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The Choice of Fish Species: An Experiment Measuring the Impact of Risk and Benefit Information

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An experiment was conducted in France to evaluate the impact of health information on consumers' choice. Fish have positive and negative health attributes, and we focus on fish species of diverging risk-benefit ratios. Successive messages revealing risks (methylmercury) and benefits (omega-3s), along with consumption recommendations, were delivered to experiment participants. Results show significant differences in reaction among participants depending on the sequencing order of information on risks and benefits. The results of the experiment are combined with a partial equilibrium model to determine the value of information. Acknowledging adjustments of equilibrium prices, health information is shown to have significant value to consumers.

Key words: experimental economics, fish consumption, health information, nutrition

Introduction

Public health communication programs aim at informing consumers about health benefits and risks associated with particular products or types of behavior. They affect consumers' choices by reducing uncertainty about the "true value" of goods, thereby improving the allocative efficiency of their consumption behavior. Nutrition information often consists of advising changes between imperfect substitutes, e.g., to choose vegetable oil (relatively rich in nonsaturated fat) rather than butter (relatively rich in saturated fat) or to eat white meat rather than red meat. In other words, nutrition information aims at "forcing" substitution between different products.

This issue is particularly important for fish consumption since it involves a complex balance between benefits (with nutritional considerations) and risks (with toxicological considerations). Recently, several health agencies around the world issued messages pertaining to fish consumption. As there are large differences among fish species regarding their health-promoting content, knowledge about the tendency by consumers to substitute different fish species for each other after revelation of information is essential for designing efficient health communication. As recently noted by the U.S. National Academies (2006, p. 12), "Research is needed to develop and evaluate more

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effective communication tools for use when conveying the health benefits and risks of seafood consumption....”

The objective of this study is to evaluate the impact of health information on consumers’ choice between a relatively “risky” type of fish (tuna) and a type of fish that is not only “less risky” but in addition offers health benefits (sardines). The respective risk and benefits considered here are methylmercury and omega-3 fatty acids. An experiment was conducted in France with women of childbearing age, since fish is particularly important during pregnancy. The women were endowed with a given quantity of either “healthy” or “risky” fish, and were then asked their willingness to exchange this endowment for a varying quantity of the other fish.¹ This procedure allows for evaluation of the substitution between products. Messages successively revealing risks and benefits were delivered to the participants, along with consumption recommendations.

The contributions of this paper are both empirical and methodological. First, from an empirical point of view, this study differs from previous works measuring the effect of information in experiments. For instance, Hayes et al. (1995); Fox, Hayes, and Shogren (2002); Noussair, Robin, and Ruffieux (2002); and Wansink, Sonka, and Hasler (2004) combine positive and/or negative (or shorter and/or longer) information for measuring the relative impact of these different options on buyers’ willingness to pay (WTP). Rather than introducing different types of messages, we change the sequence of information revelation. There is no countervailing effect, and we show that the order of benefit and risk messages has implications regarding their efficacy in changing consumption behavior.

Second, our paper provides a new methodology to combine data from economic experiments with a partial market equilibrium calibrated to the French market to obtain an estimate of the value of information (given by agents’ surplus variations). Following Foster and Just (1989) and Teisl, Bockstael, and Levy (2001), information is welfare enhancing if consumers change their consumption behavior. Conversely, if consumers’ purchases do not change, information has no value. Whereas previous studies (e.g., Huffman et al., 2003, 2007; Rousu et al., 2004, 2007) do not acknowledge the equilibrium price variations in response to product-related information, our paper completes the analysis by introducing equilibrium price variations. The results provide insights into distributional effects of health information both for consumers “at risk” and concerned by the revealed information, and for consumers who are not directly concerned by the information but by resulting price modifications. This methodology provides a means to extrapolate results gained in the lab “to the world beyond” (see Levitt and List, 2007, p. 154).

The paper continues with a brief presentation of risks and benefits of fish consumption. In the following sections, we describe the experiment and discuss the results. The paper concludes with a discussion of the implications for public health policy.

¹This approach for measuring substitution is based on Masters and Sanogo (2002) and Sanogo and Masters (2002), focusing on a single endowment point (see also Binswanger, 1980). However, these researchers used only one type of product for the initial endowment. MacCrimmon and Toda (1969) were among the first to employ the experimental determination of indifference curves. Their experiments proceed by consecutive choices between two consumption bundles in order to evaluate rates of substitution for varying endowments. This process was considered too demanding on subjects when simultaneously testing the successive revelation of information to consumers.

Fish Consumption, Health Benefits/Risks, and Regulatory Decisions

Safety and nutrition linked to fish consumption have become an increasing public health concern in recent years. In particular, methylmercury, an organic form of mercury, is a toxic compound that alters fetal brain development when there is significant prenatal exposure. Children of women who consume large amounts of fish during pregnancy are particularly vulnerable to the adverse neurological effects of methylmercury. A high level of methylmercury is concentrated in long-lived, predatory fish, such as tuna, shark, and swordfish.

The regulatory choice of how to manage this risk is complex because the nutrients in fish are also essential to the health of a developing fetus. Omega-3 polyunsaturated fatty acids, along with iodine, selenium, and phosphorus, confer benefits to the fetus such as infant cognition and improvement in cardiovascular health (European Food Safety Authority, 2005, p. 1). Recognizing the importance of this safety and nutrition information, several countries have begun to broadcast specific advisories, including the United States beginning in 2001, Canada in 2002, the UK in 2003, and Ireland, Australia, and New Zealand in 2004. These communications advise vulnerable groups (small children, pregnant women, and women of childbearing age) to consume fish while avoiding species at the high end of the food chain such as shark, swordfish, king mackerel, tilefish, and tuna because of high levels of mercury contamination. The advisories mitigate the broad applicability of the general recommendation by nutrition and health experts to consume fish twice or three times a week motivated by the health benefit of a sufficient consumption of omega-3 fatty acids decreasing the risk of heart disease in adults.

The content and details of the advisories vary among countries because of idiosyncratic characteristics regarding the patterns of fish consumption and the types of fish commonly caught. Since 2001, the U.S. has been active in targeting and disseminating the information to childbearing age and pregnant women (U.S. Environmental Protection Agency, 2004). The EPA advisory was found to have its intended effect, as pregnant women reduced their consumption of fish (Oken et al., 2003). The 2004 U.S. advisory begins by explicitly citing the benefits of regular fish consumption because of the content of omega-3 polyunsaturated fatty acids. There are substantial differences regarding both sequence of information revelation and species mentioned in warnings. All the messages explicitly note the benefits of fish consumption, while they differ about the details linked to the benefits, since omega-3s or fatty fish rich in omega-3 are not always mentioned. The U.S. and Australia/New Zealand mention the benefits at the beginning of their advisories, while the other countries refer to these benefits at the end of their advisories. Hence, our experiment is useful in assessing the effect of different sequences of information revelation.

The French situation is interesting because no major diffusion of information has been decided upon yet. Some warnings have been posted on the website of the Agence Française de Sécurité Sanitaire des Aliments, the French food safety agency (AFSSA, 2004), but no major broadcasting of information was implemented by the sanitary authorities.² This absence of informative campaigns suggests that in France very few childbearing women know about the potential risk of methylmercury exposure. In contrast to the methylmercury issue, information on omega-3 fatty acids is relatively widespread in France

² One year following the experiment reported in this paper, the French food safety agency issued a press release on methylmercury (AFSSA, 2006) that led to a few articles in the popular press. Tuna, in particular, is not mentioned in this press release. To the best of our knowledge, no major dissemination of information via obstetricians, maternity hospitals, or booklets is actually planned in France.

through mass media or advertising campaigns. This allows us to measure the effect in the laboratory under controlled circumstances.

The Experiment

This section successively details the sample, the choice of products, the revealed information, and the experimental procedure.

The Sample

As pregnancy and breastfeeding status or being a young child are crucial indicators for the risks linked to methylmercury, we selected women of childbearing age, between 18 and 45 years old, for our sample. The experiment was conducted in Dijon, France, in multiple sessions in January 2006. A sample of 115 women was randomly selected based on the quota method and is representative of age groups and socioeconomic status for the population of the city. Women were contacted by phone and informed that they would be required to eat both tuna and sardines during the experiment.

The Products

As discussed more fully below, tuna and sardines were selected as products because (a) they are frequently consumed in France and (b) their nutritional content is significantly different.

First, this experiment focused on canned fish, known and consumed by almost all French consumers. Canned tuna and canned sardines are commonly consumed, but the quantities consumed are quite different: 65% of canned fish consumed in France is tuna and 11% is sardines (OFIMER, 2003). There is an asymmetry in consumption habits with an "a priori preference" for tuna, while the nutritional considerations revealed in the messages favor sardine consumption.

We chose fish cans that are similar in a maximum number of elements—namely, brand, sauce, weight, packaging, and price. This allows us to isolate the substitution between the two different types of fish and the impact of information on consumers' choices. The two cans are of the French brand "Connétable." As shown by table 1, the weights and the prices from the selected cans were very similar. The closeness in weight and price permits a direct comparison of the products by participants in the experiment. However, the price per kilogram was significantly above the average price in France, which suggests we selected high-quality products.

The second reason for the selection of tuna and sardines was the considerable difference in the contents of mercury and omega-3, as reported in table 2. Tuna contains high mercury and low omega-3 levels, whereas sardines contain high omega-3 and low mercury levels. The contrasted contents in mercury and omega-3s have important consequences for information revealed during the experiment.

The Revealed Health Information

During the experiment, information about risk and benefits was communicated. We restricted attention to one benefit, omega-3 fatty acids, and one risk, methylmercury.

Table 1. Description of Fish Cans

Connétable Cans	Grams	2005 Price/Can in Supermarket (€)	Price/Kilogram (€)	2002 Average Price in France (€)
Tuna (albacore)	80	1.65	20.62	6.1
Sardines	87	1.69	19.42	8.2

Sources: Authors' calculations; OFIMER (2003) for the last column.

Table 2. Average Omega-3 and Methylmercury Content for Canned Tuna and Canned Sardines in Europe

Fish Type	Omega-3s (n-3 PUFA) (g/100g raw fish)	Methylmercury (mg/kg fresh matter)
Canned Tuna	0.5	0.210
Canned Sardines	3.3	0.052

Sources: Sidhu (2003, table 5, p. 341) for omega-3s; Crépet et al. (2005, table 1, pp. 181–182) for methylmercury.

The messages were inspired by elements coming from health agencies in the various countries described above.

While the complete information revealed to subjects is given in appendix A, it is possible to summarize the content delivered at different points in the experiment as follows (where 1a, 1b, 2a, and 2b correspond to specific message numbers fully defined in the appendix):

- 1a. Information about the presence of omega-3 fatty acids in fish, with a ratio of omega-3s in sardines to tuna equal to 6:1.
- 1b. Explanation about the health benefits coming from omega-3s and recommendation regarding the weekly consumption of fish.
- 2a. Information about the presence of methylmercury in fish, with the ratio of methylmercury in tuna to sardines equal to 4:1.
- 2b. Explanation about the health risks posed by methylmercury and recommendation to avoid tuna.

We detailed ratios quantifying the relative content of nutrients and contaminants based on table 2, which is unusual compared to public health advisories. This choice provides scientific credibility in our context and fits the restricted choice between only two types of fish in the experiment. We separate the information regarding the nutrient and hazard content in fish (messages 1a and 2a, respectively) from the description of the health effects and the consumption recommendation (messages 1b and 2b, respectively). This split allows us to measure consumers' ability to interpret "raw" information (1a and 2a) and their ability to modify their purchasing decisions after receiving recommendations (1b and 2b).

The Experiment Procedure

During the choice procedure, women were asked to choose between an endowment of six cans of Fish I and a variable number of cans of Fish II, ranging from 1 to 12. Participants were endowed with either six cans of tuna (groups A and B) or six cans of sardines (groups C and D). Different endowments are essential for obtaining complete information about substitution and for determining welfare changes.

The experiment was divided into several steps, detailed in the box below:

— EXPERIMENT STEPS —	
1.	Participants received general instructions and signed a consent form.
2.	Participants filled out a computer-assisted questionnaire on health and nutrition behavior and socio-demographic characteristics.
3.	Participants had one minute to examine cans of both tuna and sardines. Then the can price of the endowed Fish I was posted on the computer screen and participants were asked to give an estimation of the retail price of a can of Fish II.
4.	Participants had two minutes to taste both types of fish.
5.	The choice procedure was explained and the choice experiment was conducted in the following stages: <ol style="list-style-type: none"> without health information; after receiving message 1a in groups A and C, or message 2a in groups B and D; after receiving message 1b in groups A and C, or message 2b in groups B and D; after receiving message 2a in groups A and C, or message 1a in groups B and D; after receiving message 2b in groups A and C, or message 1b in groups B and D.
6.	Participants replied to a short exit questionnaire.
7.	The products remitted to participants were randomly identified out of the selected choices. Participants also received €10 indemnity and a brochure explaining the risks linked to methylmercury.

In each of the five stages of the choice procedure (under step 5), participants were requested to indicate their selection in 12 different situations on a single sheet of paper (see appendix B). The number of cans of Fish II varied from 1 to 12. For each line corresponding to one situation, participants had to choose either the six cans of Fish I or the indicated number of cans of Fish II. To avoid satiation effects, only one choice situation was randomly selected among the total of 60 choices made during the five stages. Following their response to a brief exit questionnaire in step 6, each of the women then received in step 7 the number of cans of Fish I or Fish II they preferred in this randomly selected choice situation. This procedure is preference revealing, because each choice situation has a positive probability of being selected. The choice mechanism was explained and illustrated in a trial round before the first choice was made, thereby permitting an evaluation of preferences after product tasting and without health information.

For the following stages, information was successively revealed on the computer screen. Each message was posted for at least 30 seconds before participants could proceed to the relevant instructions. Each time, the speaker invited the women to carefully read the message before making new choices. When new information was provided, the previous message was retained in grey, while the new message appeared in blue.

Table 3. Experiment Design

Initial Endowment (Fish I)	Information Provided About:	
	Omega-3 Fatty Acids (1a and 1b) Methylmercury (2a and 2b)	Methylmercury (2a and 2b) Omega-3 Fatty Acids (1a and 1b)
Tuna	Group A: $N = 27$	Group B: $N = 31$
Sardines	Group C: $N = 28$	Group D: $N = 29$

The experiment was conducted in four treatments, varying the fish species in the initial endowment (tuna or sardines) and changing the order of information about the risk of methylmercury (messages 2a and 2b) before the information about benefits of omega-3 fatty acids (messages 1a and 1b) and vice versa. Table 3 describes the experiment design and the corresponding number of respondents, given by N .

Interpretation of Results

The idea developed by Binswanger (1980) and later adopted by Masters and Sanogo (2002) is to use respondents' choices to infer their relative preference and WTP. Based on product substitution, this methodology is particularly tailored to our empirical question searching for details regarding the consumption of fish species. The number of cans of Fish II at which the consumer switches from six cans of Fish I to Fish II can be interpreted as the point of indifference (Sanogo and Masters, 2002, p. 257). In contrast to Sanogo and Masters' approach that estimates WTP for almost perfect substitutes differing only in their information content, we are interested in estimating the substitution between two imperfect substitutes. Tuna and sardines differ not only in the risk/benefit dimension but also in other preference dimensions such as taste.

In this experiment, the consumer owns a given quantity of $\bar{q}_I = 6$ cans of Fish I. The experiment provides the selected quantities of Fish II, q_{II} . The consumer being indifferent between the two product bundles is denoted as $\bar{q}_I \sim q_{II}$. Based on the 12 observed choices at stage j , with $j \in \{i, ii, \dots, v\}$ (refer to the experiment procedure section above), the experiment allows us to isolate the quantity \tilde{q}_{II}^j for which $\tilde{q}_{II}^j - 1 < \bar{q}_I^j$ and $\tilde{q}_{II}^j > \bar{q}_I^j$. We use this quantity at which subjects switch to define the switching ratio. The implicit switching ratio for good II in terms of the price of good I is specified as:

$$(1) \quad SWR_{II}^j = \frac{6}{\tilde{q}_{II}^j},$$

where $j \in \{i, \dots, v\}$ denotes the five stages of choices under the different contexts of information (see the preceding section). Equation (1) is an estimation of preferences for good II (relative to good I). An increasing switching ratio SWR_{II}^j during the experiment implies increasing relative preference for good II.

This framework can be adapted to reveal relative WTP. Because the observed can price \hat{p}_I of the endowed Fish I was posted before subjects' choices, it is possible to determine the unknown WTP for Fish II at stage j , wtp_{II}^j . From the above paragraph, it follows that

$$wtp_{II}^j(\tilde{q}_{II}^j - 1) < \hat{p}_I \tilde{q}_I^j \text{ and } wtp_{II}^j * \tilde{q}_{II}^j \geq \hat{p}_I \tilde{q}_I^j.$$

Rewriting the previous inequalities leads to:³

$$(2) \quad \frac{6}{\tilde{q}_{II}^j} \leq \frac{wtp_{II}^j}{\hat{p}_I} < \frac{6}{\tilde{q}_{II}^j - 1}.$$

Inequality (2) implies that the switching ratio (1) approximates the relative WTP for good II,⁴ in terms of the price of good I, \hat{p}_I , i.e.:

$$(3) \quad SWR_{II}^j \approx \frac{wtp_{II}^j}{\hat{p}_I}.$$

If during the experiment $q_{II}^j > \tilde{q}_{II}^j$ is satisfied for every $q_{II} \in \{1, \dots, 12\}$ (only Fish II was selected), we arbitrarily set $\tilde{q}_{II}^j = 1$. If no $\tilde{q}_{II}^j \in \{1, \dots, 12\}$ is observed for a respondent, we set $\tilde{q}_{II}^j = 13$. Based on this convention, $SWR_{II}^j \in [6/13, 6]$. Boundary choices ($\tilde{q}_{II}^j = 1$ or $\tilde{q}_{II}^j = 13$) may lead to an under- or overestimation of the substitution between products. Despite this limitation, the methodology is useful for providing information regarding the consumers' substitution response.

Experiment Results

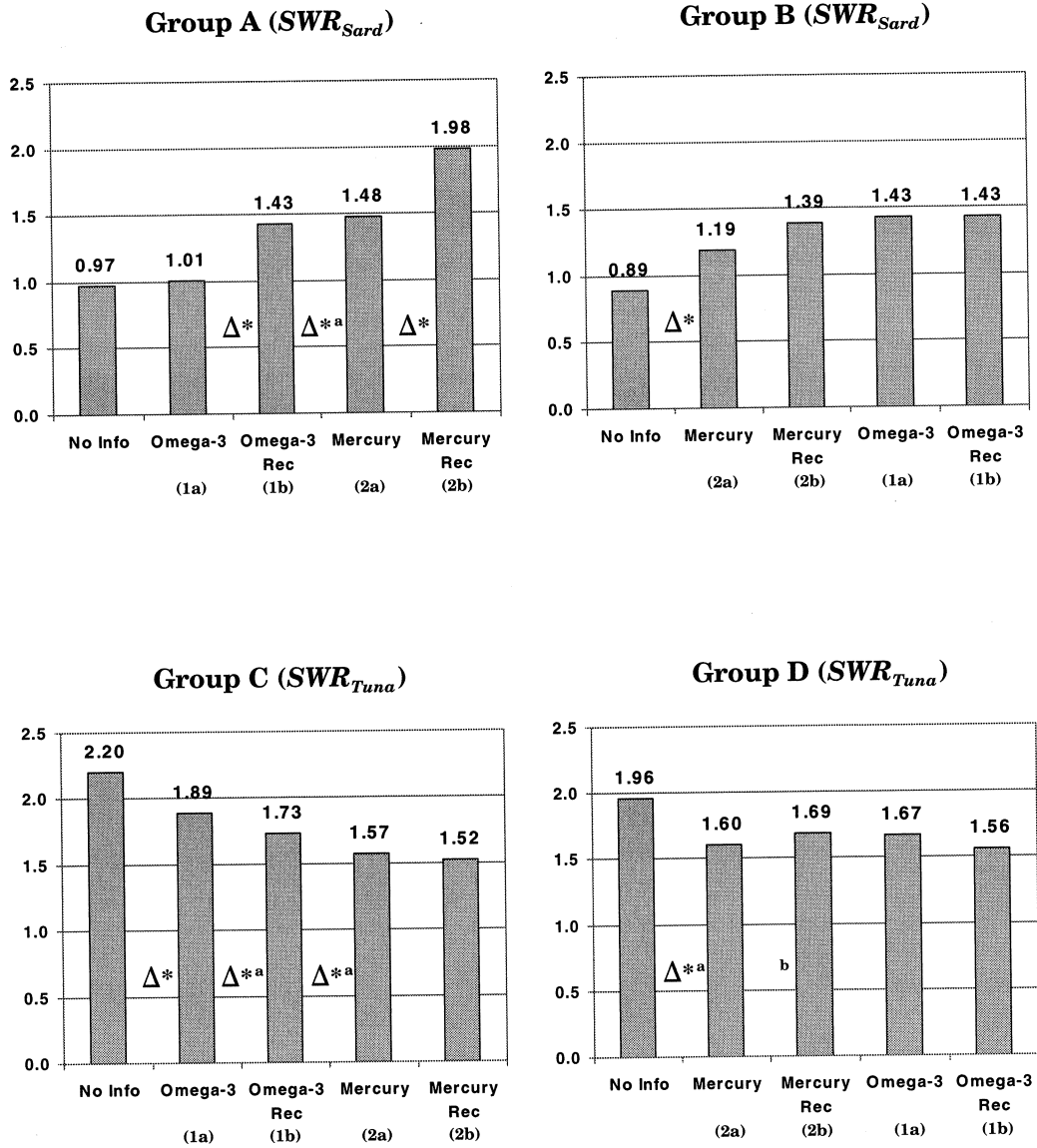
From respondents' choices, we computed the switching ratio SWR_{II}^j for products at different information stages. Based on equation (1), figure 1 presents the average switching ratio SWR_{II}^j by group for all respondents at the successive stages of information revelation. Recall that in groups A and B (C and D), consumers were initially endowed with six cans of tuna (sardines).

The first bar of every graph in figure 1 indicates participants' SWR_{II}^j after tasting both products and without health information (initial stage i). The SWR_{II}^j for sardines by groups A and B is lower than the SWR_{II}^j for tuna by groups C and D. This means that women attending the experimental sessions had a higher initial preference for tuna, which is consistent with product shares observed in the French market. Many more participants consistently chose tuna, no matter how large the number of cans of sardines they could receive (10 subjects in group A and B combined), or how small the number of cans of tuna became (four subjects in groups C and D).

The revelation of information leads to several interesting results in figure 1. First, the information leads to an increase in the switching ratio of groups A and B and a decrease for groups C and D, a result that implies health information matters to the women. We tested for the significance of these differences using the Wilcoxon test for paired samples and indicate the significant differences at the 5% level using Δ^* in figure 1.

³ Note that, although at step 3 of the experiment, we announced the actual market price of Fish I, \hat{p}_I , and the value of the participant's endowment, this step is not necessary for the results that follow. Instead of using \hat{p}_I as in Masters and Sanogo (2002), it is possible to use the unknown WTP for Fish I, wtp_I . In step 3, subjects also gave their estimation of the retail price of a can of Fish II. The estimates are on average very close to the observed retail prices detailed in table 1. Indeed, the average price for sardines estimated by groups A and B was 1.55€ (actual retail price = 1.69€). The average price for tuna estimated by groups C and D was 1.59€ (actual retail price = 1.65€).

⁴ This relative WTP is an average WTP, as it is derived for a discrete change in demand. Hence, and under the assumption of decreasing marginal WTP, one would expect that WTP at the margin is overestimated. This type of average WTP evaluation is difficult to avoid in experimental economics or contingent choice studies as the size of the good is often changed in discrete steps of significant size to assure that sufficient stakes are involved.



Notes: Δ^* denotes significant difference at the 5% level as tested by the Wilcoxon test for comparing paired sample choices SWR_{II}^j and SWR_{II}^{j+1} , with $j \in \{i, v\}$ for the different stages of information revelation. On the X-axis, "Omega-3 Rec" and "Mercury Rec" indicate that a recommendation was revealed to subjects (see appendix A).

^a Denotes differences are no longer significant when testing after deleting extreme observations of $q_{II} = 1$ or $q_{II} = 13$.

^b Denotes differences that become significant when testing after deleting extreme observations of $q_{II} = 1$ or $q_{II} = 13$.

Figure 1. Mean Switching Ratios ($SWR_{II} = 6/\tilde{q}_{II}$)

Overall, the information linked to the complete revelation of the four consecutive messages (the difference between the fifth bar and the first bar in each of the figure 1 graphs) has a larger effect on the switching ratio for sardines than for tuna. Indeed, the average switching ratio for sardines increases by 1.01 in group A, while the average switching ratio for tuna decreases by 0.68 in group C (same order of information). Moreover, the switching ratio for sardines increases by 0.54 in group B, while it decreases for tuna by 0.40 in group D. The effect of information is not symmetric in the initial endowment, as the change in the switching ratio for sardines is larger.⁵

Second, the order of the messages is crucial. Whatever the order, however, the information about mercury (message 2a; see appendix A) leads to a significant change in switching ratio. If we consider the difference between the fifth bar and the first bar of the graphs in figure 1, the switching ratio increase for sardines is larger by 0.47 in group A compared to group B, and the SWR decrease for tuna is larger by 0.28 in group C compared to group D. In particular, if messages 2a and 2b on methylmercury precede messages 1a and 1b on omega-3s (for groups B and D), then the major shift in the switching ratio comes from the information on methylmercury and the information on omega-3s no longer causes subsequent change in substitution.

Information on omega-3s only significantly changed the switching ratio, if it came before information about mercury (for groups A and C). Nevertheless, the information about methylmercury still has a larger impact on the switching ratios than the information about omega-3s (see group A). Including extreme observations (with $q_H = 1$ and $q_H = 13$) matters to explain significance of additional information on the change in switching ratio denoted in figure 1 by Δ^{*a} in groups A and C, as extreme points are mainly coming from subjects initially not interested in sardines, with $\tilde{q}_{sard}^i = 13$ inside group A and $\tilde{q}_{tuna}^i = 1$ inside group C at stage i .⁶ The efficacy of mentioning omega-3s' benefits before methylmercury risks seems to justify the choice made by the U.S. and Australia/New Zealand to clearly introduce the benefits of fish consumption at the beginning of their advisories about mercury.

Third, our findings reveal that additional explanation of the health effect matters. Indeed, in groups A, C, and D (see note "b" in figure 1), the switching ratio after recommendation revealed in messages 1b or 2b (third bar in the graphs of figure 1) significantly shifts compared to the first rounds of information in messages 1a or 2a detailing only the relative content in the nutrient/contaminant (the second bar). Only in group A is this effect significant at the end of the experiment (stage v, fifth bar). This result suggests that information satiation is easily achieved (see also Wansink, Sonka, and Hasler, 2004).

⁵ The literature reveals that an endowment effect exists if consumers prefer to keep their endowed good (Kahneman, Knetsch, and Thaler, 1990) and if goods have no close substitutes (Haneman, 1991; Shogren et al., 1994).

⁶ The difference between the average SWR after and before information (equivalent to the fifth bar and the first bar, respectively, in figure 1) for the entire subgroup with $\tilde{q}_{sard}^i = 13$ or $\tilde{q}_{tuna}^i = 1$ is larger in absolute value than the difference for the other subjects with $2 \leq \tilde{q}_H^i \leq 12$. Sixty percent of subjects initially not interested in sardines with $\tilde{q}_{sard}^i = 13$ inside groups A and B switched toward sardines after the revelation of information with $\tilde{q}_{sard}^j \leq 12$ for $j \neq i$. Forty-five percent of subjects initially not interested in sardines with $\tilde{q}_{tuna}^i = 1$ inside groups C and D switched toward sardines after the revelation of information with $\tilde{q}_{tuna}^j \geq 2$ for $j \neq i$.

Welfare Analysis for Estimating the Value of Information

We now turn to a welfare analysis estimating the value of information. For simplicity, we consider only the impact after the complete revelation of information in the last stage $j = v$, which allows pooling of groups A and B and groups C and D, respectively. Switching ratios from the experiment are combined with a model measuring imperfect substitution between sardines and tuna, with the model calibrated to the French market.

The Model

The switching ratio SWR_{II}^j between Fish II and Fish I at stage j is an indicator of preference for Fish II. Using expression (3), a relative measure of the impact of information on preferences for Fish II is given by:

$$(4) \quad \delta_{II} = \frac{SWR_{II}^v - SWR_{II}^i}{SWR_{II}^i} = \frac{wtp_{II}^v - wtp_{II}^i}{wtp_{II}^i},$$

where the complete revelation of health information is defined by stage $j = v$, and the initial situation without health information is defined by $j = i$. Thus, δ_{II} represents the relative change in the per unit willingness to pay for Fish II coming from health information. A positive value of δ_{II} signifies an increase in the willingness to pay for Fish II. The results for groups A and B yield the relative change in the willingness to pay for sardines, δ_s , and those for groups C and D the relative change in the willingness to pay for tuna, δ_T .

To model this impact of health information on market demand, we combine Spence's (1976) quasilinear utility function with the approach introduced by Polinsky and Rogerson (1983) for the treatment of health information in a demand function. Spence's specification of the utility function of imperfect substitutes is consistent with the assumption of separability of the two goods in question from all other goods, which drives the experiment (details can be provided by the authors upon request). Using this utility function, the inverse demands for consumers purchasing tuna and sardines are written as:

$$(5) \quad \begin{cases} p_t^j = \alpha_t - \beta_t X_t - \gamma X_s - I_j \bar{r}_t, \\ p_s^j = \alpha_s - \beta_s X_s - \gamma X_t + I_j \bar{h}_s, \end{cases}$$

where X and p denote market quantities and prices for tuna (t) and sardines (s), respectively. The parameters α and β specify the linear portions of the demand function, and γ relates to the rate of substitution. The per unit health risks (benefits) for consumers associated with the consumption of tuna (sardines) are denoted by average values equal to \bar{r}_t and \bar{h}_s . I_j is the indicator function for the information stage, with $I_i = 0$ without health information, and $I_v = 1$ with health information.

For the "at risk" subgroup z corresponding to the one from the experiment, the demand is modeled for the proportion of individuals the subgroup represents in the French population. Then, for subgroup z , and by using (4), it is possible to calculate the average change in willingness to pay for sardines ($\bar{\delta}_s^z$) over subjects in groups A and B, and the

average change in willingness to pay for tuna ($\bar{\delta}_T^z$) over subjects in groups C and D. By using the previous definitions of $p_t^v - p_t^i$ and $p_s^v - p_s^i$, the average values of per unit risks and per unit benefits for subgroup z are designated by:

$$(6) \quad \begin{cases} \bar{r}_t^z = -p_t^i \bar{\delta}_T^z, \\ \bar{h}_s^z = p_s^i \bar{\delta}_S^z, \end{cases}$$

where p_t^i and p_s^i are set at observed market prices \hat{p}_t and \hat{p}_s . Consequently, incorporating both endowments (tuna and sardines) in the experiment leading to $\bar{\delta}_S^z$ and $\bar{\delta}_T^z$ is essential.

Calibration

Parameters of the model are calibrated such as to predict prices and quantities in France (under the absence of information) for the year 2002 (see table 4), the most recent complete year when the analysis was undertaken (OFIMER, 2003). The supply and demand equations are represented by linear approximations with the corresponding elasticity at the point of approximation (as in Lichtenberg, Parker, and Zilberman, 1988; Sobolevsky, Moschini, and Lapan, 2005). For the supply side, we assigned values to the supply function $X_f = d_f + e_f p_f$, with $f = t$ or s for tuna or sardines, using elasticities found in the literature (see table 4). For the calibration of demands described in equation (5), values were assigned to the parameters based on elasticities we estimated in table 4 for consumers of both tuna and sardines, Ω_1 , with $I_i = 0$, i.e., for a situation without health information. Demands were separately calibrated for consumers purchasing only tuna, Ω_2 , and consumers purchasing only sardines, Ω_3 .⁷ The aggregation of demands of different subgroups gives the overall demand.

It was assumed that only the demands of those consuming both types of goods (consumers Ω_1 in table 4) were modified by the information.⁸ Among them, we distinguished between consumers concerned with the health information, or “at risk” (i.e., households with women of childbearing age and/or with young children under age 14—group 1), for whom $\bar{r}_t^z > 0$ and $\bar{h}_s^z > 0$ [see equation (6)], and those consumers “not at risk” (not concerned with the health message of this experiment), for whom $\bar{r}_t^z = 0$ and $\bar{h}_s^z = 0$. Based on statistics provided by INSEE (1999), the households “at risk” represent 50.5% of French consumers.⁹ From the experiment, the respective average values are $\bar{\delta}_S^z = 1.28$ for groups A and B, and $\bar{\delta}_T^z = -0.21$ for groups C and D. For measuring different contexts of diffusion, we distinguish between case 1, where the entire 50.5% of concerned households receive health information, and case 2, where only half of these concerned consumers are reached by this information.

⁷ Details on the estimation of demand elasticities and the calculation of welfare effects are available from the authors upon request (see Marette et al., 2007).

⁸ Alternative specifications do not significantly change the results presented here.

⁹ For simplicity, we assumed that households without women of childbearing age or without young children are not concerned by the revealed information, even if omega-3s are relevant to all the population because of their impact on cardiovascular risk.

Table 4. Demand Specifications for Households Purchasing Both Canned Tuna and Canned Sardines in France in 2002

Variable	Description	Values	
<i>Tuna</i>	Overall consumption in France in 2002 (tons)	63,845	
	Average price/can in 2002 (€)	6.1	
	Supply elasticity ^a	0.2	
<i>Sardines</i>	Overall consumption in France in 2002 (tons)	11,484	
	Average price/can in 2002 (€)	8.2	
	Supply elasticity ^a	0.2	
<i>Consumers Ω_1</i>	Households purchasing both sardines and tuna		
	% of households consuming sardines and tuna ^b	65%	
	Demand elasticities: ^c	Tuna	Sardines
	Own-price	-0.580*	-0.476*
	Cross-price	-0.059*	0.144*
<i>Consumers Ω_2</i>	Households purchasing only tuna		
	% of households consuming only tuna ^b	32.5%	
	Own-price elasticity of demand ^c	-0.534*	
<i>Consumers Ω_3</i>	Households purchasing only sardines		
	% of households consuming only sardines ^b	2.5%	
	Own-price elasticity of demand ^c	-0.451*	

Sources: OFIMER (2003); SECODIP (2002).

Note: An asterisk (*) denotes significance at the 5% level in the regression between the log of quantities and the log of prices.

^a Supply elasticities reported by Babula and Corey (2004) for tuna in the U.S., where "fishery [is] exploited at or near its maximum yields" (see p. 145). Due to lack of credible estimation for France, we assume technologies between these two countries are similar. We also assume that sardine fisheries exhibit the same technology.

^b Percent over the overall number of consumers purchasing only tuna or only sardines.

^c Authors' estimation for the elasticity with SECODIP data in 2002.

Results

Table 5 reports the economic impact of information on prices and surpluses of agents for the year 2002. The demand shifts imply a fall in the equilibrium price for tuna ($\Delta p_t < 0$) and an increase in the equilibrium price for sardines ($\Delta p_s > 0$). The price variation for sardines is larger than the absolute value of the price variation for tuna, because $|\bar{\delta}_S^z| > |\bar{\delta}_T^z|$. Consequently, gross profits for tuna producers ($\Delta \Pi_T$) fall, while gross profits for sardine producers ($\Delta \Pi_S$) surge.¹⁰

Despite the subsequent price changes, consumers in households at risk benefit from the information since ΔCS_2 is positive. Consumers not concerned by the information suffer from the subsequent change in market prices with a negative ΔCS_1 . This loss comes from the large price increase for sardines that outweighs the positive impact of the small price decrease for tuna.

Table 5 shows a positive net welfare gain, $\Delta W > 0$, from informing households at risk despite some losses for tuna producers and for consumers not concerned by the revealed

¹⁰ The estimated price effect for sardines appears quite large and ignores long-term industry adjustments and substitution of tuna by other products.

Table 5. Economic Effects of Information on Prices and Different Groups (in euros, €)

Description		Unit	Case 1	Case 2
Price Variations:				
Δp_t	Tuna absolute	€	-0.28	-0.14
$\Delta p_t/\hat{p}_t$	Tuna relative	%	-4.6%	-2.3%
Δp_s	Sardine absolute	€	3.70	1.85
$\Delta p_s/\hat{p}_s$	Sardine relative	%	45.2%	22.6%
Surplus Variation when Prices Vary:				
$\Delta \Pi_T$	Tuna producers	€	-21,579,855	-10,832,098
$\Delta \Pi_S$	Sardine producers	€	54,931,214	26,503,449
ΔCS_1	Non-concerned consumers	€	-13,830,515	-12,576,828
ΔCS_2	Concerned consumers	€	7,609,339	8,403,685
ΔW	Total welfare	€	27,130,183	11,498,207
$\Delta W/W$	Relative welfare	%	2.8%	1.2%
Surplus Variation with Constant Initial Prices:				
$\Delta \tilde{C}_2$	Concerned consumers	€	40,196,836	20,098,418
$\Delta CS_2/\Delta \tilde{C}_2$	Concerned consumers w/price adjustments relative to scenario w/constant prices	%	18.9%	41.8%
$\Delta W/\Delta \tilde{C}_2$	Value of information w/price adjustments relative to scenario w/constant prices	%	67.4%	57.2%

information. The result is robust for all configurations presented in table 5. (This is also the case for other scenarios conducted in a sensitivity analysis not reported here due to space considerations.)

Ignoring price variations in the market after the revelation of information leads to an overestimation of consumers' surplus gain (equal to the net welfare gain under constant prices), indicated by $\Delta \tilde{C}_2$, since the ratios $\Delta CS_2/\Delta \tilde{C}_2$ and $\Delta W/\Delta \tilde{C}_2$ given in the last two rows of table 5 are relatively low. The relatively large price increase for sardines is costly for consumers who adjust their behavior in response to information, so that the benefit of the information on their surplus is partially thwarted by a negative effect coming from this price increase for sardines. This overestimation of welfare effects, with $\Delta CS_2/\Delta \tilde{C}_2 < 1$ and $\Delta W/\Delta \tilde{C}_2 < 1$, was overlooked in previous estimations of the value of information coming from experimental economics.

Conclusion

Public health communication about fish consumption is a difficult task because of the complexity of health risks and benefits that present themselves in different weights for different segments of the population. In order to test the ability of benefit and risk advisories to change consumer behavior, we report results of a non-hypothetical choice experiment involving the evaluation of substitution rates.

The experimental procedures are found to have important implications for the evaluation of product substitution. We show that the order of information and consumption recommendations matters. Efficiency of information can be improved by first discussing benefits before talking about risks. By following this sequence, the information about

benefits is still absorbed. It seems useful to begin an advisory to women of childbearing age by first emphasizing the benefits coming from omega-3 polyunsaturated fatty acids, followed by a clear consumption recommendation. This option was adopted by the United States and Australia/New Zealand, and should be considered by other countries.

Another important finding of this investigation is the value of information estimated by combining experimental results with a quantitative market calibration for forecasting price reactions and welfare variations. The accuracy of the predictions of the partial equilibrium analysis is of course conditional on the underlying model specification and assumptions being correct. This new methodology could be used by policy bodies for ex ante estimation of labeling/recommendation policies for predicting market reactions.

The results reported here are limited to the substitution between two fish species. One extension of this work could consider the introduction of more species, fully representing French consumption. Another extension might introduce the possibility for consumers to change their total fish consumption, since we arbitrarily constrained their choices to a value equivalent to six cans. One way to relax the separability assumption of the two goods would be to offer participants at the end of the experiment the possibility to exchange the six cans they received versus the numeraire or to measure WTP for each fish using, e.g., the Becker, DeGroot, and Marschak (1964) mechanism. Another extension could give subjects the choice of obtaining or refusing additional information during the experiment.

By correcting for idiosyncratic characteristics, the experiment could also be replicated in other countries for better understanding consumers' reactions. It could be applied in studies focusing on women's observed reactions to fish consumption advisories. For instance, the methodology of this study could be useful for directly tackling some points of the research agenda recently raised by the U.S. National Academies (2006).

The experimental work on health information emphasizes that when issuing an advisory it is imperative to consider several important factors, such as consumers' reactions and preferences for fish species, before deciding the type of information and/or the media to use. The results of this paper point to the importance of developing economic analyses prior to the dissemination of an advisory regarding methylmercury.

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Appendix A: Complete Information Revealed to Experiment Subjects

(The precise messages are translated from the original French.)

Messages Linked to Omega-3 Fatty Acids:

- **Message 1a for groups A and B (with the endowment of 6 cans of tuna).** Fish is important for the diet equilibrium. Fish is a good source of protein, vitamins, and minerals. Fish content is high in omega-3 fatty acids and low in saturated fat. Tuna contains six-fold less omega-3 fatty acids than sardines.
- **Message 1a for groups C and D (with the endowment of 6 cans of sardines).** Fish is important for the diet equilibrium. Fish is a good source of protein, vitamins, and minerals. Fish content is high in omega-3 fatty acids and low in saturated fat. Sardines contain six-fold more omega-3 fatty acids than tuna.
- **Message 1b for all groups.** The regular consumption of omega-3 fatty acids helps to reduce the risks of cardiovascular diseases and it contributes to brain development and growth of children. Public health authorities advise eating fish at least twice a week.

Messages Linked to Methylmercury:

- **Message 2a for groups A and B (with the endowment of 6 cans of tuna).** Fish contains methylmercury (organic form of mercury) naturally present in water and coming from industrial pollution. All fish contain traces of methylmercury. By accumulation, larger fish that have lived longer have the highest level of methylmercury. Tuna contains four-fold more methylmercury than sardines.
- **Message 2a for groups C and D (with the endowment of 6 cans of sardines).** Fish contains methylmercury (organic form of mercury) naturally present in water and coming from industrial pollution. All fish contain traces of methylmercury. By accumulation, larger fish that have lived longer have the highest level of methylmercury. Sardines contain four-fold less methylmercury than tuna.
- **Message 2b for all groups.** The mercury effects on health have been shown by several medical studies. The results of these studies show a lack of brain development in the fetus and in children exposed to mercury. Public health authorities advise pregnant women, childbearing women, and young children to avoid the consumption of predatory fish such as tuna.

Appendix B:
The 12 Choice Situations
for Groups A and B

SITUATION 1	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 1 sardine can
SITUATION 2	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 2 sardine can
SITUATION 3	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 3 sardine cans
SITUATION 4	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 4 sardine cans
SITUATION 5	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 5 sardine cans
SITUATION 6	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 6 sardine cans
SITUATION 7	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 7 sardine cans
SITUATION 8	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 8 sardine cans
SITUATION 9	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 9 sardine cans
SITUATION 10	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 10 sardine cans
SITUATION 11	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 11 sardine cans
SITUATION 12	<input type="checkbox"/> 6 tuna cans	- or -	<input type="checkbox"/> 12 sardine cans

Note: For the 12 situations selected by groups C and D, the sardine cans replace the tuna cans on the left, and the tuna cans replace the sardine cans on the right.