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Risk Preference Elicitation and the Role of Personality and Intelligence

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Risk tolerance metrics are consistently used in economics experiments as a means to inform researchers how the aggregation of individual choices affects market, organizational, or financial outcomes. Economic theory, however, is silent on their use as a predictive metric for ascertaining why individuals exhibit a particular risk preference. Insight as to the possible drivers of why individuals exhibit a given risk preference may lie in the cognitive and non-cognitive characteristics embodied in an individual. The key hypothesis of the proposed effort is to ascertain if a correlaiton between risk and personality exists and, if so, to what extent do certain traits influence risk preference.

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Foreword

Risk tolerance metrics are consistently used in economics experiments as a means to inform researchers how the aggregation of individual choices affects market, organizational, or financial outcomes. Economic theory, however, is silent on their use as a predictive metric for ascertaining why individuals exhibit a particular risk preference. Insight as to the possible drivers of why individuals exhibit a given risk preference may lie in the cognitive and non-cognitive characteristics embodied in an individual. The key hypothesis of the proposed effort is to ascertain if a relationship between risk and personality exists and, if so, to what extent do certain traits influence risk preference.

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Introduction

Sea Enterprise[1] advocates the optimal resourcing of tomorrow's fleet to achieve enhanced productivity and procurement. Its current Naval transformation initiative focuses on the right mix of civilians/military/contractors, capital, labor productivity enhancements, and removal of barriers to efficiency gains. To meet the demand for efficiency gains, as measured by cost avoidance and cost savings, Navy leadership is exploring the concept of aligning resource allocation decisions to the most efficient level of decision-making. This concept is one that the private sector has long recognized can be profitable.

Force Utilization through Unit Readiness and Efficiency (FUTURE), a 5-year research and development program, blends behavioral research and economic theory in a virtual experimental environment. It employs artificial intelligence and optimization techniques to create simulation-based decision support tools to determine resource allocation and cost-benefit determinations across units and battle groups. It is comprised of a web-based suite of tools that houses a multifaceted simulation environment to assess the impact of alternative human resource allocation policies on individual, team, and unit efficiency and readiness. Through the use of science, technology and re-engineering of manpower planning and distribution and assignment processes, it is possible to provide Naval units with more visibility and control over their input costs and empower unit commanders to efficiently generate combat readiness.

FUTURE will provide unprecedented visibility over costs, enable the Navy to pinpoint gains in efficiency with respect to human resources management, and create a simulation environment to allow testing of how policies and incentive options affect member behavior. With greater visibility and control over input costs and given the tools they need to analyze the cost implications of their decisions, operational commanders will be guided toward making decisions that optimally tradeoff readiness, cost, and risk. Coupled with appropriate incentives, this shift in control can be an effective means of lowering manpower and personnel resource allocation costs and maximizing the Navy's human capital investment.

The incentive structures that guide free markets cannot be equated to the functioning of specialized markets, such as the provision of a Navy. Efficiency gains in a free market are exhibited by profits, and hence, the firm's resource allocation decisions are motivated by positive money returns that accrue to the decision-maker. In contrast, under the current Navy system gains in efficiency as a result of individual or unit level decisions do not accrue to the decision maker. The current incongruence in incentives must be addressed in order to develop the business process proposed in FUTURE.

Developing incentive compatibility schemes requires a multi-faceted approach to examining human decision-making. Shifting manpower and personnel resource allocation decisions from a centralized authority down to the appropriate decision-making unit could result in a misalignment of individual choice outcomes and organizational objectives. In an effort to mitigate this problem, a series of iterated

[1] Clark, V. (2002).Sea Power 21. *Proceedings*, October.

experiments to identify various types of pecuniary and non-pecuniary incentives to align individual decisions and organizational objectives was conducted. Adoption of incentive programs to ensure individual choice aligns with organizational objectives may be contingent on individual risk preferences and cognitive and non-cognitive characteristics.

Research Objective

Economic theory assumes that individuals are rational utility-maximizing agents. In a simple case, when individuals are presented with a set of alternatives from which to choose, individuals will choose that outcome that maximizes their satisfaction. Individuals have full information on all available alternatives and the outcome of any given choice or set of choices is known a priori. However, when uncertainty is introduced into the decision–making process, individuals must evaluate the probability of the utility that each alternative provides. Choosing poorly has explicit costs. That is, the expected payoff or value of a poor choice is not a utility-maximizing outcome.

For choices with uncertain outcomes the individual must calculate the probability of each possible alternative. The expected value or utility associated with each uncertain alternative is calculated by summing up the value or payoff of each alternative weighted by the probability of a successful outcome. The probability or expected value associated with each possible outcome is a proxy for risk. Which expected payoff or gamble the individual is observed choosing is a measure of individual risk preference.

Individuals have varying tolerance towards risk. They are assumed to be risk averse in cases where a certain outcome with a lower payoff is preferred to an uncertain outcome with a higher expected payoff. Risk neutrality is observed when individuals are indifferent between a certain payoff and an uncertain expected value with the same payoff. In contrast, risk-seeking behavior occurs when individuals consistently choose a gamble over a certain payoff with a higher payoff value.

The standard metric for measuring risk preference over a series of gambles was developed by Holt and Laury (2002)[2]. In this series of experiments, individuals were asked to choose from a menu of lotteries, with each lottery differing in its payoff value. Holt and Laury (2002) show that risk preferences can be inferred from such lottery experiments. Enhanced modifications to the original risk preference measures designed by Holt and Laury (2005), such as controlling for ordering effects conditioned on payment levels, will be employed in the proposed effort. [3]

Risk tolerance metrics are consistently used in economics experiments as a means to inform researchers how the aggregation of individual choices affects market, organizational, or financial outcomes. Economic theory, however, is silent on their use as a predictive metric for ascertaining why individuals exhibit a particular risk

[2] Holt, C. A. & Laury, S. K. (2002). Risk Aversion and Incentive Effects. *American Economic Review, 92(5),* pp.1644-44.
[3] Holt, C. A. & Laury, S. K. (2005). Risk Aversion and Incentive Effects: New Data without Order Effects. *American Economic Review, 95(3),* pp.902-904.

preference.[4] Insight as to the possible drivers of why individuals exhibit a given risk preference may lie in the cognitive and non-cognitive characteristics embodied in an individual.

An emerging field in economics, behavioral economics, links economic theory with psychology. Increasingly, psychology is being used to provide insight on human behavior, which traditional economic models have rationalized or assumed away. This effort proposes to map risk preferences with various cognitive and non-cognitive measures. Psychological traits such as trust, fairness, openness, conscientiousness, extraversion and neuroticism may provide insight as to why individuals exhibit a given risk tolerance. The key hypothesis of the proposed effort is to ascertain if a relationship between risk preference and personality exists, and if so, to what extent do certain traits influence risk preference.[5]

Brief Overview of Experimental Methods in Economics

Empirical research in economics and finance has typically been limited to field studies that use data from the naturally occurring economy (e.g., stock market prices or consumer spending patterns). Over the past three decades, laboratory methods have been accepted as an alternative means of generating data and evaluating economic theory. Experimental research has been published in highly reputable academic journals, and experiments are conducted at major universities across the United States. Funding for economics experiments has been provided by a wide variety of agencies, including the National Science Foundation and government agencies like the U.S. Department of Energy and U.S. Department of Defense.

In economics experiments, human subjects make decisions in a controlled environment, and they receive cash rewards based on those decisions. The decisions involve no physical, financial, or psychological risk. The relationship between decision and reward is explained fully to the subjects. Participation is voluntary, and requires no prior financial commitment on the part of an individual.

The basic experimental economics methodology is to create an artificial, controlled, and monitored environment that is homomorphic to a naturally-occurring economic institution. Subjects are allowed to interact in that institution, making any decisions that they feel are in their best interests. For example, a subject may be a buyer in a market, and lower buying prices would mean greater profit for that subject. The subject would have to decide at which price he/she is willing to buy. At the end of the experimental session, the subjects are paid whatever earnings that accrued to them from their decisions. Details of each aspect of the methodology are:

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[4] Economic theory assumes that individuals assign a utility value to each expected payoff. Utility per se cannot be directly observed nor can a direct quantifiable measure be derived. Utility levels are simply assumed.

[5] While personality traits can be shown to be stable over time, risk tolerance is likely to be domain specific. For the purposes of this effort, risk will be measured using a domain neutral instrument. Using a domain neutral instrument will allow for a baseline correlation of risk and personality traits to be identified, if any.

Paying Salient Rewards in Economics Experiments[6]

The validity of experimental research in economics is founded on the concept of *induced value*. Real people must make real decisions about objects or activities that have real value. Control is the essence of experimental methodology, and it is critical that the experimenter control or specify individual values so that he/she can state that values do or do not differ in a specific way. Generally speaking, most laboratory experiments in the area of economics presume that decision-makers are autonomous, own-reward maximizers. The four precepts behind the concept of induced value are nonsatiation, saliency, dominance, and privacy. These precepts are defined as:

Nonsatiation: Given a costless choice between two alternatives, identical except that the first yields more of the cash reward than the second, the first will always be chosen (i.e., preferred) over the second by an autonomous individual. An economist would say utility is a monotone increasing function of the cash reward.

Saliency: The cash rewards in an experiment should have motivational relevance. Subjects are guaranteed the right to claim a reward which is increasing in the good outcomes, and decreasing the bad outcomes. That is, some decisions have higher rewards than others, and the mapping of decisions into rewards is well-defined and consistent.

Not all cash rewards are salient. For example, a flat fee is often used to compensate subjects for participating in psychology experiments. This type of reward is nonsalient: it is a flat fee that is independent of the decisions made by the participant. The cumulative earnings of a subject over the course of an economics experiment are salient, as they are based on experimental outcomes and will vary as the subject's decisions vary.

Dominance: To ensure that control over preferences for the cash rewards is maintained, the reward structure must dominate any subjective costs (or values) associated with participation in the activities of an experiment.

All individual actions have subjective costs, even simple tasks like pressing keys on a computer keyboard. For example, suppose a subject was repeatedly asked to press either the Enter key or the Backspace key. Paying the subject $0.01 each time she presses the Enter key and $0.02 she presses the Backspace key would be a salient reward in a medium in which she is nonsatiated. A simple theory might predict the subject would always press the Backspace key and never the Enter key.

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[6] Blackstone, T., Van Boening, M., Mckee, M., & Rutstrom, E. (2002). *How Robust is the Theory of Consumer Choice in the Face of Discrete Goods with Multiple Attributes: An Experimental Approach* (NPRST-TN-02-1)Millington, TN: Navy Personnel Research, Studies, and Technology.

But such a trivial payment may not be sufficient to dominate the subjective costs of the exercise: the subject might sometimes press the Enter key to relieve boredom.

Similarly, the complexity of the task must be considered. Activities that require extensive thought or calculations must be compensated appropriately, independent of nonsatiation and saliency. The discussion of saliency above referred to the choice between two *costless* alternatives.

Privacy: Each subject in an experiment is given information only on his/her own payoff alternatives. Individuals may bring egalitarian, altruistic, or such other preferences from everyday social life into the laboratory. Thus a participant's valuation of the reward medium will be interdependent on the rewards which others receive. This would result in a loss of control, as well-defined valuations may not be induced and individuals would not be autonomous, own-reward maximizers. (In certain specific applications, a researcher may want to investigate to what degree knowledge of others' payoff alternatives would affect outcomes.)

In economics experiments, cash rewards are designed so as to compensate subjects not only for their participation (i.e., achieve dominance), but also to compensate them for their opportunity cost (i.e., time that could be spent in the pursuit of leisure, knowledge, other income, etc.). As a rule of thumb, the "going wage rate" for a typical person in the subject pool is used as the benchmark. For college students, this rate is approximately $6–$8 an hour. A different subject pool, like professional currency traders, may require substantially higher rewards.

A nonsalient show-up fee is also paid to the subjects. This payment is a reward to subjects for honoring their commitment. While this payment is substantial, it is a necessary cost: attrition and no-show rates are much higher in its absence. Cancellation of experiments due to insufficient subjects results in high dollar, time, and effort costs on the part of the researcher.

Experimental Design

Volunteer subjects were recruited from the student body of the University of North Alabama (UNA). Students were informed that the experiment would require 35–45 minutes of their time and that they would be paid for their participation immediately upon completing the questionnaires. Payment varied between $5 and $30 with payment allocated as follows: a $5 show-up fee; $17 for completing the demographic, trust, and personality questionnaires; and between $3 and $8 based on the results of the risk preference elicitation game. All questionnaires were administered using a paper-and-pencil format.

The first questionnaire was designed to collect basic identification and demographic information and included self-reporting of ACT/SAT and grade point average. A key measure in the proposed effort is a measure of cognitive ability. While empirical results are mixed as to the validity of self-report measures, such as college grade point average (GPA), SAT, or ACT scores, as a proxy for IQ, in general, IQ scores were not available for the UNA subject pool.[7] To mitigate the potential problems with self-reporting of IQ proxy measures, subjects were asked to self-report GPA and ACT/SAT achievement scores. Scores were collected on for both the ACT/SAT and GPA in order to test for some degree of validity of the cognitive measure.

Students were than asked to complete the International Personality Item Pool (IPIP-NEO) short version. The short version of the IPIP-NEO consists of 120 questions and measures the same traits as the longer version using significantly less subject time. [8] The IPIP-NEO captures standard Big 5 personality metrics (agreeableness, openness, conscientiousness, neuroticism, and extraversion) and facet level metrics that would allow for a finer analysis of any relationship between risk preference and personality.

Researcherss hypothesized that the degree of trust might be positively correlated to individual risk preference. As an additional control, students completed an additional 6-item trust questionnaire. The 6-item trust questionnaires, used as a separate measure of trust might provide a finer delineation of the relationship between trust and risk preference. The questionnaire captures relevant non-cognitive metrics that are hypothesized most likely to influence risk preference.

A risk preference measure was adopted from Holt and Laury's (2002) design. Individuals were asked to choose from ten options or series of gambles. Each option is associated with a monetary value; however, the probabilities of winning any given payout vary across the ten options. The measure of individual risk preference, whether the individual is risk averse, neutral, or seeking, is dependent on the subject's choices over the ten options.

At the completion of the task, a 10-sided die is rolled to determine the monetary payout to a subject conditional on his/her choices.

Results

Of the 193 participants in the study, 31 percent were female, 53 percent Caucasian, and 96 percent were between 18–29 years of age (See Table 1). The demographic composition of the experimental subject pool closely mirrors the composition of entry level enlisted Navy personal, with the exception of the racial composition. Approximately, 65.50 percent, 12.82 percent, and 3.25 percent of entering military recruits identify themselves as Caucasian, African-American, or Asian/Pacific Islander, respectively (U.S. Department of Defense Manpower Data Center, 2007). The

[7] Mohd Kosnin, A. (2006) *Reassessing Self-Assessment of Ability: Possible Influence of Metacognition*. In: Seminar TVE06, 09-10 December 2006, (Unpublished).
[8] See http://www.personal.psu.edu/faculty/j/5/j5j/IPIP/.

experimental subject data deviates from the 2007 Navy demographic characteristics. Participant demographics more closely mimic the composition of the population of the United States.

While there may be some under or over reporting of GPA, the distribution of self reported GPAs closely reflects the GPA distribution officially reported by the University of North Alabama's Institutional Research Office. The distribution of GPAs within the participant sample shows that 85 percent of the reported GPAs exceeded 2.0 (on a 4.0 scale). It is beyond the scope of this study to map GPA with AFQT; however, the military's preferred candidate and from which the majority of recruiting is conducted, are those recruits with a minimum AFQT score of 50 on a 99 point scale. The university subject pool is a sufficiently robust representation of military recruits.

Table 1
Demographics

Gender (N = 193)		**Grade Point Average**		**Age**	
Female	31%	**>1.9**	1%	**17-19**	19%
Male	69%	**2.0-2.9**	40%	**20-22**	54%
		3.0-3.4	24%	**23-25**	19%
Race		**>3.5**	21%	**26-29**	4%
African American	22%	**Missing**	14%	**>30**	3%
Asian	18%			**Missing**	1%
Caucasian	53%				
Hispanic	4%				
Other / Missing	3%				

Examining risk preference by gender (Table 2), showed no significant differences in risk preference between males and females. Individuals were categorized as Risked Mixed, in those cases where participants did not indicate their risk preference or where it could not be clearly determined. The high proportion of individuals who fell into the Risk Mixed category indicated a flaw in either the experimental design or in the clarity of the questionnaire instructions.

Data collection for this study occurred over four separate sessions. After the completion of the second session, it was determined that the lack of clarity of the questionnaire instructions led to the high proportion of Risk Mixed responses. The instructions were modified, tested for clarity using a sub-sample of non-subject participants and administered in Sessions 3 and 4. Modification of the instructions reduced the number of Risk Mixed category observations from 32–37 percent to 11–16 percent.

Table 2
Risk Preference by Gender

	Risk Seeking	Risk Neutral	Risk Averse	Risk Mixed
Female	23.7%	44.1%	8.5%	23.7%
Male	25.4%	44.0%	8.2%	25.4%

Risk preference showed that Caucasians are twice as likely to be risk seeking relative to African Americans and three times as likely as Asians (Table 3). Cultural differences, parental/individual household wealth might account for this difference in preferences. What is worth further exploration, but beyond the scope of the current study, is the small number of subjects who are categorized as risk averse regardless of gender or race. The low Risk Averse response could be a result of wealth effects or the design of the study. Subjects were paid a preannounced certain sum for each section of the study. The exception was the risk preference portion of the experiment. Subject payments ranged from $3–$8, depending on the choices they designated and the roll of a 10-sided die. The maximum earnings, $8, from the risk game only accounted for 26 percent of the total possible earnings. The expected payoff of winning $8 as a percentage of total possible earnings may have influenced individuals to opt out of the Risk Averse strategy.

Table 3
Risk preference by race

Race	Risk Seeking	Risk Neutral	Risk Averse	Risk Mixed
African American (N = 43)	27.9%	34.8%	4.7%	32.6%
Asian (N = 34)	23.5%	29.41%	2.9%	44.19%
Caucasian (N = 103)	23.30%	51.46%	8.74%	16.5%
Hispanic (N = 7)	42.86%	42.86%	0 %	14.29%
Other/Missing (N = 6)	16.67%	66.67%	0%	16.67%

The primary objective of this study was to ascertain if a correlation between personality and risk preference could be identified. A statistically significant relationship between personality and risk preference for money could be beneficial in individualizing compensation packages, setting bonuses, or informing various auction designs.

Using the NEO-IP, individual Big 5 personality constructs and 16 personality facets were obtained from subjects. To determine if personality and or cognitive ability could explain risk preference behavior the following multinomial models were tested:

(1) Risk Preference = f(GPA, gender, race, neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness)

(2) Risk Preference = f(GPA, gender, race, adventurousness, vulnerability, excitement seeking, assertiveness, cautiousness, and trust)

Models (1) and (2) included those personality constructs or facets hypothesized most likely to correlate with individual risk preference behavior. For both models, the results revealed no statistical significance between risk preference and personality or cognitive ability. The lack of statistical significance obtained from the models may be driven by the structure of the dependent variable. The multi-categorical nature of the dependent variable (Risk Seeking, Risk Averse, Risk Neutral, Risk Mixed) coupled with the paucity of observations in each category (approximately 40–50 observations in each category) may not provide a sufficient number of observation to accurately ascertain statistical significance. Insignificance of the models may also be a result of inclusion of the Risk Mixed category. The Risk Mixed classification captures subject responses where no clear risk preference could be identified; therefore, including personality constructs of the Risk Mixed observations in the model may add sufficient noise to dilute any possible significant results. Model results, however, did not improve even when the Risk Mixed category was omitted from the model.

Controlling for selected personality facets (See Table 4), a comparison of the differences in risk preference between the Risk Seeking and Risk Averse respondents, with Risk Averse being the base case, reveals that Risk Seekers are less cautious and more impulsive than Risk Averse subjects. Surprisingly, there is no statistical difference between the two risk categories as to how excitement seeking, trust facets, and imagination are related to risk preference.

Table 4
Risk preference and personality measures: Specific facets Risk Seeking and Risk Averse observations

Neuroticism: Immoderation	F(1,57) = 4.77	MSE = 7.1	p < .05	r = -.28
Extraversion: Excitement Seeking	F(1,57) = .6	MSE = 373.6	p < .45	r = -.10
Openness: Imagination	F(1,57) = 3.01	MSE = 657.2	p < .09	r = -.22
Agreeableness: Trust	F(1,57) = .78	MSE = 454.0	p < .38	r = -.12
Conscientiousness: Cautiousness	F(1,57) = 5.04	MSE = 14.3	p < .03	r = .29

Conclusions

The findings of this study show indicate no statistical relationship between intelligence, as proxied by self-reported GPA, and risk preference. The results do indicate a weak relationship between risk preference and personality constructs. Increasing the sample size, clearer instructions on the risk preference elicitation game, and expanding the relative risk categorization from 3 to 8 categories may yield more robust measures of personality and risk. The correlations, intended to populate an intelligent agent simulation system, are not sufficiently robust to provide valid information to code human behaviors into FUTURE's agent-based system.

In an attempt to overcome the deficits in the current experimental design and outcomes, the subject pool will be expanded by an additional 300 observations. The experimental design discussed in this report will be modified not only to capture a broader subject pool demographic, but will use an eight category relative risk preference elicitation measure.

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