Differences in information searching in risk judgment between sophisticated and no sophisticated subjects.[1]

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Abstract:

The study was designed to investigate the relative input of basic dimensions of a risky situation (i.e. payoffs and probabilities as well as positive and negative information) into risk judgment based on analysis of information search pattern. The modified version of MouselabWeb public domain software proposed by Willemsen and Johnson (http://www.mouselabweb.org) was used as an investigative tool. Experiment was conducted in two groups: the first – 'sophisticated' group consisted of 75 young researchers working for NASA Ames Research Center, who have greater knowledge of statistics and mathematics than ordinary people. In the 'no sophisticated' group were 67 Polish social sciences students[2]. As expected NASA group considered more information then Polish students and searched more for information about probabilities. In spite of these differences, average risk rates are similar in both groups. It was also observed that risk rates were positively related to the amount of considered information about probabilities and negatively related to the amount of information about payoffs. No difference was observed in the amount of positive and negative information.

Keywords: risk perception, risk judgment, information search patterns, Mouselab

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2 The Polish data was collected by master's student Marta Boczkowska under the academic supervision of prof. Joanna Sokolowska.

Introduction:

In many experiments on risk perception, subjects asked to judge riskiness without additional instructions completed this task without apparent difficulties (Brachinger, M. Weber, 1997). Moreover, judgments made by subjects from different countries were consistent (Keller, Sarin, M. Weber, 1986). Despite these consistencies, numerous attempts to define perceived risk have not resulted in a single, commonly accepted definition of this concept. One major point of controversy regards the relative contribution of negative and positive aspects of a situation into risk judgment (e.g. Fishburn, 1982; Slovic, 1987 *vs.* Coombs, Lehner, 1984; E.U. Weber, Bottom, 1989). Another one is related to relative input of probabilities and outcomes (e.g. Slovic, 1967; Slovic, Lichtenstein, 1968b; Payne, 1975 *vs.* Shapira, 1994; Huber, Wider, Huber, 1997; Brandstatter, Giegerenzer, Hertwig, 2006). It was difficult to answer effectively, which aspect has relatively bigger input into risk judgment, in experiments, in which typically, respondents have to evaluate riskiness of monetary gambles. Therefore a different method – Mouselab – was used in presented experiments. Mouselab is one of process tracing methods and enable to follow the whole process of risk judgment based on information search, contrary to input-output experiments, which provide only the result – risk rates due to gambles' parameters.

The relative input of positive and negative aspects. One of the earliest definitions of risk as an independent concept was proposed by Markowitz (1959), who related the risk of an investment to the uncertainty or variability of a return. However, his definition has not been supported by empirical data (*e.g.* Coombs, Lehner, 1981, 1984; Keller, Sarin, M. Weber, 1986; Sokolowska, Pohorille, 2000).

Coombs and Lehner (1981, 1984) proved that changes in expectation or dispersion resulting from transformations of good and bad outcomes had asymmetric effects on risk judgments. For example, for a lottery where individuals have an equal chance of winning or losing $10, adding $10 to the loss increased perceived risk more than adding the same amount to the win decreased the risk. This led to a bilinear weighted utility model (Coombs, Lehner 1981, 1984). In this model, risk is a linear combination of contributions from 'bad' and 'good' outcomes with higher weights of the bad aspects. This model is in agreement with the results of the majority of researches, which point that negative information (amount and probability of loss) has bigger impact into risk judgment (e.g. Fishburn, 1982, Lopes, 1984, Coombs, Donnel, Kirk, 1978; Slovic, Lichtenstein 1968b; Payne, 1975; Finger, Voelki, 2004).

However, some results point at the importance of positive aspects (MacCrimmon, Wehrung, 1988, Shapira, 1994). Note, that in everyday language risk is used in different contexts. These either emphasize its negative connotation related to the possibility of undesirable outcomes or underline extra rewards that can be gained only at the price of uncertainty and possible loss. For example, Latin proverbs adopted in several languages relate risk to uncertainty ('do not buy a pig in a poke') and possible loss ('gold may be bought to dear'), or define risk as a necessary condition of success ('nothing ventured, nothing gained').

Thus, the new method was used to adjudicate that issue.

The relative input of payoffs and probabilities. In quasi-laboratory experiments it has been found out that perceived risk depends mostly on probability of loss (Slovic 1967; Slovic, Lichtenstein 1968b; Payne 1975; Coombs, Donnell, Kirk 1978). Field studies, in contrast, indicate that the most important factor in risk perception is the magnitude of loss. For example, Shapira (1994) found that managers, who compared riskiness of two lotteries with the same expected value but different probabilities and magnitudes of loss, based their judgments on the magnitude of loss. Furthermore, most executives asked for estimates of the 'worst possible outcome' or the 'maximum loss' and referred to it in defining risk. One possible reason for focusing on the amount of loss might be that estimating probabilities is difficult in the real world. Thus, people may believe that these estimates are inaccurate and so well rely on the more credible information, *i.e.* estimates of the worst outcome. Similar finding was reported by Huber, Wider and Huber (1997), who studied hypothetical risky managerial decisions. In this experiment, one group of participants was given a minimal description of a situation and could search for additional information. Only 22% of them asked for information about probability. Not one of the respondents asked for precise probabilities. Another group of respondents was given precise probability information. Less than 20% of them mentioned the word 'probability' or 'likelihood' in their verbal protocols.

One serious limitation in investigating the relative input of payoffs or probabilities into risk judgment is that each aspect is measured on a different scale. Probabilities are measured on the scale from 0 to 1 and payoffs from minus infinity to plus infinity. In order to avoid this limitation Kuhn and Budescu (1996) checked the relative impact of ambiguous information about payoffs and probabilities on risk rates. In their experiments subjects evaluated riskiness of situations either with precisely described probabilities of loss (e.g. 5%) and with an ambiguous negative payoff (e.g. from $45 to 105) or with ambiguous probabilities (e.g. from

3 to 7%) and with a precise loss (e.g. $75). They demonstrated that vagueness of probabilities and outcomes affected perceived risk similarly and independently. However, in a follow-up study, they reduced the salience of the probability dimension by decreasing the probabilities and increasing the magnitude of the losses (Kuhn et al. 1999). They found that, in response to these modifications, most subjects became more concerned about vagueness of negative outcomes than about probabilities. Thus, again one might express concerns about relative variability of each dimension.

Thus, one may propose the alternative way to deal with different scales of payoffs and probabilities, which is to check out which information is used by people when judging risk. Type, amount and order of searched information as well as reaction time can be registered by process tracing methods, e. g. Mouselab. Thus, Mouselab was used in the presented researches in order to investigate relative importance of information about payoffs and probabilities in risk judgment. What is more, the experiments were carried out with two groups of respondents: ordinary people and those who are trained to use probabilistic representation of reality. It has been expected that the second group with good knowledge in statistics and mathematics should be more sensitive to information about probabilities. In contrast, no differences between groups have been expected in use of information about positive and negative aspects of risky situations. In the line with previous findings, in both groups negative information should affect risk perception more than positive information.

Thus, the following hypotheses and research questions were verified in the presented experiments:

1. Information about negative aspects of a risky situation impact risk judgment more than information about positive aspects.
2. What is the relative input of information about payoffs and probabilities into risk judgment?
3. Training in statistics and mathematics enhanced the relative importance of information about probabilities in risk judgment (and has no impact on relative importance of information about positive and negative aspects).

Method:

Subjects. Participants were examined in two groups, in the first group called 'sophisticated' were 75 Ph.D. Postdoctoral students from NASA (National Aeronautics and Space Administration): 33 women, 42 men, average age – 29. In the second group called a 'no sophisticated' group were 67 Polish students (mostly in social sciences and humanities): 35 women, 32 men, average age – 24. The research was anonymous and individual. It was assumed that NASA students regularly operated with a greater knowledge of statistics and mathematics. This might impact information search patterns, information evaluation and risk judgment.

Stimuli. Respondents were presented with six risky situations related to financial risk: real estate loan, investment in stocks, investing inheritance, gambling, soccer game and horse racing. In an every scenario participants were asked to advise a friend to judge riskiness of each of an alternative option. Real estate loan consisted of three five-year loans in a different currency: (A) Swiss francs, (B) Euros and (C) British pounds. Investing inheritance related to investing inherited $200,000 in: (A) real estate, (B) fine art or (C) gold. Investment in stocks consisted of buying shares of one of three new firms producing hair loss treatment products. Gambling scenario concerned three casino games: (A) a roulette, (B) a slot machine and (C) craps. Soccer game was a situation of betting $500 on the winner of the European Championship within: (a) Italian, (B) Spanish and (C) British team. Horse racing was also connected with betting $1500 on horse, one of three favorites: (A) Karina, (B) Red and (C) Diamond.

Every scenario included description of the situation with three possible options. Each option contained possible outcomes (2 gains, 2 losses and break even) and their probabilities, which was 30 pieces of data to get. Those detailed information was presented in the information board.

Design. Respondents used a computer-based information acquisition system (*Mouselab)*, which is a computerized version of an information table (Payne, 1976). The software is based on a public domain *MouselabWeb* proposed by Willemsen and Johnson (2006) (http://www.mouselabweb.org/). The concept of information board refers to the assumption that the way how people think, make decisions and perceive risk might be observed by the way how they acquire and analyze information – amount, time, order, etc. (Figure 1). The table consisted of detailed pieces of data about each option, those information are hidden in boxes at the beginning, then appear when needed.

	option A	option B	option C
gain			
p_{gain}			
…			
…			
loss			
p_{loss}			

Figure 1. The scheme of the information board.

In the original *MouselabWeb* boxes were uncovered after respondent's click. One information was available at the time, then disappeared after clicking on the another box. In the version used in this experiment once uncovered box waited open and was available for a participant until risk judgment was completed.

In a pilot study a perceptive effect was observed. In western culture people read from the left to the right side of the page and from the top to the bottom. It means that people 'read' information board and start searching for information from the left upper corner and then move to other boxes within table. In order to avoid that effect both a basic (vertical – options presented in columns and dimensions in rows) and a reversed (horizontal – options presented in rows and dimensions in columns) table were designed. There were no significant differences between these two sets of information boards. In this paper only experiments with reversed table are presented. Moreover, in order to avoid that effect with the presentation of positive (gains) and negative (losses) information on the top of the table, two orders (positive or negative information on top) were reversed.

Procedure. Respondents were presented with every scenario and asked to search for detailed information within the information board, as many as necessary, to estimate risk rates for each option. The risk was rated on an 11-point scale (from 0 'not risky at all' to 10 'extremely risky').

Results:

Cognitive effort and risk judgment: the amount of used information. As mentioned before, it was possible to open 30 boxes. On average respondents used 50% of available information (*M=17,34; SD=9,83*). NASA group acquired significantly more information (*M=19,29; SD=9,74*) then Polish students (*M=15,08; SD=9,46*). Moreover, Polish students used *ca* the same amount of information for all scenarios but one (real estate loan). It has also been observed that in NASA group amount of information considered was decreasing systematically till the end of the experiment. These observations were confirmed by ANOVA with one within-subject factor (6 scenarios: $F_{(5, 625)}=2,66; p<0,05$) and one between-subject factor (group: $F_{(1, 125)}=7,69; p<0,01$). All relations are presented on the chart (see Figure 2).

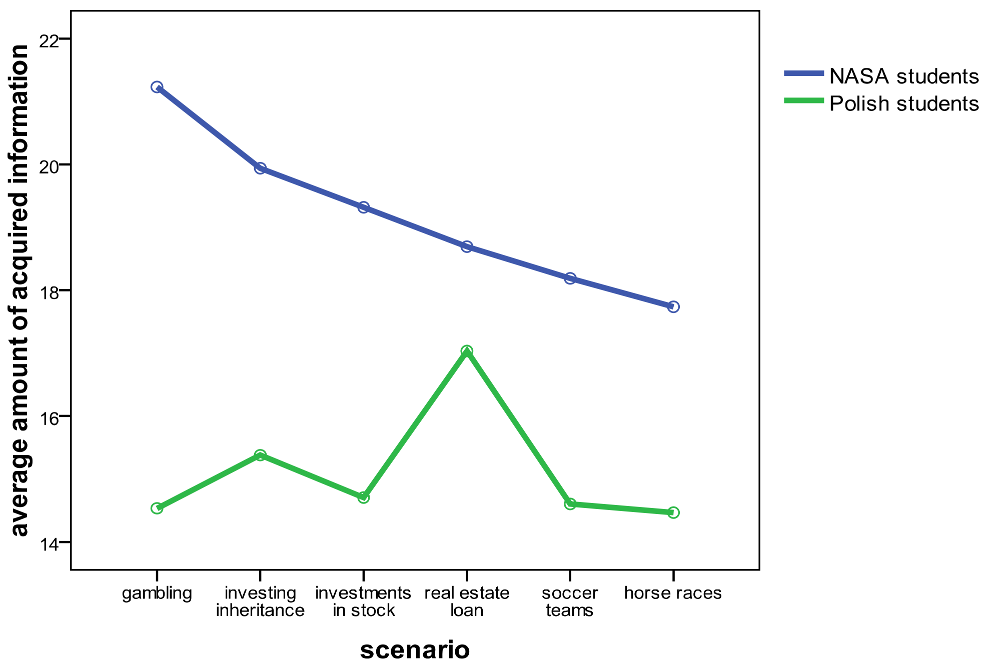

Figure 2. Differences in the amount of acquired information in two groups within six scenarios.

The relative input of negative and positive aspects into risk judgment: the ratio of positive and negative information. As mentioned before (see page 6), two orders of positive and negative information in the table were deliberated to control a possible perception effect. Indeed, no influence of the order of presentation on the ratio of positive to negative acquired information was observed. ANOVA with one within-subject factor (scenario) and two between-subject factors (group, order: $F_{(1, 109)}=3{,}87; p>0{,}05$) was performed.

Since the differences between groups in amount of used information was found out, direct comparison of positive and negative information cannot be carried out. Thus, the ratio of positive to negative information[3] acquired by respondents in two groups was compared. As can be easily seen from Figure 3, no differences between groups were found. All respondents used *ca* the same amount of positive and negative information to evaluate risk: the range of the ratio was very narrow and extends from 0,90 to 1,14 for all 6 scenarios.

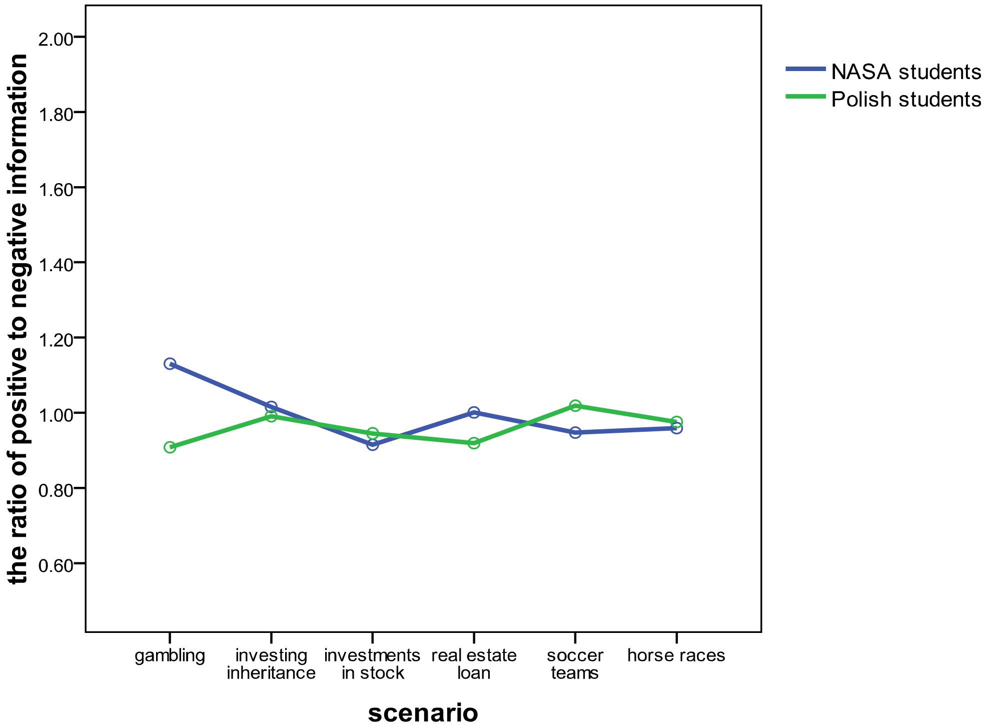

Figure 3. The ratio of the acquired positive to negative information within six scenarios for both groups.

These observations were confirmed by the results of ANOVA with one within-subject factor (6 scenarios: $F(_{5, 555})=0{,}56; P>0{,}05$) and one between-subject factor (2 groups: $F(_{1, 111})=0{,}24; p>0{,}05$). Thus, contrary to the expectation no greater focus on negative aspects of a risky option was observed. There is no correlation between average fraction of positive information

[3] The information about break even outcome was excluded from this analysis.

to all and average risk rates, *r=0,07; p>0,05*. The same for average fraction of negative information, *r=0,01; p>0,05*. Moreover, when splitting into groups this patter is maintained.

The relative input of payoffs and probabilities into risk judgment: the ratio of both kinds of information used. The next research question refers to the relative input of payoffs and probabilities into risk judgment. Similarly to previous research question, the direct comparison of the amount of information about payoffs and probabilities used to judge risk cannot be performed, since NASA group considered more information. Thus, the ratio of the amount of acquired information about payoffs to probabilities was analyzed. As can be seen from Figure 4 more information about payoffs were searched for in the group with Polish students (*M=0,51; SD=0,23*) and more information about probabilities in the group with NASA students (*M=0,55; SD=0,19*). The pattern was similar for all scenarios. This has been confirmed by results of ANOVA with one Within-Subject Factor (6 scenarios: $F_{(5, 520)}=1,31$; $p>0,05$) and one Between-Subject Factor (2 groups: $F_{(1, 104)}=4,69$; $p<0,05$).

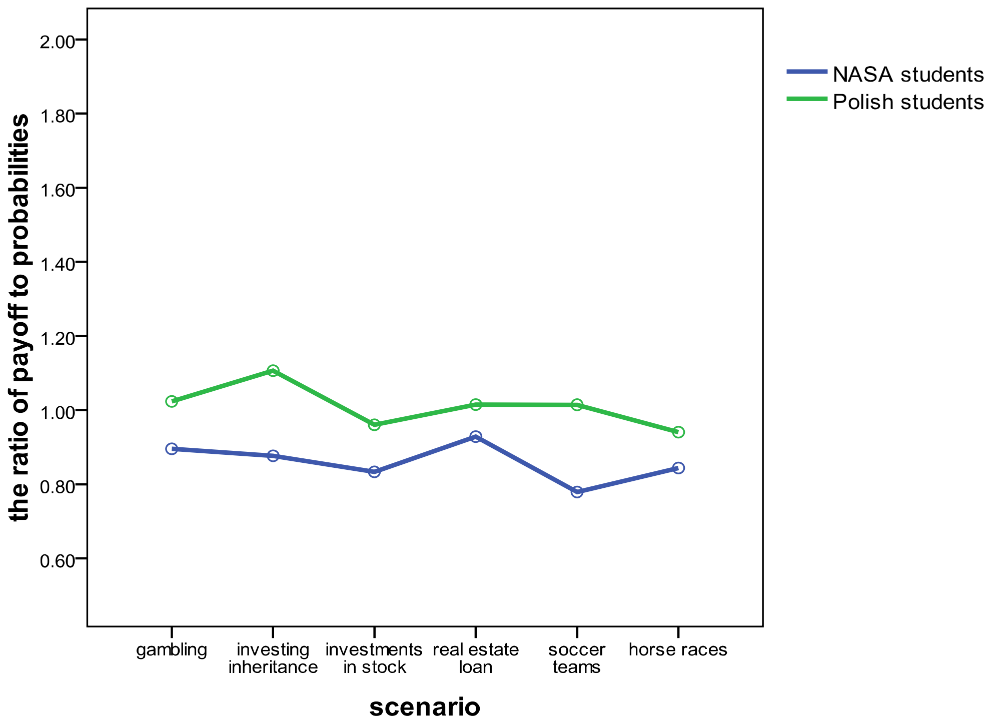

Figure 4. The ratio of the acquired information about payoffs and probabilities within six scenarios for both groups.

The above result is in agreement with the expectation that subjects who have background in hard sciences put more attention to probabilities than ordinary people.

Risk rates. Generally speaking, there were no differences in average risk rates in both groups, (*t(140)=0,28; p>0,05*). No matter whether risk was judged by NASA group (M=5,33; SD=1,35) or Polish students (M=5,28; SD=0,95) the rates were similar.

Furthermore, the significant correlations between risk rates and the amount of acquired information about values and probabilities were observed in both groups (see Table 1). Negative correlation was observed between the amount of acquired information about payoffs and risk rates. The more information about payoffs was collected, the lower risk rates were assigned. Similarly, the correlation between acquired pieces of data related to probabilities and risk rates was positive (more probabilities – higher risk rates). What is more, the relation between risk rates and considered information about payoff and probabilities is more meaningful for students from NASA. In this group the correlation explains 17% of the variance, when in the group with Polish students 13%.

Table 1. Correlations between risk rates and the amount of acquired information about payoffs and probabilities.

NASA group			**Polish students**		
		Risk rates			**Risk rates**
payoffs	Pearson correlation	-0,41	**payoffs**	Pearson correlation	-0,36
	Sig. (2-tailed)	0,000		Sig. (2-tailed)	0,003
	N	75		N	67
probabilities	Pearson correlation	0,41	**probabilities**	Pearson correlation	0,36
	Sig. (2-tailed)	0,000		Sig. (2-tailed)	0,003
	N	75		N	67

Conclusions:

The presented results show that NASA students searched for more pieces of data than Polish students to rate the riskiness of each option. Moreover, they acquired more information about probabilities than Polish students who searched rather for information about payoffs. These results confirm the assumption that NASA students have greater knowledge in statistics and mathematics. Moreover, they are trained to use probabilistic representation of reality, which might also impact the quantity and quality of acquired information. In everyday life information about probabilities are difficult to access and are not provided in an explicit way. This might be the reason, why students in social sciences and humanities are not used to attaching this type of information.

Although the difference between groups in considering payoffs or probabilities is according to assumed differences between groups, it is difficult to ascertain the relative input of one dimension. The input might be determined by the character of the group. On the other hand, the presented researches were closer to field studies than quasi-experiments. According to previous findings respondents were more focused on payoffs in field studies (Shapira, 1994; MacCrimmon, Stanbury, Wehrung 1980). This result was confirmed in Polish group contained naive, ordinary respondents. The unlike result in NASA group was caused by the character of the group.

The results also show that there were no differences between groups in searching for positive and negative information to judge risk. In terms of diversity of participants in both groups, there were no assumptions to conclude about the differences between those groups in operating with positive or negative information. On the other hand, contrary to the previous findings from a literature (Fishburn, 1982, Lopes, 1984, Coombs, Donnel, Kirk, 1978; Slovic and Lichtenstein 1968b; Payne, 1975; Finger and Voelki, 2004), negative information did not have bigger impact into risk judgment, as it was assumed. The same amount of negative and positive pieces of data was considered.

What is more, in both groups a negative correlation between the amount of acquired information about payoffs and risk rates was found. The more information respondents obtained about payoffs of outcomes, the lower risk rates they assigned. Contrary to the information about probabilities. The more information respondents got about probabilities of outcomes, the higher risk rates they assigned.

Generally speaking the risk rates in both groups were similar, so different information search patterns led to the similar results related to risk perception.

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