = \frac{1}{2}\right)$. The author also proves that "the decision-maker will (almost) never avoid the doctor if the visit is useful and he expects to learn little from it, but may do so if very bad news are possible" (page 1074).

[11] As an example, think about the test for the genetic mutation responsible for Huntington's disease. The test is unequivocal and the disease is incurable and terrifying. The low acceptance rate of such a test is documented, among others studies, in Quaid and Morris (1993): only 15% of people at risk for Huntington's disease who initially expressed interest in the test ultimately followed through and got their results.

3. The patient's problem

As explained before, first the patient chooses the precision of health information to search for and observes the realization of the signal, then he updates his beliefs according to the signal realized, and finally chooses the action a. Later on we will call *stage 1* the moment where the patient chooses the precision of the signal q, and *stage 2* the moment where he chooses the action a. Both stages take place in period 1. We proceed for backwards induction.

- STAGE 2. At the end of period 1 the patient updates beliefs and chooses the action a given the signal observed. Thus, we can define the optimal action as:

$$a_i^*\left(q, w_1, w_2 | s_i\right) = \arg\max_a E\left[w_i - \left(w_i - a\right)^2 | s_i\right]$$

  Note that, according to the signal observed, two optimal actions exist: $a_1^*\left(q, w_1, w_2 | s_1\right)$ and $a_2^*\left(q, w_1, w_2 | s_2\right)$. If the signal is fully informative, the two optimal actions respectively are: $a_1^*\left(1, w_1, w_2 | s_1\right) = w_1$ and $a_2^*\left(1, w_1, w_2 | s_2\right) = w_2$. Whereas, if the signal is fully uninformative, the two optimal actions are the same: $a_1^*\left(\frac{1}{2}, w_1, w_2 | s_1\right) = a_2^*\left(\frac{1}{2}, w_1, w_2 | s_2\right) = a^*\left(\frac{1}{2}, w_1, w_2\right)$.

- STAGE 1. At the beginning of period 1, anticipating both Bayesian up-dating and the optimal action $a_i^*\left(q, w_1, w_2 | s_i\right)$, the patient chooses the precision of the signal by maximizing the following function:

$$\begin{aligned} U(q; w_1, w_2) &= \frac{1}{2} u\left(E\left[w_i - \left(w_i - a_1^*\left(q, w_1, w_2 | s_1\right)\right)^2 | s_1\right]\right) + \quad (3.1)\\ &\quad \frac{1}{2} u\left(E\left[w_i - \left(w_i - a_2^*\left(q, w_1, w_2 | s_2\right)\right)^2 | s_2\right]\right) \quad (3.2)\end{aligned}$$

  The function $U(q; w_1, w_2)$ represents anticipatory utility from an *ex-ante* perspective: when choosing the precision of the signal q, the patient anticipates that, if the signal s_i will be observed, the optimal action will be a_i^* and the subsequent expected physical utility $E\left[w_i - \left(w_i - a_1^*\right)^2 | s_i\right]$. In other words, each term in the function $U(q; w_1, w_2)$ measures anticipatory utility deriving from the observation of a specific signal. The two signal-specific anticipatory utilities are weighed by the probability $\frac{1}{2}$ that each signal is observed.

We are now able to write the patient's problem:

$$\begin{cases} \max\limits_{q} U(q; w_1, w_2) \\ \\ s.t. : q \in \left[\frac{1}{2}, 1\right] \end{cases} \tag{P1}$$

In the next two subsections we derive, first, the optimal action, and then the function $U(q; w_1, w_2)$. The second part of subsection 3.2 is devoted to the economic interpretation of anticipatory utility. Moreover, taking the two limit cases for the signal precision (the fully informative signal and the fully uninformative one), we derive in our setting the main result of K. Some clarifying examples are presented. The main contribution of our paper is provided in section 4, where conditions for an interior solution are derived and discussed.

3.1. STAGE 2: the choice of the action a

When the patient observes signal s_i, posterior beliefs for the state of health w_1 and w_2 respectively are z_i =prob$(w_1|s_i)$ and $1 - z_i$ =prob$(w_2|s_i)$ according to table T1. The patient will choose action a such that his expected physical health is maximized. Given signal s_i, expected physical health is:

$$E\left[w_i - (w_i - a)^2 |s_i\right] = z_i \left[w_1 - (w_1 - a)^2\right] + (1 - z_i) \left[w_2 - (w_2 - a)^2\right]$$

It is easy to verify that, when signal s_1 is observed, the optimal action corresponds to the mean of the two health status weighed by the posterior beliefs $z_1 = q$ and $1 - z_1 = 1 - q$:

$$a_1^* (q, w_1, w_2|s_1) = qw_1 + (1 - q)w_2 = E_{z_1}(w_i) \tag{3.3}$$

In the same way, when the patient observes signal s_2, posterior beliefs for the state of health w_1 and w_2 respectively are $z_2 = 1 - q$ and $1 - z_2 = q$. Thus, given signal s_2, the optimal action is:

$$a_2^* (q, w_1, w_2|s_2) = (1 - q)w_1 + qw_2 = E_{z_2}(w_i) \tag{3.4}$$

Since $q \geq 1 - q$ and $w_1 > w_2$, $w_1 \geq a_1^* (q, w_1, w_2|s_1) \geq a_2^* (q, w_1, w_2|s_2) \geq w_2$ holds. Signal s_1 represents 'good news' for the patient because the preferred state of health w_1 is more likely. When s_1 is observed, the optimal action $a_1^* (q, w_1, w_2|s_1)$ is relatively closer to w_1. On the contrary, signal s_2 represents 'bad news' for the patient because the preferred state of health w_1 is more unlikely. When s_2 is observed, the optimal action $a_2^*(q, w_1, w_2|s_2)$ is relatively closer to w_2. As observed before, when the signal is fully informative $a_1^*(1, w_1, w_2|s_1) = w_1$ and $a_2^*(1, w_1, w_2|s_2) = w_2$. Whereas, when the signal is fully uninformative the unique optimal action is: $a^*\left(\frac{1}{2}, w_1, w_2\right) = \dfrac{w_1 + w_2}{2}$. In general, as the signal becomes more informative, the action $a_i^*(q, w_1, w_2|s_i)$ becomes more accurate and the patient's expected loss decreases.

We can now calculate indirect expected physical utility when signal s_i is observed:

$$E\left[w_i - (w_i - a_i^*(q, w_1, w_2|s_i))^2 |s_i\right] = z_i\left[w_1 - (w_1 - a_i^*)^2\right] + (1 - z_i)\left[w_2 - (w_2 - a_i^*)^2\right] \quad (3.5)$$

or, by substituting the value of $a_i^*(q, w_1, w_2|s_i)$ expressed respectively in (3.3) and (3.4) and rearranging:

$$f_1(q; w_1, w_2) \equiv E\left[w_i - (w_i - a_1^*(q, w_1, w_2|s_1))^2 |s_1\right] = qw_1 + (1-q)w_2 - q(1-q)(w_1 - w_2)^2 \quad (3.6)$$

$$f_2(q; w_1, w_2) \equiv E\left[w_i - (w_i - a_2^*(q, w_1, w_2|s_2))^2 |s_2\right] = (1-q)w_1 + qw_2 - q(1-q)(w_1 - w_2)^2 \quad (3.7)$$

Note that, because of the term $-q(1-q)(w_1 - w_2)^2$ which appears in both $f_i(q; w_1, w_2)$, $i = 1, 2$, expected physical utilities, given the signal observed, are always convex in q.

3.2. STAGE 1: the anticipatory utility function $U(q; w_1, w_2)$

By substituting (3.6) and (3.7) in (3.1) we find the expression for emotional utility as a function of the precision of the signal q and the states of health w_1 and w_2:

$$\begin{aligned} U(q; w_1, w_2) &= \frac{1}{2}u\left(qw_1 + (1-q)w_2 - q(1-q)(w_1 - w_2)^2\right) + \\ &\quad \frac{1}{2}u\left((1-q)w_1 + qw_2 - q(1-q)(w_1 - w_2)^2\right) \end{aligned} \quad (3.8)$$

Let us define $L(q; w_1, w_2) \equiv q(1-q)(w_1 - w_2)^2$. $L(q; w_1, w_2)$ appears in both terms of $U(q; w_1, w_2)$ and represents the physical utility loss due to an inaccurate action. The lower is q and the higher is the loss. The physical loss reaches its maximum for the fully uninformative signal $q = \frac{1}{2}$: $L(\frac{1}{2}; w_1, w_2) = \frac{1}{4}(w_1 - w_2)^2$.

The expression for anticipatory utility as written in (3.8) shows that the patient faces the following trade off. On the one hand, by increasing information learning, he makes action a more effective. Since the loss $L(q; w_1, w_2)$ decreases in q, information learning makes both indirect expected physical utilities $f_i(q; w_1, w_2)$, $i = 1, 2$, increase. On the other hand, the more the signal is informative the more anticipatory utility associated to signal s_2 decreases. In other words, anxiety is increasing in the precision of the signal q. When the signal is fully informative anxiety reaches its maximum. In fact, in such a case, if s_2 occurs the patient perfectly infers that the true state is the bad one.

Let us consider the function $U(q; w_1, w_2)$ in the two extreme cases (the fully informative and the fully uninformative signal) to derive in our setting K's main result. When $q = 1$, anticipatory utility is:

$$U(1; w_1, w_2) = \tfrac{1}{2}u(w_1) + \tfrac{1}{2}u(w_2) \tag{3.9}$$

Here there is no physical loss because the action a is accurate: $L(1; w_1, w_2) = 0$. $U(1; w_1, w_2)$ is lower (or anxiety is higher) the more concave is the function $u(\cdot)$. Whereas, when the signal is fully uninformative:

$$U(\tfrac{1}{2}; w_1, w_2) = u\left(\frac{w_1 + w_2}{2} - \tfrac{1}{4}(w_1 - w_2)^2\right) \tag{3.10}$$

Here there is no information learning and, thus, no anxiety arises. However the utility loss reaches its maximum. Obviously the value of the loss $L(\frac{1}{2}; w_1, w_2)$ is increasing in the difference between the two states of nature w_1 and w_2 : the higher is $(w_1 - w_2)$ and the higher is the negative consequence of the totally inaccurate action $a^*\left(\frac{1}{2}; w_1, w_2\right) = \dfrac{w_1 + w_2}{2}$.

We are now able to state K's Observation 1 (page 1078) in our setting. By comparing full-information learning (3.9) and no-information learning (3.10) we observe that:

Remark 1. *The more concave is the function $u(\cdot)$ and the lower is the distance between w_1 and w_2, the more the patient prefers the fully uninformative signal $\left(q = \frac{1}{2}\right)$ to the fully informative one $(q = 1)$.*

Corollary 1. *It exists a function $u(\cdot)$ sufficiently concave and a distance between w_1 and w_2 sufficiently low such that the patient prefers the fully uninformative signal $\left(q = \frac{1}{2}\right)$ to the fully informative one $(q = 1)$.*

According to intuition, when the fear of bad news is sufficiently high and/or when the negative consequence of the most inaccurate action is not too harmful, the patient prefers no information learning to full information learning.

Note that, even when the patient is information averse, if the physical damage due to the fully inaccurate action is sufficiently high, the patient will always choose full information learning. In other words, whatever the concavity of the function $u(\cdot)$, a large physical loss due to the inaccurate action prevents the patient from very anomalous attitude towards information. This is a consequence of the fact that here information has a positive (decision-making) value: the optimal action is contingent to the state of health. As it was mentioned in the discussion on the concavity of function $u(\cdot)$ in the previous section, when on the contrary information has no decision-making value, an information averse patient always prefers to stay ignorant.

To see Corollary 1 in practice, let us consider first the simple case where $w_1 = 1$ and $w_2 = 0$. Thus, anticipatory utility becomes:

$$U(q;1,0) = \tfrac{1}{2}u\left(q^2\right) + \tfrac{1}{2}u\left((1-q)^2\right) \tag{3.11}$$

Here $U(\frac{1}{2};1,0) = u\left(\frac{1}{4}\right)$ and $U(1;1,0) = \frac{1}{2}u\left(1\right)+\frac{1}{2}u\left(0\right)$. Let us consider the power utility function $u(x) = \frac{x^{1-\gamma}}{1-\gamma}$, where $x, \gamma > 0$. It is well known that the power function exhibits decreasing absolute risk aversion and constant relative risk aversion (represented by the parameter γ). For our purpose it is useful to re-interpret the parameter γ as the index of relative aversion to *information*. It can be easily checked that for $\gamma \geq \frac{1}{2}$, $U(\frac{1}{2};1,0) \geq U(1;1,0)$. In words: when the index of relative aversion to information is higher than $\frac{1}{2}$, the patient prefers no-information to full information learning. In section 5 the implications of different types of functions on anticipatory utility will be explored.

Let us see, now, how the difference between w_1 and w_2 affects anticipatory utility. Take the case $w_1 = w$ and $w_2 = 0$ such that the function $U(q;w_1,w_2)$ becomes:

$$U(q;w,0) = \tfrac{1}{2}u\left(qw - q(1-q)w^2\right) + \tfrac{1}{2}u\left((1-q)w - q(1-q)w^2\right) \tag{3.12}$$

and assume again that the function $u(\cdot)$ is the power function with $\gamma = \frac{1}{2}$. It can be easily checked that, whenever $w < 1$, the patient prefers no-information to full information learning: $U(\frac{1}{2};w,0) \geq U(1;w,0)$. In other words, given an index of relative aversion to information equal to $\frac{1}{2}$, if the consequence of the inaccurate action is sufficiently low ($w_1 - w_2 < 1$), the patient chooses to stay ignorant.

A graphical representation of the two functions $U(\frac{1}{2};w,0)$ and $U(1;w,0)$ is worthwhile at this stage. In figure 1, function $u(w)$ is increasing and concave. Point A is anticipatory utility when no physical utility loss exists: $u\left(\frac{w}{2}\right)$. Point B indicates anticipatory utility with full information learning: $U(1; w, 0)$.

Definition 1. *Let us call w^* the distance between the two health status such that no-information learning provides the same utility as full information learning, or*

$$w^* : u\left(\frac{w^*}{2} - \tfrac{1}{4}w^{*2}\right) = \frac{1}{2}u(0) + \frac{1}{2}u(w^*)$$

In figure 1, point C represents anticipatory utility from no-information learning $U(\frac{1}{2}; w^*, 0)$.[12] With respect to the difference between w_1 and w_2, Corollary 1 can be reformulated in the following way:

Corollary 2. *When anticipatory utility is normalized by setting $w_1 = w$ and $w_2 = 0$ such that w represents the difference between the good and bad states of health, the patient prefers no-information to full information learning for $w < w^*$ and the opposite for $w > w^*$.*

P roof. Let us call $L^* \equiv L(\frac{1}{2}; w^*, 0) = \frac{1}{4}w^{*2}$. From figure 1 it is clear that $U(\frac{1}{2}; w, 0) > U(1; w, 0)$ for $L(\frac{1}{2}; w, 0) < L^*$ and $U(\frac{1}{2}; w, 0) < U(1; w, 0)$ for $L(\frac{1}{2}; w, 0) > L^*$. By comparing L and L^* Corollary (2) can be stated. ■

Insert figure 1 about here

Again from figure 1, a necessary condition such that $L(\frac{1}{2}; w, 0) < L^*$ is that $L(\frac{1}{2}; w, 0) < \frac{w}{2}$. The previous inequality reads $\frac{1}{4}w^2 < \frac{w}{2}$, or $w < 2$.

Remark 2. *A necessary condition such that the patient prefers no-information to full information learning is that the difference between the two states of health is lower than 2.*

This proves again that, whatever the concavity of the function $u(\cdot)$, anomalous attitudes towards information arise only if the physical loss due to the inaccurate action is low enough.

[12] In standard expected utility theory, $\frac{w^*}{2} - \frac{1}{4}w^{*2}$ would correspond to the Certainty Equivalent of the lottery where the two possible outcomes 0 and w^* have the same probability to occur.

3.3. Information-neutrality

Suppose that the function $u(\cdot)$ is linear such that the patient is neutral to information. In this case, anticipatory utility (2.1) turns out to be equivalent to physical expected utility:

$$\begin{aligned} \tilde{U}(q; w_1, w_2) &= \frac{1}{2}\left(qw_1 + (1-q)w_2 - q(1-q)(w_1 - w_2)^2\right) + \qquad (3.13) \\ & \quad \frac{1}{2}\left((1-q)w_1 + qw_2 - q(1-q)(w_1 - w_2)^2\right) \\ &= \frac{w_1 + w_2}{2} - q(1-q)(w_1 - w_2)^2 \qquad (3.14) \end{aligned}$$

This implies that the emotional patient maximizes standard expected utility as if he has no anticipatory feelings. $\tilde{U}(q; w_1, w_2)$ is convex in q : the patient always chooses $q = 1$. In other words, the patient chooses full information learning.

Remark 3. *When the patient is information-neutral, he always chooses full information learning. This is as if the emotional patient maximizes expected physical utility.*

Note that expected physical utility $E\left[w_i - (w_i - a_i^*)^2 \,|s_i\right]$ is the patient's indirect utility conditional on the signal observed. Such indirect utility is always convex in q : the higher is the precision of information, the higher is the average accuracy of the action and the higher is expected physical utility.

From the previous remark we note a first interesting characteristic of the function $U(q; w_1, w_2)$. Since expected physical utility $E\left[w_i - (w_i - a_i^*)^2 \,|s_i\right]$ is convex in q, even if the function $u(\cdot)$ is concave, in our model anticipatory utility can be locally and/or globally convex in the interval $\left[\frac{1}{2}, 1\right]$. This is a specific feature of C-L's model of Psychological Expected Utility. In E-S's paper, on the contrary, expected utility over beliefs is *always concave* in beliefs for decision-maker who are averse to information.

4. Interior solution

We want to verify if and when the patient's problem P1 admits an interior solution for q; in other words under which conditions the patient chooses an imprecise source of health information. Recall that $f_i(q; w_1, w_2) \equiv E\left[w_i - (w_i - a_i^*)^2 \,|s_i\right]$, $i = 1, 2$, as expressed respectively in (3.6) and (3.7). Anticipatory utility (3.8) can be rewritten as:

$$U(q; w_1, w_2) = \tfrac{1}{2}u\left(f_1(q; w_1, w_2)\right) + \tfrac{1}{2}u\left(f_2(q; w_1, w_2)\right)$$

By deriving with respect to q we find:

$$\frac{\partial U(q; w_1, w_2)}{\partial q} = \tfrac{1}{2}u_1'\left(f_1\right)f_1'\left(\cdot\right) + \tfrac{1}{2}u_2'\left(f_2\right)f_2'\left(\cdot\right) \tag{4.1}$$

where $u_i'\left(\cdot\right)$ and $f_i'\left(\cdot\right)$, $i = 1, 2$, respectively are the first derivative of $u(\cdot)$ with respect to $f_i(q; w_1, w_2)$ and the first derivative of $f_i(q; w_1, w_2)$ with respect to q. Recall that $u(\cdot)$ is increasing and concave and $f_i(q; w_1, w_2)$, $i = 1, 2$, is convex in q.

Using expressions (3.6) and (3.7), the first derivatives of $f_1(q; w_1, w_2)$ and $f_2(q; w_1, w_2)$ with respect to q respectively are:

$$f_1'(q; w_1, w_2) = (w_1 - w_2)\left[1 + (w_1 - w_2)(2q - 1)\right] \tag{4.2}$$

$$f_2'(q; w_1, w_2) = (w_1 - w_2)\left[-1 + (w_1 - w_2)(2q - 1)\right] \tag{4.3}$$

Condition 1. $q < \frac{1+(w_1-w_2)}{2(w_1-w_2)}$.

Lemma 1. *Problem P1 admits an interior solution if and only if Condition 1 holds.*

P roof. An interior solution exists if and only if $\frac{1}{2}u_1'f_1' + \frac{1}{2}u_2'f_2' = 0$ for some values of $q \in \left]\frac{1}{2}, 1\right[$. Recall that $u_i'\left(\cdot\right)$, $i = 1, 2$, is positive. Let us consider f_1' and f_2' as represented by expressions (4.2) and (4.3). From expression (4.2) $f_1' > 0\ \forall q \in \left[\frac{1}{2}, 1\right]$, or $f_1(q; w_1, w_2)$ is increasing in q in the relevant interval. This implies that an interior solution for P1 exists if and only if $f_2' < 0$ or if $f_2(q; w_1, w_2)$ is decreasing in q for $q \in \left]\frac{1}{2}, 1\right[$. It is easy to check that the derivative of $f_2(q; w_1, w_2)$ is negative if and only if Condition 1 is verified. ■

Condition 1 implies that expected physical utility, conditional on signal s_2 being observed, is decreasing in q. To intuit Lemma1 note that, when Condition 1 holds, $u_2'f_2' < 0$: the derivative of *emotional* utility conditional to the bad signal is negative as well. An increase in the precision of the signal q has a double effect on $f_2(q; w_1, w_2)$. First, expected physical utility decreases because the bad state of health is now more likely; this can be called the "anxiety effect" and corresponds to the term -1 in expression (4.3). Second, expected physical utility increases because the action is more accurate and the loss function falls; this can be called the "action accuracy effect" and corresponds to the term $+(w_1 - w_2)(2q-1)$ in expression (4.3). Condition 1 implies that *the "anxiety effect" dominates the "action accuracy effect"*. In other words, under Condition 1 and when the bad signal is observed, the emotional costs of more precise information prevails over the physical benefits. This is possible whenever the distance between w_1 and w_2 is sufficiently low. The previous reasoning is in line with Corollary 1 and 2 which, as mentioned before, show that the patient always chooses full information learning when the action inaccuracy is too harmful.

Before analyzing the implications of Condition 1, let us consider that, when $q = \frac{1}{2}$, $f_1(q; w_1, w_2) = f_2(q; w_1, w_2)$ and the derivative (4.1) is always equal to zero. This is stated in the following remark:

Remark 4. *For $q = \frac{1}{2}$, the first derivative of $U(q; w_1, w_2)$ is always zero: when the patient stays ignorant anticipatory utility always reaches either a local maximum or a local minimum.*

As will be discussed below, whether $q = \frac{1}{2}$ corresponds to a local maximum or to a local minimum for the function $U(q; w_1, w_2)$ depends on the degree of patient's aversion to information.

Note that $\frac{1+(w_1-w_2)}{2(w_1-w_2)}$ is larger than $\frac{1}{2}$ whatever $w_1 - w_2$. Together with Lemma 1 this implies that:

Corollary 3. *An interior solution for problem P1 exists for $\frac{1}{2} < q < \frac{1+(w_1-w_2)}{2(w_1-w_2)}$. When the difference between the two states of health $w_1 - w_2$ approaches infinity, no-information learning $\left(q = \frac{1}{2}\right)$ is the unique solution. For $w_1 - w_2 < 1$, Condition 1 is always slacking and an internal solution is more likely.*

P roof. Since $\frac{1+(w_1-w_2)}{2(w_1-w_2)}$ is decreasing in $w_1 - w_2$, the higher is the difference between the two states of health and more binding is Condition 1. In particular, when the difference between the two states of health goes to infinity $\frac{1+w_1-w_2}{w_1-w_2} \to \frac{1}{2}$. Thus, the solution $q = \frac{1}{2}$ is unique. When $w_1 - w_2 = 1$ Condition 1 results in $q \leq 1$. Whereas, for $w_1 - w_2 < 1$, Condition 1 is always verified. ■

Again, the previous corollary is in line with the fact that the higher is the utility loss $L(q; w_1, w_2)$ (or the larger is the distance between the two states of health) and more likely the patient will choose full information learning.

Let us consider now the second derivative of the function $U(q; w_1, w_2)$. As it was said before the function is not necessarily concave. In fact:

$$\frac{\partial^2 U(q;w_1,w_2)}{\partial q^2} = \tfrac{1}{2}u_1''(f_1)\left(f_1'(\cdot)\right)^2 + \tfrac{1}{2}u_1'(f_1)f_1''(\cdot) + \tfrac{1}{2}u_2''(f_2)\left(f_2'(\cdot)\right)^2 + \tfrac{1}{2}u_2'(f_2)f_2''(\cdot) \quad (4.4)$$

where $u_i''(\cdot)$ and $f_i''(\cdot)$, $i = 1,2$, respectively are the second derivative of $u(\cdot)$ with respect to $f_i(q;w_1,w_2)$ and the second derivative of $f_i(q;w_1,w_2)$ with respect to q. Note that, since anticipatory utility is increasing in expected physical utility and expected physical utility is convex w.r.t. q, the second term and the last one of (4.4) are both positive. Whereas, given our assumption on patient's attitude towards information, the first term and the third one are both negative (whatever the sign of $f_2'(\cdot)$).[13]

To proceed further and investigate how patient's aversion to information affects his optimal choice, let us normalize again the states of health such that $w_1 = w$ and $w_2 = 0$. As written before, the function $U(q;w_1,w_2)$ becomes:

$$U(q;w,0) = \tfrac{1}{2}u\left(qw - q(1-q)w^2\right) + \tfrac{1}{2}u\left((1-q)w - q(1-q)w^2\right) \quad (4.5)$$

We are interested in the condition such that the fully uninformative signal is either a local minimum or a local maximum:

Lemma 2. *The fully uninformative signal is a local maximum if patient's absolute aversion to information for $q = \frac{1}{2}$ is higher than 2 and is a local minimum if the opposite holds.*

P roof. When $q = \frac{1}{2}$, it is easy to see that:

$$\left.\frac{\partial^2 U(q;w,0)}{\partial q^2}\right|_{q=\frac{1}{2}} = 2w^2 u'\left(\frac{1}{2}w - \frac{1}{4}w^2\right) + w^2 u''\left(\frac{1}{2}w - \frac{1}{4}w^2\right)$$

where $u_1'(\cdot) = u_2'(\cdot) = u'(\cdot)$, thus:

$$\left.\frac{\partial^2 U(q;w,0)}{\partial q^2}\right|_{q=\frac{1}{2}} \gtrless 0 \Leftrightarrow -\frac{u''\left(\frac{1}{2}w - \frac{1}{4}w^2\right)}{u'\left(\frac{1}{2}w - \frac{1}{4}w^2\right)} \lessgtr 2$$

■

[13] Note that, when the function $u(\cdot)$ is convex, expression (4.4) is always positive. This means that anticipatory utility exhibits a global minimum for $q = \frac{1}{2}$ and the information loving patient will always choose full information learning.

What is interesting for our purpose is the fully uninformative signal as a local minimum. In fact, when this is the case, patient's anticipatory utility increases, at least locally, with the signal precision. Lemma 2 gives us important insight on which degree of absolute "information aversion" is compatible with an internal solution.

We are now able to state our main result. From Lemma 2:

Proposition 1. *If anticipatory utility is decreasing in* q *for* $q = 1$*, then a sufficient condition for an internal solution is an index of patient's absolute aversion to information lower than* 2 *for* $q = \frac{1}{2}$.

The following is a necessary condition on the maximal distance between the two health status such that anticipatory utility is decreasing in q for $q = 1$.

Condition 2. $w < 1$.

Note that, under Condition 2, Condition 1 is always verified.

Remark 5. *Anticipatory utility in* $q = 1$ *can be decreasing in the signal precision only if Condition 2 holds.*

P roof. When $q = 1$, it is easy to see that:

$$\left.\frac{\partial U(q; w, 0)}{\partial q}\right|_{q=1} = \frac{1}{2}\left(w + w^2\right) u_1'(\cdot) + \frac{1}{2}\left(-w + w^2\right) u_2'(\cdot)$$

For $q = 1$ anticipatory utility is decreasing in the signal precision if:

$$(1 + w)\, u_1'(\cdot) - (1 - w)\, u_2'(\cdot) < 0$$

Since $u(\cdot)$ is increasing in f_i, a necessary condition such that $\left.\frac{\partial U(q;w,0)}{\partial q}\right|_{q=1} < 0$ is $w < 1$. ■

Note that, under Condition 2, both $f_1(q; w, 0)$ and $f_2(q; w, 0)$ are positive over the interval $\left[\frac{1}{2}, 1\right]$. Moreover, over the same interval, $f_1'(q; w, 0)$ is positive and $f_2'(q; w, 0)$ is negative.

Proposition 1 states that, when anticipatory utility is decreasing w.r.t. q for $q = 1$, a sufficient condition such that an internal solution to problem P1 exists is that $q = \frac{1}{2}$ corresponds to a local minimum. On the one hand, when anticipatory utility is decreasing with respect to the signal precision for $q = 1$, starting from the fully informative signal, the patient increases his anticipatory utility by locally reducing information precision. As stated by Condition 2, this can occur only if the difference between good and bad news is sufficiently low. In fact, in this case, the loss from the inaccuracy of the action is low enough. Moreover, as stated in Corollary 3, Condition 2 also assures that the "anxiety effect" dominates the "action accuracy" effect. On the other hand, as Lemma 2 shows, the fully uninformative signal is a local minimum when aversion to information is not too high. Thus, according to intuition, partial information learning can be optimal when the patient is not too afraid of bad news. With partial information learning the action a is more appropriate than in the case of full ignorance and anxiety does not increase too much.

Interestingly enough, an interior solution is possible not only when the fully uninformative signal is preferred to the fully informative one, but also when the opposite is the case. We will show some numerical examples in the next section. Here we can use the previous reasoning to better characterize the internal solution. Let us assume that an internal solution exists, we can state that:

Corollary 4. *When the index of absolute aversion to information is lower than* 2*, the distance between the two health status is lower than* 1 *and an interior solution exists: the closer to* 2 *is patient's index of absolute aversion to information and/or the closer to* 0 *is the distance between* w_1 *and* w_2*, the closer to* $\frac{1}{2}$ *is the optimal precision of the signal. Conversely, the closer to* 0 *is patient's aversion to information and/or the closer to* 1 *is the distance between* w_1 *and* w_2*, the closer to* 1 *is the optimal precision of the signal.*

Our results show that a patient may prefer partial information learning only when the cost due to the inaccurate action is not too high, or when the distance between the two states of health is sufficiently low. In the real world, a health risk fitting such a condition is probably the so-called BRCA1 genetic mutation. The BRCA1 mutation is implicated in many hereditary breast cancer cases, and carries with it a very high risk of ovarian cancer.[14] However, both preventive measures that a carrier can take to detect the illness at an early stage and an effective treatment for the disease are available, such that bad news disclosed by the BRCA1 test is not so terrifying (in contrast to the Huntington's disease). Survey evidence suggested that there should be high testing rates (90% of those at risk for breast and ovarian cancer reported that they would be

[14] See Lerman *et al.* (1994) and (1998), Jacobsen *et al.* (1997).

very interested in getting test results; see Lerman *et al.* 1994), but in practice, the uptake rate has turned out to be far lower than expected: only 40% of those who declared interest in the test. Jacobsen *et al.* (1997) provide survey evidence on the importance of psychological factors against testing: fully 85% of the subjects in the study identified as a reason not to take the test the resulting increased concerns about developing breast cancer, 72% increased worry about family members, 27% felt that a bad result would leave them in a state of hopelessness and despair. The 40% of people who chosen to get tested, actually revealed their preference for perfect information learning. Our model predicts that, if their aversion to information is not too high, women who preferred not to be tested can have chosen partial information learning about their probability to be a carrier of the mutation instead of staying ignorant.

4.1. The case with anticipatory utility *and* expected physical utility

In this subsection we show that, using anticipatory utility (2.1) instead of the complete function (2.2) as patient's objective is without generality loss. It can be easily checked that, when $w_1 = w$ and $w_2 = 0$, total utility is:

$$\hat{U}(q; w, 0) = \tfrac{1}{2}u\left(qw - q(1-q)w^2\right) + \tfrac{1}{2}u\left((1-q)w - q(1-q)w^2\right) + \tfrac{1}{2}w - q(1-q)w^2 \qquad (4.6)$$

Lemma 1, Remark 4, Corollary 3 and Condition 2 still hold. Whereas, since a convex term has been added to patient's objective function, Lemma 2 and Proposition 1 must be slightly modified in order to take into account that an internal solution exists for a value of information aversion higher than before.

Lemma 3. *The fully uninformative signal is a local maximum if patient's absolute aversion to information for $q = \frac{1}{2}$ is higher than $2 + \varepsilon$ and is a local minimum if the opposite holds. The term ε is positive and equal to $\frac{2}{u'\left(\frac{1}{2}w - \frac{1}{4}w^2\right)}$.*

Proposition 2. *If total utility is decreasing in q for $q = 1$, then a sufficient condition for an internal solution is an index of patient's absolute aversion to information lower than $2 + \varepsilon$ for $q = \frac{1}{2}$.*

Note that it is less likely than before that total utility is decreasing in q for the fully informative signal,[15] however the condition such that the fully uninformative signal is a local minimum is less stringent.

To summarize, when the patient maximizes total utility, an internal solution is compatible with levels of information aversion higher than the values we obtained when anticipatory utility was considered alone. In the next section we will provide some numerical simulations to show the difference between the two cases.

5. Simulations

Let us consider again anticipatory utility and the power function $u(x) = \frac{x^{1-\gamma}}{1-\gamma}$, with γ re-interpreted as the parameter of constant relative aversion to information.[16] According to Proposition 1, let us take an index of patient's absolute aversion to information lower than 2 for $q = \frac{1}{2}$. Thus, it must be: $-\frac{u''\left(\frac{1}{2}w-\frac{1}{4}w^2\right)}{u'\left(\frac{1}{2}w-\frac{1}{4}w^2\right)} = \gamma\left(\frac{1}{2}w - \frac{1}{4}w^2\right)^{-1} < 2$ or $\gamma < w - \frac{1}{2}w^2$. Note that the function $w - \frac{1}{2}w^2$ in increasing and concave for $w \in [0,1]$. It reaches its maximum $\frac{1}{2}$ for $w = 1$. It can be checked that, for $w < 1$ and $\gamma < w - \frac{1}{2}w^2$, the function $U(q;w,0)$ is well defined over the interval $q \in \left[\frac{1}{2}, 1\right]$ and that the derivative of anticipatory utility in $q = 1$ is negative. Figures 2 and 3 show anticipatory utility in the interval $q \in \left[\frac{1}{2}, 1\right]$ when $u(\cdot)$ is the power function and $\gamma = .4$. It can be noticed that, for $w = .9$ (figure 2) the fully informative signal is preferred to the fully uninformative one, whereas, for $w = .7$ (figure 3) the opposite is the case. However, in both situations anticipatory utility is maximized for an intermediate level of q. As we explained, other things equal, the closer to 1 the difference between the two health status the higher is the preference for full information learning with respect to staying ignorant. Moreover, the closer to 1 the difference between the two health status and the closer to 1 is the optimal precision of the signal.

Insert figure 2 and 3 about here

By comparing figure 3 and 4 where w is the same $(w = .7)$, we can observe the effect of a decrease in γ on the shape of $U(q;w,0)$. For $\gamma = .35$ (figure 4), anticipatory utility associated to the fully uninformative signal is much lower than for $\gamma = .4$ (figure 3). Moreover, the internal

[15] In fact, $\left.\frac{\partial \hat{U}(q;w,0)}{\partial q}\right|_{q=1} = \frac{1}{2}\left(w + w^2\right) u_1'(\cdot) + \frac{1}{2}\left(-w + w^2\right) u_2'(\cdot) + w^2$.

[16] To the best of our knowledge, no empirical parameter estimates of individual relative *information* aversion are available. The estimates of relative *risk* aversion vary considerably, but values in the 0.5-3 interval are often referred to.

maximum in figure 4 corresponds to a signal more informative than in figure 3. In words, the lower is patient's relative aversion to information γ the more informative is the optimal signal.

Insert figure 4 about here

Remark 6. *With the power function* $u(x) = \frac{x^{1-\gamma}}{1-\gamma}$*, the fully uninformative signal is a local minimum for* $\gamma < w - \frac{1}{2}w^2$*. When such inequality hold and for* $w < 1$*, patient's anticipatory utility is decreasing in* q *for the fully informative signal. Thus, an interior solution exists. It can be either that the fully uninformative signal is preferred to the fully informative one or the opposite.*

It is interesting to compare the case where $w = .7$ and $\gamma = .4$ (figure 3) to the case where the same values of the parameters are associated to full utility (4.6). Figure 5 shows that, with total utility, the interior solution is closer to full information learning. Finally, figure 6 shows total utility when $w = .7$ and $\gamma = .5$, that is when aversion to information slightly increases. As we expected, the optimal precision of the signal decreases.

Insert figure 5 and 6 about here

To conclude, let us consider anticipatory utility with the exponential function $u(x) = \frac{-e^{-\alpha x}}{\alpha}$ which exhibits constant absolute aversion to information α. The fully uninformative signal is a local minimum for $\alpha < 2$. However, with the exponential function, even though $w < 1$, $\frac{\partial U(q;w,0)}{\partial q} > 0 \; \forall q \in \left[\frac{1}{2}, 1\right]$. Thus, in this case, the optimal choice is full information learning.

Remark 7. *With the exponential function* $u(x) = \frac{-e^{-\alpha x}}{\alpha}$*, for* $\alpha < 2$ *and* $w < 1$ *anticipatory utility is monotonically increasing in* $q \in \left[\frac{1}{2}, 1\right]$ *: the patient chooses full information learning.*

6. Conclusion

In this paper we have addressed the issue of information acquisition on health status by a patient who fears about future health. Following the strand of economic and psychology literature on anticipatory feelings, we have investigated a model of choice under uncertainty enriched by adding beliefs to the description of uncertain consequences, so as to capture anticipatory feelings such as anxiety or hopefulness. Our Bayesian decision maker has expected-utility preferences over outcomes that are described with the decision maker's action, the state of nature and also the decision maker's belief.

The peculiarity of our model is that a third alternative with respect to staying ignorant and going to the physician (who provides full information) is considered. In fact, we discuss the possibility to search for other signals that can be interpreted as health information sources characterized by different content precision. For example, by searching for information disseminated on the Internet the patient is able to choose different accuracy of information. In this framework, we have shown that anxiety costs might induce the patient to choose information sources less precise than a physician advise or a medical test. By deliberately choosing an imprecise source of information, the patient is able to decrease the level of anxiety induced by information.

From a policy perspective our result shows that the disclosure of *partial* information can be beneficial to anxious patients. However, this insight holds when strategic interaction with an informed physician is not taken into account. In particular, our model considered the simple case where information from sources other than a physician and doctor's advise are substitutes for the patient. It could be interesting to analyze the complementary case, where the patient searches for information disseminated on the Internet *before* seeing his doctor and decides whether and how to use such information when interacting with the physician. In other words, physician's agency could be enriched both by considering patient's anxiety and the fact that the information previously obtained by the patient from other sources is possibly used to influence physician's behavior. This issue is related to two recent papers focusing on information transmission in physician agency (C-L 2004, K 2005).[17] These models investigate credibility problems arising when the patient experiments anticipatory feelings and the physician cares about his patient's emotions. However, information learning by the patient is not considered in either model.

Information acquisition by anxious patients is not the only relevant context for our analysis. In fact, a similar issue arises in other contexts with uncertainty where an unskilled decision maker may decide to rely on personally acquired information or, alternatively, on experts' advice, such as, for example, in the case of the decision on financial plans.

More generally the issue of information learning is related to the literature on *selective attention*. This literature develops the idea that individuals consciously decide what information to expose themselves to and what information to avoid. In particular, while people search selectively for information that conveys good news or that reinforces their pre-existing beliefs, they avoid

[17] See Barigozzi and Levaggi (2005) for a survey on the new developments in physician agency.

information that conveys bad news or conflicts with priors beliefs. The idea of self-manipulation of beliefs to increase one's utility is particularly natural in the field of finance: recently Karlsson, Loewenstain and Seppi (2005) analyzed investors' selective exposure to information on financial markets in a model where individuals condition their information learning decisions on imperfect prior information that can be positive or negative. They show that investors who observed bad news exhibit the so called "ostrich effect".

References

[1] Barigozzi F., and R. Levaggi (2005), "New Developments in Physician Agency: the Role of Patient Information", working paper n.550, Department of Economics, University of Bologna.

[2] Bundorf, M.K., L.Baker, S. Singer and T. Wagner (2004), "Consumer Demand for Health Information on the Internet", NBER Working Paper No. 10386.

[3] Caplin, A. and K. Eliaz (2003), "AIDS and Psychology: A Mechanism-Design Approach", *RAND Journal of Economics*, 34 , 631-646.

[4] Caplin A, and J. Leahy (2001), "Psychological Expected Utility Theory and Anticipatory Feelings", *Quarterly Journal of Economics*, 55-80.

[5] Caplin A, and J. Leahy (2003), "Behavioral Policy", in *Essays in Economics and Psychology*, I. Brocas and J. Carrillo eds., Oxford University Press.

[6] Caplin, A. and J. Leahy (2004), "The Supply of Information by a Concerned Expert", *Economic Journal*, 114 , 487-505.

[7] Eliaz, K., Spiegler R. (2004), "Can Anticipatory Feelings Explain Anomalous Choices of Information Sources?", forthcoming in *Games and Economic Behaviors*, available on http://homepages.nyu.edu/~ke7/working.htp

[8] Fox, S., & Rainie, L. (2002). Vital decisions: How Internet users decide what information to trust when they or their loved ones are sick. Pew Internet & American Life Project: Online Report. Retrieved June 10, 2002 from http://www.pewinternet.org/reports/pdfs/PIP Vital Decisions May2002.pdf

[9] Jacobsen, Paul, Heiddis Valdimarsdottir, Karen Brown, and Kenneth O¢t, (1997), “Decision-Making about Genetic Testing Among Women at Familial Risk for Breast Cancer,” Psychosomatic Medicine, 59, 459-466

[10] Karlsson N., G. Loewenstain and D. Seppi (2005), "The ‘Ostrich Effect’: Selective Exposure to Information About Investment", mimeo.

[11] Kozsegi, B. (2003), “Health Anxiety and Patient Behavior”, *Journal of Health Economics*, 22 , 1073-1084.

[12] Kozsegi, B. (2005) Emotional Agency, *Quarterly Journal of Economics*, forthcoming.

[13] Lerman, Caryn, M. Daly, M. Masny, and A. Balsheim, (1994), “Attitudes about Genetic Testing for Breast-Ovarian Cancer Susceptibility” Journal of Clinical Oncology, 12 843-850.

[14] Lerman, C., C. Hughes, S. J. Lemon, D. Main, C. Snyder, C. Durham, S. Narod and H. T. Lynch, "What You Don’t Know Can Hurt You: Adverse Psychological Effects in Members of BRCA1-Linked and BRCA2-Linked Families Who Decline Genetic Testing”, *Journal of Clinical Oncology* 16 (1998), 1650-1654.

[15] Moscarini G., L. Smith, (2001) "The Optimal Level of Experimentation", *Econometrica*, November, 1629-1644.

[16] Quaid, K and M. Morris, 1993, “Reluctance to Undergo Predictive Testing: the Case of Huntington’s Disease”, American Journal of Medical Genetics, 45, 41-45.

[17] Tu, H. T. and J. L. Hargraves (2003), "Seeking Health Care Information: Most Consumers still on the Sidelines", Center for Studying Health System Change: 1-4.

[18] T.H. Wagner, T.Hu and J.H. Hibbard, (2001), "The demand for Consumer Health Information", *Journal of Health Economics*, 20 , 1059-1075.

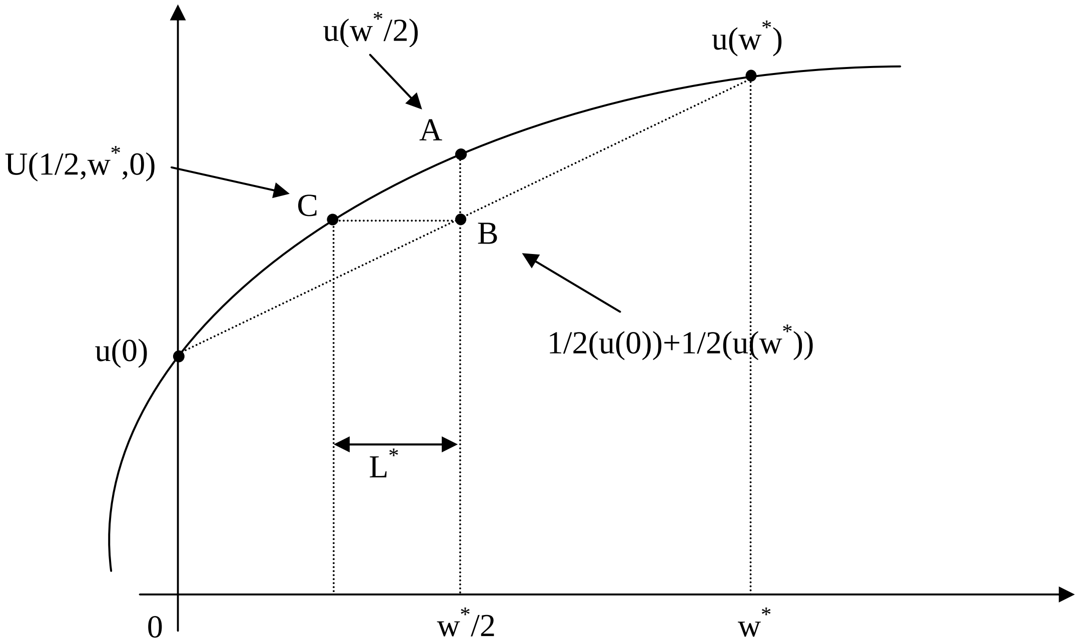

Figure 1: anticipatory utility with the fully informative signal (point B) and with the fully uninformative signal (point C) when the loss is L^*.

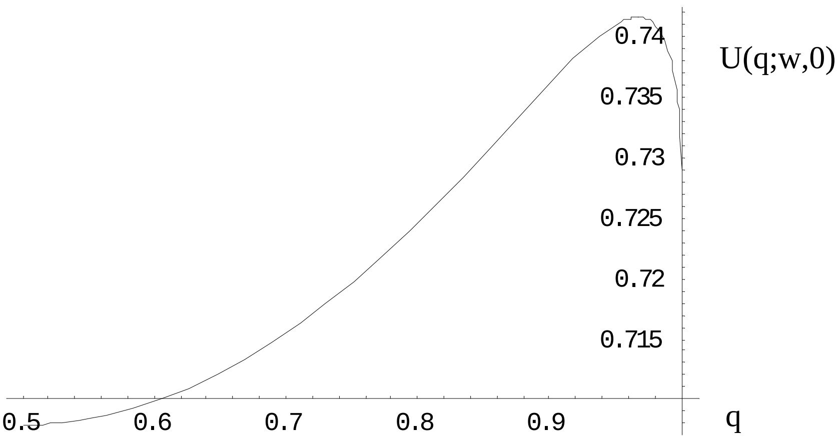

Figure 2: the function u(.) is the power function with γ=0.4 and *w*=0.9. Here an internal solution for *q* arises with the fully informative signal preferred to the fully uninformative one.

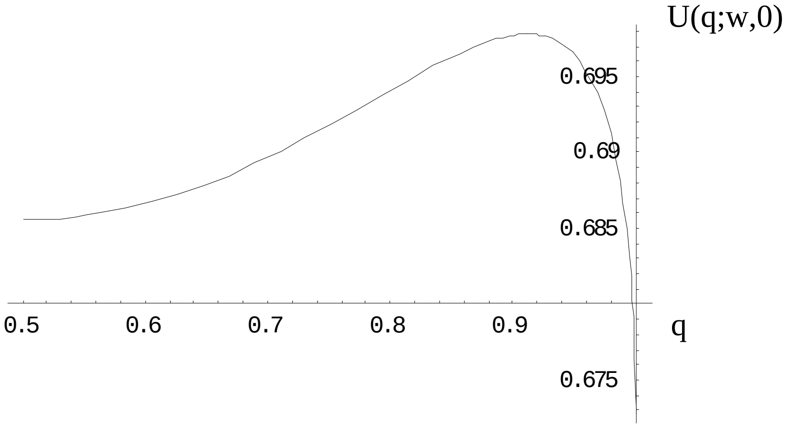

Figure 3: as before γ=0.4, but *w*=0.7. Here an internal solution for *q* arises with the fully uninformative signal preferred to the fully informative one.

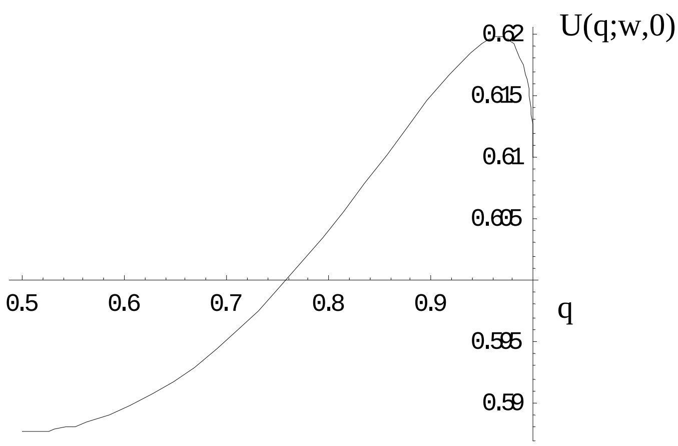

Figure 4: here the power function is characterized by γ=0.35 and *w*=0.7.

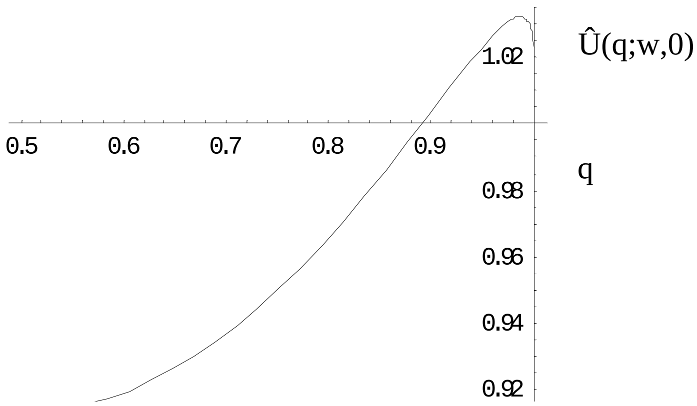

Figure 5: γ=0.4, and w=0.7 as in figure 3, but here total utility is considered.

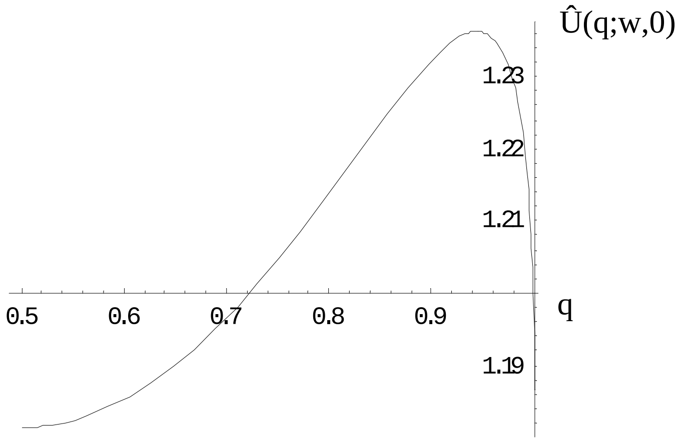

Figure 6: total utility when the power function is characterized by γ=0.5 and w=0.7.