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Authors	Toyoko Endo, Shuzo Fujimura
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Can airline customers value aircrafts' safety represented by technical terms?

Toyoko Endo*, Satoshi Ito, Shuzo Fujimura
Tokyo Institute of Technology, Graduate School of Innovation Management

1. Introduction

With respect to human information processing about products or services in the situation where his/her motivation, capability or knowledge was insufficient, the elaboration likelihood model (Petty & Cacioppo, 1986) and the heuristic-systematic model (Chaiken, 1980) presumed that the peripheral route, or heuristic, processing took charge of lowering his/her cognitive load and evaluating intuitively based on perceived credibility and attractiveness of the information provider.

Many businesses, in fact, have implemented the theory of the peripheral route approaches to generate a positive reception from customers, especially when technical information is involved. The same holds true for our theme "aircrafts' safety". According to major airline customer surveys of Japan (Nikkei Business, 2012; JCSI, 2013), the safety has been listed as the most important element to consider when choosing a carrier to fly with. However, the evaluations of safety in them were almost exclusively based on overall corporate images and reputations. They stood on neither technical reasons nor some quantified data.

Omori (2015) discussed in his case investigation of Japan Airline (JAL)'s managerial crisis after the serial unsafe events caused in 2005 that as a result of media's emotional amplification of such unsafe events in a way to bring back memories of JAL's severe crash in 1985, its corporate competitiveness was severely damaged. According to Omori (2015), the unsafe events of JAL back then were technically irrelevant to cause any aviation accidents. If JAL had succeeded in providing information to help their customers think more objectively about the aircrafts' safety, then it could have been able to build more mutually beneficial relationship with its customers.

Then, what technical data could objectively represent aircrafts' safety? Some international surveys such as Airline Ratings (2014) and JACDEC (2013) used the occurrence of aviation accidents in the past as an indicator. However, aviation accidents are stochastically rare events and can also be caused by reasons other than airlines' operational management such as airframe damage by extraneous factors, and judgment errors by air controllers.

We believe the frequency of occurrence of an aircraft maintenance discrepancy, not comprehensively but specifically, could serve as the indicator because it is the direct result of the airlines' proactive technical management. Also, the figure is quantifiable and publicly accessible. Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) defines the aircraft maintenance discrepancy as the events which any important system for safety installed in the aircraft, such as engines, communication and electrical systems, do not function normally during flights. Airlines are obligated to report such events to MLIT for the sake of future accident prevention. However, no prior survey has attempted to communicate this concept to airline users or studied the users' possible responses to it.

Using the frequency of aircraft maintenance discrepancy as a safety indicator, we conducted an exploratory study to find out about airline users' decision making approaches toward the safety.

2. Study Design

In our study, we conducted an online questionnaire survey. The participants were asked to express their willingness to pay (WTP) for their own travels in cases of nine alternative airlines A to I, each with different number of maintenance discrepancies reported annually. The initial value was set at Airline E whose discrepancy frequency was 10 cases per 10,000 flights (0.1%) and its airfare was 30,000JPY. Relative to the initial point, the participants were asked to decide their WTP for Airline A (0.001%) to D (0.05%) and F (0.15%) to I (1%) within the range of ±30,000JPY by 5,000JPY intervals. They were also given an option not to choose, regardless of pricing (Figure 1).

	Airlines (System Failure Frequency per 10,000 flights)								
price	A 0.1/10,000 (0.001%)	B 0.5/10,000 (0.005%)	C 1/10,000 (0.01%)	D 5/10,000 (0.05%)	**E 10/10,000 (0.10%)**	F 15/10,000 (0.15%)	G 20/10,000 (0.20%)	H 50/10,000 (0.50%)	I 100/10,000 (1%)
60,000	○	○	○	○	－	－	－	－	－
55,000	○	○	○	○	－	－	－	－	－
50,000	○	○	○	○	－	－	－	－	－
45,000	○	○	○	○	－	－	－	－	－
40,000	○	○	○	○	－	－	－	－	－
35,000	○	○	○	○	－	－	－	－	－
30,000 (equivalent to Airline E)	○	○	○	○	○	○	○	○	○
25,000	－	－	－	－	－	○	○	○	○
20,000	－	－	－	－	－	○	○	○	○
15,000	－	－	－	－	－	○	○	○	○
10,000	－	－	－	－	－	○	○	○	○
under 5000	－	－	－	－	－	○	○	○	○
ineligible choice	○	○	○	○	○	○	○	○	○

Figure 1. The questionnaire format was designed for the respondents to express their WTP values within the range of ±30,000JPY starting from the initial value 30,000JPY of Airline E. The "ineligible choice" option was set up for the respondents who found the airline unacceptable, regardless of the price.

It is widely known as anchoring that people make estimates by starting from an initial value that is adjusted to yield the final answer (Slovic and Lichtenstein, 1971) and different initial value yield different estimates, which are biased toward the initial values (Kahneman, 2011). Therefore, we needed to adopt the initial values representing the real-world condition. Since 2009 through 2013, the average annual discrepancy frequency of five major Japanese airlines was 8.62 cases per 10,000 flights. Based on that figure and for the sake of simplicity, the initial point was set at 10 cases per 10,000 flights. In addition, the price of the same airline at the initial point was set at 30,000 JPY, an average price for a domestic one-way flight in Japan. However, its route and flight distance were not designated by us but left to the assumption by each respondent in order to avoid a deviation caused by the difference of their sense of monetary value. The respondents also learned beforehand that the other qualities such as comfort, convenience, and punctuality, except for maintenance discrepancy, were constant among all the airlines, A through I.

Slovic, Finucane, Peters and MacGregor (2004) explained that emotions and preferences interfered with human's decision making process and mental substitution or replacement of problem occurred. And they called such phenomena as affect heuristics. In our study, the respondents were to solve the given problem on determining a price for each airline, together with more emotional processing of deciding their acceptable range. We therefore added the “ineligible choice” option to price alternatives which enabled us to analyze the results from multiple perspectives.

Four types of explanations on aircraft maintenance discrepancy were compiled as follows:

(1) The events which any important system for safety installed in the aircraft, such as engines, communication and electrical system, do not function normally during flights. Airlines are obligated to report such events to MLIT. (Ordinance for Enforcement of the Civil Aeronautics Act 221-2)

(2) The actual frequencies of aircraft maintenance discrepancy of Japanese airlines in the last five years were within the range of 1 to 30 cases per 10,000 flights. (The approximations were based on the safety reports of the five Japanese airlines: ANA, JAL, SKY, SNA, and ADO, 2009-2013.)

(3) Although the aircraft maintenance discrepancy, when occurred multiply or with other unsafe events, could lead to an aviation accident, normally a single case of maintenance discrepancy neither affects the aircraft's normal operation, nor becomes an immediate cause for an aviation accident. (ANA, 2013; JAL, 2013; AIRDO, 2013)

(4) No Japanese airline caused plane crash due to aircraft maintenance discrepancy in the last 30 years.

All respondents were informed of (1) and (2) above. A half of the respondents were randomly assigned to the control group and given two additional facts (3) and (4) referring to general consequences. Later, we call the group given the (1) and (2) explanations only Group 1 and the control group Group 2. If the acceptable range of Group 2 knowing the possible damage to them is close to zero is wider than that of Group 1, it will suggest that communicating safety explained thoroughly with this technical indicator may be useful for preventing reputational damages. As for the WTP, the educational effect can be considered if the figures of Group 2 are significantly lower than Group 1.

From an ethical perspective, we presented information (3) and (4) to Group 1 who had to think and answer based on only (1) and (2) above after they completed their questionnaire because learning about the safety by halves could lead them to anxiety and we needed to prevent it.

3. Respondent Population

Among the 5,000,000 registrants of Intage Inc., one of the largest survey firms in Tokyo, we collected 2,161samples equally spaced by age brackets 20's—60's. The survey was conducted from March 3 through 5, 2015. The predetermined selection rules were to limit the participants only to those who had actually traveled by air within the last 12 months and to exclude airline workers in oreder to make sure that the respondents were not professionally-biased. We screened out inconsistent data such as the ones showing higher values for higher/worse discrepancy levels and lower values for the lower/better discrepancy levels. Eventually, we gained 1,713 samples for our analysis (Table 1).

Table 1
Baseline Characteristics of Respondents

Group 1, n (%)		866 (100)
Age	20s, n (%)	170 (19.6)
	30s, n (%)	150 (17.3)
	40s, n (%)	178 (20.6)
	50s, n (%)	188 (21.7)
	60s, n (%)	180 (20.8)
Group 2		847 (100)
Age	20s, n (%)	156 (18.4)
	30s, n (%)	158 (18.7)
	40s, n (%)	172 (20.3)
	50s, n (%)	175 (20.7)
	60s, n (%)	186 (22.0)

Note. N= 1,713

4. Statistical Analysis

The selection and non-selection ratios of each airline in both groups were compared and examined, using the chi-squared test. The respondents were stratified into nine layers based on their acceptability ranges. We calculated the price changes from the initial value. And the differences of the changes between the groups were compared and analyzed, using Mann-Whitney’s U-Test.

5. Results

At Airline C (0.01%) , D (0.05%) and E (0.1%, the initial point), the selection ratios of Group 2 were significantly higher than Group 1 (Table 2). At the two airlines with the lowest maintenance discrepancies, Airline A (0.001%) and B (0.005%), the selection ratios did not differ significantly between the groups. At the Airlines F (0.15%) to I (1%) whose discrepancy levels were higher/worse than the initial point Airline E, no significance between the groups was observed.

The WTP was converted to percentage of the initial value 30,000JPY and stratified by the acceptable ranges (Table 3). When comparing the mean scores at the same discrepancy levels of the following three groups of the layers, (a) of those who did not accept the initial value; (b) of those who accepted the initial value but set the lowest threshold above Airline I; and (c) of those who did not set any threshold, the ones in the layer (a) tended to price lower and those in the layer (c) priced higher than the others. Within the ranges of their pricing decisions, the respondents' cognitive loss towards the airlines with double (Airline G) or tenfold (Airline I) the aircraft maintenance discrepancies of Airline E, the initial point, were much more than their cognitive gain from the airlines with a half (D) or one tenth (C) maintenance discrepancies of Airline E. The changes in cognitive losses and gains were widest near the initial point and the sensitivity diminished with distance from it. These results of loss aversion and diminishing sensitivity conform to the prospect theory (Tversky & Kahneman, 1979).

The WTP did not respond to the definite discrepancy frequency in proportion but rather seemed to be evaluated in the order of the discrepancy levels. The significant difference between Group 1 and 2 was limited to the partial areas with their frequency level lower/better than the initial point. There was no significant difference in the region whose discrepancy level was higher/worse than the initial point.

6. Discussion and Conclusion

The Group 2's significantly high selection ratios at Airlines C, D, and E suggest that the information on the general consequences of the aircraft maintenance discrepancy may alleviate the users' zero risk demand. Simultaneously, the same knowledge does not serve as an alleviator towards the airlines causing more discrepancies than the initial point. Significant difference was not observed in Airline A and B presumably because they were considered unquestionably safer than the real-life airlines.

On the WTP, our study assumes two types of rational decision makers depending on their sensitivity to potential risks. Given that our respondents understood correctly that the benefits from all airlines were equal, the most rational act for those who wish to avoid possible hazard, even if only slightly, is to choose Airline A at the lowest possible price, which is equal to the initial value 30,000 JPY. The other rational act for those who are insensitive to the indicator is to accept all airlines only at the lowest possible prices.

However, the former rational thinkers turned out to be 2% among all respondents. The latter rational thinkers were only 1% among all. The remaining great majority set up their acceptability range and made their pricing decisions within it. The result in which most of the respondents show their decisions differing from the aforementioned rational behaviors suggests that the idea of aircraft safety submerged into the minimum price does not fit in their evaluation logic.

In this study, we confirmed a type of affect heuristics where the original problem was disassembled into two stages of the human information processing. The one is to define the scope of decision making and the other is to make adjustments within their payable ranges. And such an adjustment is also subject to be influenced by the intuition.

Table 2
Difference Between Two Groups: Decisions to Choose/Not To Choose Airline

			Group		
Airlines	Decision to	Statistics	1	2	P value
A (0.001%)	Choose	Count	783	786	0.07
		Expected Count	793.2	775.8	
		Adusted Residual	-1.8	1.8	
	Not to Choose	Count	83	61	
		Expected Count	72.8	71.2	
		Adusted Residual	1.8	-1.8	
B (0.005%)	Choose	Count	749	752	0.14
		Expected Count	758.8	742.2	
		Adusted Residual	-1.4	1.4	
	Not to Choose	Count	117	95	
		Expected Count	107.2	104.8	
		Adusted Residual	1.4	-1.4	
C (0.01%)	Choose	Count	701	718	**0.03**
		Expected Count	717.4	701.6	
		Adusted Residual	-2.1	2.1	
	Not to Choose	Count	165	129	
		Expected Count	148.6	145.4	
		Adusted Residual	2.1	-2.1	
D (0.05%)	Choose	Count	625	647	**0.04**
		Expected Count	643.1	628.9	
		Adusted Residual	-2.0	2.0	
	Not to Choose	Count	241	200	
		Expected Count	222.9	218.1	
		Adusted Residual	2.0	-2.0	
E (0.10%) *	Choose	Count	520	549	**0.04**
		Expected Count	540.4	528.6	
		Adusted Residual	-2.0	2.0	
	Not to Choose	Count	346	298	
		Expected Count	325.6	318.4	
		Adusted Residual	2.0	-2.0	
F (0.15%)	Choose	Count	441	442	0.60
		Expected Count	446.4	436.6	
		Adusted Residual	-0.5	0.5	
	Not to Choose	Count	425	405	
		Expected Count	419.6	410.4	
		Adusted Residual	0.5	-0.5	
G (0.20%)	Choose	Count	402	402	0.66
		Expected Count	406.5	397.5	
		Adusted Residual	-0.4	0.4	
	Not to Choose	Count	464	445	
		Expected Count	459.5	449.5	
		Adusted Residual	0.4	-0.4	
H (0.50%)	Choose	Count	306	315	0.42
		Expected Count	313.9	307.1	
		Adusted Residual	-0.8	0.8	
	Not to Choose	Count	560	532	
		Expected Count	552.1	539.9	
		Adusted Residual	0.8	-0.8	
I (1.00%)	Choose	Count	262	269	0.50
		Expected Count	268.4	262.6	
		Adusted Residual	-0.7	0.7	
	Not to Choose	Count	604	578	
		Expected Count	597.6	584.4	
		Adusted Residual	0.7	-0.7	

* Reference Point initially given to the respondents.
P values according to the chi-square test: significant results highlighted.

Table 3

WTP For Airlines With Different Frequencies of System Discrepancy

Group 1

Company	Frequency	Lower Limit								
		A	B	C	D	E	F	G	H	I
A	0.001%	1.25	1.25	1.26	1.39	1.30	1.38	1.36	1.34	1.33
B	0.005%	-	1.21	1.21	1.34	1.26	1.33	1.29	1.28	1.27
C	0.01%	-	-	1.13	1.24	1.18	1.23	1.18	1.20	1.21
D	0.05%	-	-	-	1.14	1.13	1.13	1.09	1.12	1.14
E	**0.10%**	**-**	**-**	**-**	**-**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
F	0.15%	-	-	-	-	-	0.61	0.69	0.71	0.83
G	0.20%	-	-	-	-	-	-	0.56	0.58	0.75
H	0.50%	-	-	-	-	-	-	-	0.38	0.65
I	1.00%	-	-	-	-	-	-	-	-	0.55
G1 Respondents, n(%)		34 (4)	48 (6)	76 (10)	105 (13)	79 (10)	39 (5)	96 (12)	44 (6)	262 (33)

Group 2

Company	Frequency	Lower Limit								
		A	B	C	D	E	F	G	H	I
A	0.001%	1.19	1.24	1.27	1.36	1.26	1.33	1.27	1.37	1.27
B	0.005%	-	1.20	1.20	1.30	1.22	1.28	1.22	1.29	1.22
C	0.01%	-	-	1.13	1.20	1.16	1.23	1.15	1.18	1.16
D	0.05%	-	-	-	1.09	1.10	1.13	1.07	1.09	1.11
E	**0.10%**	**-**	**-**	**-**	**-**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
F	0.15%	-	-	-	-	-	0.64	0.69	0.70	0.81
G	0.20%	-	-	-	-	-	-	0.57	0.55	0.73
H	0.50%	-	-	-	-	-	-	-	0.35	0.63
I	1.00%	-	-	-	-	-	-	-	-	0.54
G2 Respondents, n(%)		34 (4)	34 (4)	71 (9)	98 (12)	107 (14)	40 (5)	87 (11)	46 (6)	269 (34)

The difference of average values between Group 1 and Group 2. (G1- G2)

Company	Frequency	Lower Limit								
		A	B	C	D	E	F	G	H	I
A	0.001%	0.06	0.01	(0.01)	0.03	0.04	0.05	0.09**	(0.03)	0.06
B	0.005%	-	0.01	0.01	0.04	0.04	0.05	0.07**	(0.01)	0.05**
C	0.01%	-	-	0.00	0.04	0.02	0.00	0.03	0.02	0.05**
D	0.05%	-	-	-	0.05	0.03	0.00	0.02	0.03	0.03**
E	**0.10%**	**-**	**-**	**-**	**-**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
F	0.15%	-	-	-	-	-	(0.03)	0.00	0.01	0.02
G	0.20%	-	-	-	-	-	-	(0.01)	0.03	0.02
H	0.50%	-	-	-	-	-	-	-	0.03	0.02
I	1.00%	-	-	-	-	-	-	-	-	0.01

**: $P < 0.05$

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