by W. V. Harlow and Keith C. Brown

Understanding and Assessing Financial Risk Tolerance: A Biological Perspective

At some level, all asset allocation techniques require a consideration of variables involving both capital market expectations and an individual's tolerance for risk. Although the latter information is as important as the former, an evaluation of investor-specific risk aversion is typically done in an ad hoc *fashion. Our understanding of financial risk tolerance can be extended by investigating the role of certain biological and psychological traits in the formation of economic preferences.*

Specifically, a series of economic, psychological and biochemical tests were designed to establish individual-specific profiles. Risk-aversion estimates were obtained experimentally from observations of bidding behavior in computerized auctions using newly developed theoretical models. These measures were then compared with a psychometric assessment of "sensation-seeking" personality traits and with measures of neurochemical activity that have previously been found to be significantly related to human behavior. Individuals with neurochemical activity characterized by lower levels of the enzyme monoamine oxidase and with a higher degree of sensation-seeking are more willing to accept economic risk.

These results offer a theoretical link between risk tolerance and behavioral traits that is consistent with intuitions regarding economic preferences. They also provide quantitative support for some of the assessment practices currently in use. More importantly, a behavioral foundation for an individual's tolerance for financial risk offers hope that future risk-assessment procedures can be extended in a way that broadens the set of tools available to the portfolio manager.

THE MOST PRUDENT approach to allocating financial assets requires that a money manager be able to assess and integrate two distinct sets of economic data. First, the manager must evaluate a collection of capital market variables across the available set of securities so that expectations about future performance can be formed. Second, once the array of feasible portfolio choices has been assembled, the manager can make an optimal selection only after assessing the investor's attitudes toward risk. Although few would argue that this latter task is in any way the less important of the two, the evaluation of risk tolerance has received far less attention from practitioners and academics alike. The primary reason for this deficiency appears to be a general lack of understanding of the determinants of risk aversion in the investing public.

This is not to say that investment managers don't make an attempt to assess risk tolerance. What it does imply is that there is currently little theoretical basis for preferring one approach over another. In practice, we see an array of techniques, ranging from *ad hoc* questionnaires seeking information on specific personality characteristics to quantitative inferences based on actual asset holdings. The diversity of approaches highlights the uniquely personal nature of risk aversion and suggests that its assess-

Glossary

Risk Tolerance: The degree to which an investor is willing and able to accept the possibility of an uncertain outcome to an economic decision. A measure of risk tolerance is useful in summarizing an investor's perception about the tradeoff between risk and the compensation required for bearing risk.

Psychometric Characteristics: Empirical measures of psychological and behavioral traits that can be obtained from standardized questionnaires such as the Minnesota Multiphasic Personality Inventory (MMPI).

Neurochemical Activity: A broad description of the complex set of biochemical processes that take place in the central nervous system. Various components of this activity have been shown to be correlated with behavioral traits.

Sensation-Seeking: A class of psychological traits that reflect characteristics of extroversion and impulsivity in an individual's behavior (i.e., thrill and adventure-seeking, experience-seeking, disinhibition and boredom-susceptibility). Measures of sensation-seeking can be obtained from the Sensation-Seeking Scale (SSS) and other psychological profiles.

Investor's Utility Function: The mathematical equation used to describe the relation between an investor's level of well-being and his or her level of wealth. The utility function is often used to translate the income associated with an economic decision (i.e., investment) into the actual level of satisfaction obtained by the investor.

Expected Utility: The level of satisfaction an investor will realize, on average, when making an economic decision where the ultimate resolution is unknown. Calculated as the mathematical average of the utility levels associated with each possible outcome of the investment, where the probabilities of the outcomes are used as the weights.

Neuroregulating Enzymes: Biochemical substances involved in the regulation of neurochemical activity and whose presence has been linked to observable behavioral traits. This study focuses on monoamine oxidase (MAO), which is involved in the neurotransmission process.

First Price Sealed Bid Auction: An auction market where each prospective buyer of a unit of the given commodity tenders a separate bid—which is not revealed to the other participants—with the understanding that the commodity will be awarded to the individual making the highest bid.

F-Statistic: A statistical measure calculated as the ratio of two independent sample statistics, both of which have an χ^2 distribution. Used in this study to test the hypothesis that financial risk tolerance and biochemical/psychometric traits are significantly correlated.

χ^2 Statistic: A statistical measure created by the sum of a series of squared sample statistics, each of which is normally distributed with a mean of zero and a standard deviation of one. Used in this study to test the hypothesis that financial risk tolerance and biochemical/psychometric traits are significantly correlated.

Spearman Rank-Correlation Coefficient: A nonparametric statistical measure to establish the degree of correlation between two series of variables transformed into their respective rankings from highest to lowest. Used in this study to test the hypothesis that measures of financial risk tolerance and certain biochemical and psychometric variables are significantly related.

ment is likely to be as complex as that of any human behavior.

This article summarizes research that adopts a more general and fundamental approach to understanding the behavioral traits that play a role in investment decisions. The investigations reported here document a fundamental link between economic measures of risk aversion and certain biological and psychometric characteristics exhibited by investors. Specifically, using new experimental techniques adapted from research on auction pricing to derive measures of risk aversion, we show that individuals with neurochemical activity characterized by low levels of the enzyme monoamine oxidase and with a high level of "sensation-seeking" personality traits exhibit a willingness to accept economic risk. Conversely, high levels of this enzyme and a low level of sensation-seeking appear to be associated with risk-averse behavior.

These results offer a theoretical link between risk tolerance and behavioral traits that is consistent with our intuition regarding economic preferences, and they provide quantitative support for some of the assessment practices currently in use. The research certainly does not suggest that we have captured all or even the most important personality traits relevant to the economic decision-making process. Indeed, factors we omit—such as the investor's current wealth level—may play a substantive role. But the research does indicate that there are identifiable characteristics of individuals that are directly linked to economic notions of risk aversion. While such a linkage is of fundamental importance in its own right, it also provides hope that future risk-assessment procedures can be extended in a way that meaningfully broadens the set of tools available to the portfolio manager.

Current Understanding and Assessment of Risk Tolerance

It is useful to review what we already know about risk tolerance as well as a few of the specific risk-assessment techniques employed by money managers.

Several researchers over the past decade have developed survey methods to define cross-sectional differences in both the attitudes of individual investors and the portfolios they hold. As Baker and Haslem have put it, the objectives of these studies "are twofold: (1) to isolate the underlying factors that cause investors to vary in their perceptions of the desirability of specific common stocks; and (2) to see if these factors are systematically related to their socioeconomic and behavioral characteristics."[1]

Although the approaches have differed across various studies, all the studies tend to concentrate on readily observable physical and economic attributes, rather than on less easily obtained psychological ones. In this regard, variables such as age, marital status, occupation, wealth and gender are often used to classify individuals into well defined groups. Once these groups have been established, the risk tolerance for a particular group is inferred from the estimated volatility of the "aggregate" group portfolio. Blume and Friend and McInish provide typical examples of this line of research.[2]

Perhaps the most common finding of these investigations is that age and sex are significantly correlated with observable levels of portfolio risk. Both Baker and Haslem and Blume and Friend found that males were more willing than females to accept financial risk. Blume and Friend and McInish established a strong negative relation between age and the risk levels of the portfolios held. This suggests that tolerance of financial risk may be a dynamic characteristic, which varies throughout the life of an investor.

In fact, portfolio managers typically attempt to summarize risk tolerance by examining the investor's placement in his or her lifetime planning horizon. Other things being equal, longer horizons dictate riskier asset allocations. Such allocation procedures are based, in part, on the concept of a "life cycle" of economic preferences, according to which risk aversion increases with age.[3] One advantage of the life-cycle assumption is that it is fully consistent with the cross-sectional relation between age and observed investment risk reported by researchers.

Clearly, this type of aggregate information is useful to the portfolio manager. But there is nothing in this approach that allows the portfolio manager to distinguish between the risk-bearing propensities of two otherwise unique clients at the same point in their planning horizons. A far more specialized characterization of investor preferences would be necessary to answer this question satisfactorily.

As Farrelly and LeBaron stress, such individualized insights can only be ascertained through direct interaction between the portfolio manager and the client.[4] Toward this end, many assessment procedures have concentrated on the development of simple psychological profiles of individual investors. Invariably, this plan of attack has involved the classification of personality traits derived from individuals' responses to questionnaires and interviews. The implicit assumption is that such measurable psychometric variables are related to individuals' economic preferences.

It is difficult to measure the efficacy of this presumption, because informal approaches, by design, move directly from personality classification to asset-allocation decisions. Kaiser, for example, advocates the use of a personality-classification system whereby a client's personality is scaled along two axes—"careful-impetuous" and "confident-anxious."[5] The resulting stratification dictates the asset mix.

LeBaron, Farrelly and Gula recommend a multipart questionnaire designed to solicit "visceral" risk-tolerance information as a useful tool in helping clients to understand their own attitudes toward investing under uncertainty.[6] Lipper and Busby espouse the use of a comparable scheme to assess client investment expectations and "temperature" for holding risky assets. Droms has developed a "portfolio allocation scoring system" that translates client responses to seven broad questions about investment ob-

1. Footnotes appear at end of article.

jectives into a specific portfolio-allocation decision.

Barnewall has studied the relation between an individual's psychological profile and his or her occupation. Specifically, she argues that affluent investors of similar professions shouldn't be viewed as having homogeneous investment needs.[7]

More Formal Approaches

A more formal approach to the assessment of risk tolerance depends on the specification of an exact form for the investor's utility function. Once the manager selects an explicit mathematical form for investor satisfaction, the asset allocation decision becomes a basically mechanical operation.

Both Fouse and Condon develop a utility function from the investor's designation of two threshold returns and a risk ratio capturing the marginal utility above and below these two thresholds.[8] The optimal allocation then becomes the portfolio that maximizes the expected utility of the investor. A variation on this theme is provided by Fielitz and Muller, who require investors to select a single target rate of return and one of three levels of risk aversion. These two variables are used in conjunction with an assumed form of the utility function to generate a mathematical determination of the appropriate asset mix.[9]

A logical extension of such utility-based approaches is one in which the portfolio manager elicits from the investor directly a specification of his or her preferred asset allocation. In this case, however, an intelligent selection depends on the client's being fully informed about the potential financial consequences of a given allocation. To assist the investor, the portfolio manager can provide a summary of the probabilistic outcomes of different capital market decisions. These might include, for example, the probabilities of failing to achieve alternative return goals as a function of the percentage of equity held in a simple stock/bond portfolio.

Although it may seem to be an end in itself, this technique can also be used to infer the risk tolerance of the investor. As Sharpe has explained, this additional information can be useful for short-term tactical portfolio rebalancing as market conditions change.[10] Starting with the assumption that investors exhibit constant absolute risk aversion, he demonstrates how a risk-aversion parameter can be estimated from the investor's specification of an asset mix. This parameter defines the investor far more completely than any situation-specific responses would. The obvious advantage of this extension is that it enables the portfolio manager to *maintain* an optimal portfolio—that is, to update the portfolio as conditions change.

Although all the research cited above is of great potential value as a practical tool, it provides little insight into what is arguably the most important aspect of risk-tolerance assessment. Specifically, despite the myriad analytical tools available, we still don't understand *why* individuals have different attitudes to risk and *how* these attitudes may change over time. As a starting point, we might seek to establish some theoretical foundation upon which to build our collection of assessment procedures. In fact, there may exist some common thread linking many of the risk-assessment approaches currently in use. Identification of such a link would provide a better view of current practices and directions for future research.

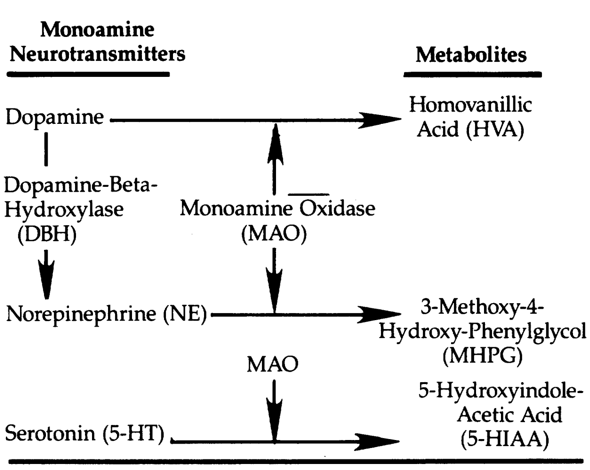
A Biochemical and Psychological Perspective

Based on the preceding discussion, it is clear that our present understanding of investor risk aversion can best be described as qualitative in nature. To begin the task of *quantifying* individual economic preferences, we need to consider some investor-specific characteristics that may play an important role in determining risk-tolerance levels. Important in this regard is a relatively new area of research that has established a relation between biological factors and specific personality traits. These investigations may suggest additional parallel relations between biological/psychological factors and economic behavior.

Research in behavioral biology has provided new insights into the interaction of neurochemical processes and human behavior.[11] In particular, the entire neurotransmission process—generally described as catecholamine systems activity—appears to be closely associated with several different personality characteristics. In other words, behavioral traits such as sensation-seeking, impulsivity and extroversion have been found to be significantly related to biochemical activity.

Figure A shows a stylized representation of some important aspects of the forces governing the three biogenic amine neurotransmitters—

Figure A Monoamine Neurotransmitters, Enzymes and Metabolites



Adapted from M. Zuckerman, ed., *Biological Bases of Sensation Seeking, Impulsivity, and Anxiety* (Lawrence Erlbaum Associates: Hillsdale, NJ, 1983).

dopamine, serotonin and norepinephrine. The figure illustrates how the production, rate of release, metabolism, disposal and receptor sensitivity of these biochemicals are related to measurable levels of two enzymes—*dopamine-beta-hydroxylase* (DBH) and *monoamine oxidase* (MAO). DBH is an enzyme that converts dopamine to norepinephrine, while MAO degrades all three neurotransmitters.

Individuals with high sensation-seeking tendencies, impulsivity and extroversion have been shown to have in aggregate lower-than-average levels of DBH and MAO (as measured within serum/plasma and blood platelets samples, respectively).[12] Furthermore, sensation-seeking traits and levels of platelet MAO show a strong tendency toward heritability, suggesting a genetic link between the two.[13]

Biological Economics?

Can we extend this connection between biological and behavioral characteristics to an investor's economic activity? Do sensation-seeking, impulsive individuals have more tolerance for risk than other individuals? Are there biological influences on economic preferences?

Zuckerman, Buchsbaum and Murphy have shown that psychometric measures of sensation-seeking traits reflect an individual's propensity to engage in risky activities, as well as some aspects of risk-taking within those activities. Furthermore, studies of individuals' anticipation of risk indicate that those who are not sensation-seekers rated a wide variety of situations as high in risk, and that the same individuals anticipated greater fear and experienced less pleasure if actually exposed to those situations.[14]

Additional evidence suggesting an interrelation between biochemical processes and economic risk aversion comes from findings of differences in cross-sectional characteristics of sensation-seeking traits and platelet MAO and plasma DBH levels. Males score significantly higher than females on all the various sensation-seeking psychometric tests in common use, and males also have lower levels of platelet MAO at nearly all ages between 18 and 75. Sensation-seeking has been found to be negatively related to age, while platelet MAO levels are positively related to age.[15]

All these findings are consistent with the cross-sectional characteristics found to be related to an individual's perception of portfolio risk. The traditional view of a life-cycle pattern of risk aversion (i.e., increasing risk aversion with age) is, for example, consistent with both observed investment behavior and the intertemporal properties of psychological and biochemical traits.

Based on this evidence, we believe that neurochemical processes and associated behavioral traits may play a role in defining an individual's economic preferences. More precisely, individuals with catecholamine activity characterized by lower levels of DBH and MAO (i.e., sensation-seeking, impulsive and extroverted individuals) may be hypothesized to be economically less risk-averse than individuals with higher levels of DBH and MAO (i.e., non-sensation-seeking, non-impulsive and introverted individuals).

Risk-Tolerance Assessment Procedures

To test the primary hypothesis set forth above, we need a tractable measure of an individual's aversion to risk. Extending the arguments of Sharpe, we presume that it is reasonable to observe a person's behavior in actual market settings and to use these observations to infer his or her general attitudes toward bearing financial risk.[16]

Unfortunately, while there is an immense amount of data on both securities prices and on the portfolio holdings of individual and institutional investors, it is difficult to determine underlying preference relationships. The reason for this, simply put, is that real life is usually a poor laboratory. It is often impossible to control for variations in the myriad factors that influence an investor's economic and social mindsets.

Fortunately, methodologies exist that allow us to simulate market conditions while separating out the influences of extraneous variables. For our investigation, we make use of theoretical and empirical models recently developed to estimate risk-aversion parameters using experimental auction markets.

The use of laboratory experiments in economics provides a manageable microeconomic environment in which relevant variables can be more precisely controlled and measured than in the "field."[17] This control allows us to specify financial risk explicitly, hence to estimate a measure of risk aversion. Given the problems associated with drawing individual inferences from aggregate market data, the use of experimental procedures is appropriate.

The Auction Market

To obtain measures of risk aversion, we employed the "first price sealed bid" auction as the relevant "market institution." The first price sealed bid auction corresponds to "the usual practice of calling for the tender of bids on the understanding that the highest . . . bid . . . will be accepted and executed in accordance with its own terms."[18] It serves our purpose by providing a market environment in which an individual's attitudes toward assuming financial risk can be directly inferred.

Specifically, in an auction for a single unit of some commodity, each of N different bidders submits a sealed bid (i.e., the bids are not made known to the other N-1 participants). The commodity is awarded to the individual who made the highest bid. If the "intrinsic" value of the commodity to the jth participant is expressed as v_j, the income derived from winning the auction is $v_j - b_j$, where b_j is the level of the bid.

Assume all investors have a utility function of the following form:

$$u_j(b_j) = (v_j - b_j)^{r_j}. \tag{1}$$

It can then be shown that, if every participant's objective is to maximize the expected utility of his or her income, each will submit a bid that can be computed as follows:

$$b_j = \left[\frac{N - 1}{N - 1 + r_j}\right] v_j, \tag{2}$$

given certain restrictions on the form of the auction and on the individual's expectations.[19]

A participant's bid in a given auction becomes a function of the value of the commodity, v_j (which can be viewed as the value at which the commodity can be resold), the number of bidders in the auction, N, and the utility function exponent, r_j. The utility function exponent captures the bidder's attitude toward risk-bearing. It is this individual-specific parameter that determines the degree of relative risk aversion.

Using the form of the bidder's utility function in Equation (1), we assume individuals exhibit constant relative risk aversion of the order $(1 - r_j)$. If r_j equals 1.00, an investor is risk-neutral, hence indifferent to the amount of financial uncertainty in his or her portfolio. If r_j is positive but less than 1.00, the individual is regarded as risk-averse.

The probability of a particular bidder winning a given auction is a function of the amount of his or her bid. The higher the bid, the greater the probability of winning the auction and receiving the commodity. Of course, as the bid (and the probability of winning) increases, the profits from winning, hence the utility derived from winning, decrease. There is thus an explicit risk-return tradeoff within this auction market. Risk-averse individuals are typified by their willingness to bid a higher proportion of their resale values (i.e., to decrease their profits from winning) in order to increase their probability of winning.

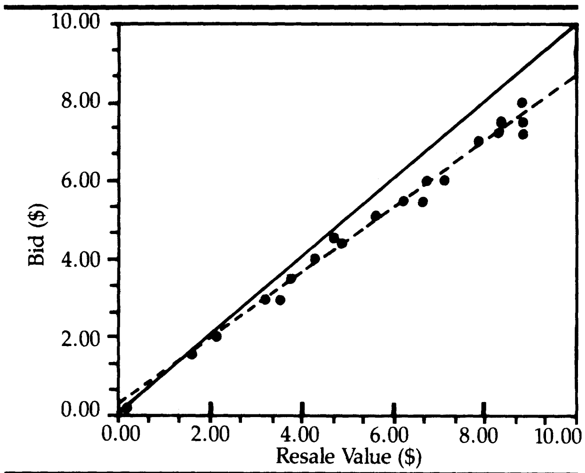
The simple risk-return tradeoff represented by this bid decision provides the mechanism by which an individual's economic risk aversion can be estimated. Specifically, if individuals bid according to the linear function in Equation (2), based upon a given set of conditions in the marketplace, then the size of their bids relative to their resale values captures their propensity to bear risk.

We used data obtained from a series of T auctions to estimate the following regression:

$$b_{jt} = \alpha_j + \beta_j v_{jt} + \varepsilon_{jt}; \; t = 1, \ldots, T. \tag{3}$$

This provides an approximate description of the jth investor's bidding behavior. From this linear

Figure B First-Price Auction Bids for Differing Resale Values



relationship, we derive an estimate of risk aversion, given by the following equation:

$$\hat{r}_j = \frac{(N - 1)(1 - \hat{\beta}_j)}{\hat{\beta}_j}. \quad (4)$$

Figure B summarizes a series of experimental bids in an actual set of first price auctions. In these auctions, the value of the abstract commodity that was the subject of the bidding process varied uniformly and randomly from $0.00 to $10.00. In each auction, the bid was typically less than the resale value (i.e., the bids fall below the 45-degree line).

For the series of auctions depicted in Figure B, there were four participants (i.e., $N = 4$). The estimate of β_j from Equation (3) is 0.8374 (i.e., the slope of the dashed line). Thus, from Equation (4), the value of $\hat{r}_j$ is 0.58. This value is consistent with the assumption of risk-averse behavior.

The Foundations of Risk Tolerance

We have hypothesized that an individual's financial risk tolerance is significantly related to certain biochemical and psychological influences. To test this supposition, we developed data for the relevant economic, biological and psychometric measures from a series of experimental sessions using a total of 183 student subjects at the University of Arizona. The first session involved placing the subjects in a simulated market environment in order to elicit information sufficient to calculate their levels of risk aversion. More precisely, these subjects, in groups of four to eight, participated in two separate sequences of 25 first price sealed bid auctions using standard experimental economic procedures.[20] To ensure a realistic market setting, we completed all auctions with actual monetary payoffs.

A second experimental session was designed to generate a psychological profile of each student involved in the study. This session was conducted in two phases. In the first, all 183 subjects participating in the auction trials were asked to complete the 40-question Sensation Seeking Scale (SSS Form V); the results were used to estimate sensation-seeking, impulsivity and extroversion behavioral traits. The SSS has a general sensation-seeking scale (Gen), as well as four subscales—thrill and adventure-seeking (TAS), experience-seeking (ES), disinhibition (Dis) and boredom-susceptibility (BS).[21]

In the second phase, 102 subjects from the initial group were asked to complete the Minnesota Multiphasic Personality Inventory (MMPI); this was employed as an independent measure of extroversion.[22] Of the various traits measured by this test, the Si (Social Introversion) scale has been found by Zuckerman *et al.* to be significantly correlated with measures of catecholamine activity. It was thus useful for our purposes.[23]

The final experimental session consisted of obtaining a measure of catecholamine activity for each of the test subjects. As discussed earlier, two neuroregulating enzymes—DBH and MAO—play important roles in the neurochemical processes. Plasma DBH and platelet MAO have both been found to be correlated with catecholamine activity and with psychometric measures of sensation-seeking, impulsivity and extroversion.

Although plasma DBH tends to be a better biochemical measure than platelet MAO, at the time of our study clinical laboratories were not available to conduct a DBH assay. Consequently, a platelet MAO measure was used despite the fact that the clinical procedures for this test are more difficult. Volunteers were asked to give a small blood sample in order to determine platelet levels of MAO. (For this investigation, MAO was measured using a C14 tryptamine enzyme substrate with units in nanomoles/hr/milligram of platelet protein.) A total of 125 subjects volunteered, 67 males and 58 females. The majority had completed all the prior experimental sessions.

Table I provides summary statistics for the

Table I Summary Statistics for Experimental Subject Groups

	Obs.	*Mean*	*Std. Dev.*	*Median*	*Minimum*	*Maximum*
Total Sample						
MAO	125	5.18	1.75	5.05	1.72	11.06
Gen	170	20.59	5.71	21.00	6.00	33.00
Si	139	24.19	9.02	22.00	8.00	50.00
Age	183	21.60	3.66	20.57	17.00	37.00
Males						
MAO	67	4.27	1.27	4.47	1.72	7.83
Gen	92	21.86	5.58	22.50	10.00	33.00
Si	76	23.83	8.65	21.50	10.00	50.00
Age	98	22.00	3.87	21.00	17.00	37.00
Females						
MAO	58	6.22	1.66	5.95	3.12	11.06
Gen	78	19.09	5.53	19.00	6.00	31.00
Si	63	24.63	9.51	25.00	8.00	47.00
Age	85	21.15	3.38	20.00	17.00	37.00

total experimental subject group and for the males and females separately. Inspection of this table reveals that the males and females differ across the biochemical and psychometric variables in a manner consistent with earlier research findings.

General Findings

To test the statistical relations between the various measures, the male and female subjects were separately rank-ordered using (1) the platelet level of the neuroregulating enzyme MAO, (2) the general (Gen) sensation-seeking score from Form V of the SSS and (3) the social introversion (Si) score from the MMPI. Within each gender group, we identified two approximately equal-sized subgroups on either side of the median value for each variable. This simple "dichotomization" procedure allowed us to define biological subgroups without having to specify an exact parametric relation between the underlying variables.

Differences between risk-aversion parameters identified from the first price bidding auctions were then compared across the gender groups and subgroups. Table II summarizes the group means of these parameters and the statistical tests of differences across groups. Panel A considers only those subjects having non-negative (i.e., rational) risk-aversion coefficients (as estimated in a manner consistent with the theoretical development of the first price auction). Panel B includes the entire sample, using all observations in the estimations of Equations (3) and (4).

The dependent variable (Y) used in the comparison is reported in Column (1) of Table II, and the biochemical/psychometric independent variable (X) used to form the two rank-ordered subgroups within each gender group is listed in Column (2). The mean value of each dependent variable and the number of observations for each subgroup are reported in Columns (3) through (5) and (9) through (11). Thus the first row of Column (4) shows that those males identified as having below-median levels of MAO had a mean $\hat{r}_j$ (risk-aversion estimate) of 0.4726.

Columns (6) and (12) report F-statistics from analysis of variance (ANOVA) tests performed to determine the statistical significances of the differences between the gender subgroups identified as having high levels of MAO, Gen and Si and those having low levels. Column (15) provides the results of F-tests for differences between the male and female groups. Columns (8) and (14) provide χ^2 statistics based on frequency distributions within two-way contingency tables for low and high ranks of both X and Y.

If neurochemical activity and sensation-seeking traits play a role in determining economic preferences, one would expect the first price auction to yield *higher* $\hat{r}_j$ values (i.e., less risk aversion or more risk tolerance) for individuals with (1) *lower* levels of MAO, (2) *higher* Gen scores and (3) *lower* Si scores. These relationships are strongly supported within the male group, based on F and χ^2 statistics. Within the female sample, however, there is no evidence of statistical differences between the MAO, Gen or Si subgroups, although the mean $\hat{r}_j$ values vary in the same direction as those for males.

Although this finding is not significant at conventional levels, females tend to be more

Table II Estimated Parameters from the First Price Auctions

Dependent Variable Y (1)	Bio/Psych Variable X (2)	Obs. (3)	Mean Y Values—Males: Low-Rank X (4)	Mean Y Values—Males: High-Rank X (5)	ANOVA[a] F (6)	ANOVA[a] R^2 (7)	Freq.[b] χ^2 (8)
Panel A ($\hat{r}_j \geq 0$):[c]							
$\hat{r}_j$	MAO	127	0.4726	0.3399	4.63**	0.036	4.39**
	Gen	167	0.2977	0.4553	8.92**	0.051	8.22**
	Si	141	0.4863	0.3166	8.01**	0.054	7.73**
$\hat{\beta}_j$	MAO	127	0.8738	0.9036	4.74**	0.037	4.39**
	Gen	167	0.9148	0.8777	10.04**	0.057	8.22**
	Si	141	0.8709	0.9097	8.78**	0.059	7.73**
$\hat{\alpha}_j$	MAO	127	0.0100	−0.0055	11.12**	0.082	8.69**
	Gen	167	−0.0020	0.0025	1.37	0.008	2.19
	Si	141	0.0029	−0.0000	0.45	0.003	0.01
Panel B (All Observations):[c]							
$\hat{r}_j$	MAO	132	0.5207	0.4086	3.64*	0.027	1.59
	Gen	174	0.3474	0.5317	12.63**	0.068	10.14**
	Si	147	0.5394	0.3829	6.76**	0.045	4.27**
$\hat{\beta}_j$	MAO	132	0.8614	0.8851	3.21*	0.024	2.05
	Gen	174	0.9012	0.8587	14.44**	0.077	9.20**
	Si	147	0.8582	0.8920	6.88**	0.045	3.61*
$\hat{\alpha}_j$	MAO	132	0.0104	−0.0005	4.49**	0.033	0.79
	Gen	174	−0.0008	0.0052	1.75	0.010	3.89**
	Si	147	0.0043	0.0012	0.37	0.003	0.56

risk-averse than males; this is evidenced by lower mean values of $\hat{r}_j$ for females. The behavioral differences between males and females may reflect the difference in mean MAO levels and in behavioral traits across the two groups. We cannot determine, however, whether males are, on average, behaving in a less risk-averse fashion relative to females because of these differences or because of differences in socialization experiences. Our inferences are therefore limited primarily to differences within each of the two gender groups.

The set of dependent variables in Table II includes the intercept term, $\hat{\alpha}_j$, from the regression in Equation (4). This term potentially has economic significance for a generalized first price bidding model.[24] Specifically, the intercept term in Equation (4) may be capturing a monetary equivalent of the utility of winning an auction and may thus be a relevant parameter characterizing some form of preferences. Alternatively, it may be capturing a bias created by imposing a linear regression model on what is actually non-linear bidding behavior.

An analysis of this term in Table II indicates significant differences between the male subgroups for MAO and Gen, based on F and χ^2 statistics. χ^2 even indicates a difference between the female Gen subgroups. In addition, Panel A indicates significant differences in the intercept terms of the male and female MAO, Gen and Si subgroups.

It should be noted at this point that several factors are contributing to the low R^2 values observed in Table II. Most notably, the subjects employed in the study were the same approximate age; this made it difficult to establish a biochemical correlation to economic preferences. As discussed earlier, the biochemical and psychological traits that are the focus of the study have an important age dependency. MAO levels increase with age, while sensation-seeking, impulsivity and extroversion decrease. By limiting the subject group to a relatively homogeneous age class, we have biased the tests against finding a behavioral relationship.

Table III presents Spearman rank-correlation coefficients for the total sample and for the male and female groups. Consistent with the results in Table II, the MAO, Gen and Si measures for the males are significantly correlated with the risk-tolerance estimates ($\hat{r}_j$, $\hat{\beta}_j$ and $\hat{\alpha}_j$) from the first price auction. No meaningful correlation based on these particular measures is exhibited within the female group.

Table II (Continued)

	Mean Y Values—Females		ANOVA[a]			
Obs. *(9)*	*Low-Rank X* *(10)*	*High-Rank X* *(11)*	*F* *(12)*	R^2 *(13)*	*Freq.*[b] χ^2 *(14)*	*Males vs. Females F*[a] *(15)*
104	0.3537	0.3275	0.27	0.003	0.04	2.41
134	0.3574	0.3495	0.03	0.000	0.74	0.47
111	0.3375	0.3889	0.97	0.009	0.01	0.86
104	0.9004	0.9054	0.16	0.002	0.04	2.12
134	0.8989	0.9012	0.04	0.000	0.74	0.26
111	0.9029	0.8917	0.81	0.007	0.01	0.56
104	−0.0052	−0.0024	0.60	0.006	0.65	3.52*
134	−0.0030	−0.0067	1.32	0.010	3.01*	4.11**
111	−0.0043	−0.0040	0.01	0.000	0.01	3.76*
109	0.4162	0.3831	0.42	0.004	0.08	2.55
140	0.3898	0.4174	0.34	0.002	1.01	0.94
116	0.4155	0.4249	0.03	0.000	0.04	0.93
109	0.8851	0.8900	0.15	0.001	0.01	2.29
140	0.8907	0.8832	0.43	0.003	1.39	0.71
116	0.8828	0.8826	0.00	0.000	0.00	0.65
109	0.0006	0.0006	0.00	0.000	0.21	1.66
140	−0.0005	−0.0021	0.25	0.002	0.11	1.46
116	0.0005	−0.0010	0.16	0.001	1.29	0.82

a. Significance is reported at the 0.05 level (**) and the 0.10 level (*).
b. χ^2 statistics based on the frequency distribution within a 2 × 2 contingency table; significance is reported at the 0.05 level (**) and the 0.10 level (*).
c. Panel A represents the sample for which $\hat{r}_j$ is estimated to be consistent with the theoretical development of the first price auction and for which $\hat{r}_j \geq 0$. Panel B reflects the sample of all observations used in obtaining parameter estimates from Equations (3) and (4).

Components of Sensation-Seeking

Recall that the general sensation-seeking (Gen) measure comprises four subscales—thrill and adventure-seeking (TAS), experience-seeking (ES), disinhibition (Dis) and boredom-susceptibility (BS). So far, we have examined only the aggregate sensation-seeking tendencies captured by the Gen measure. The subtleties of

Table III Spearman Correlation Coefficients for Individual-Specific Measures and Risk-Tolerance Parameters*

	Gen	*Si*	$\hat{r}_j$	$\hat{\beta}_j$	$\hat{\alpha}_j$
Total Sample					
MAO	−0.2056**	0.0871	−0.1337**	0.1337**	−0.1899**
Gen		−0.4087**	0.1427**	−0.1427**	0.0786
Si			−0.1243**	0.1243**	−0.0196
$\hat{r}_j$				−1.0000**	0.5245**
$\hat{\beta}_j$					−0.5245**
Males					
MAO	0.0533	0.0439	−0.1554*	0.1554*	−0.2075**
Gen		−0.3794**	0.2525**	−0.2525**	0.1350*
Si			−0.2443**	0.2443**	−0.0645
$\hat{r}_j$				−1.0000**	0.5824**
$\hat{\beta}_j$					−0.5824**
Females					
MAO	−0.2270**	0.0978	−0.0808	0.0808	−0.0864
Gen		−0.4444**	−0.0295	0.0295	−0.0853
Si			0.0468	−0.0468	0.0407
$\hat{r}_j$				−1.0000**	0.4730**
$\hat{\beta}_j$					−0.4730**

* Significance is reported at the 0.05 level (**) and the 0.10 level (*). The sample reported is for first price auction parameter estimates $\hat{r}_j \geq 0$.

Table IV Spearman Correlation Coefficients for Sensation-Seeking Subscales and Risk-Tolerance Measures*

	$\hat{r}_j$	$\hat{\beta}_j$	$\hat{\alpha}_j$
Total Sample			
TAS	0.1214**	−0.1214**	0.1308**
ES	0.0586	−0.0586	0.0861
Dis	0.1454**	−0.1454**	0.0574
BS	0.1632**	−0.1632**	0.0341
Males			
TAS	0.0671	−0.0671	0.0290
ES	0.1196	−0.1196	0.1467*
Dis	0.2271**	−0.2271**	0.1362*
BS	0.2075**	−0.2075**	0.0724
Females			
TAS	0.1585**	−0.1585**	0.1828**
ES	0.0147	−0.0147	0.0619
Dis	0.0249	−0.0249	−0.0902
BS	0.0590	−0.0590	−0.1119

* Significance is reported at the 0.05 level (**) and the 0.10 level (*). The sensation-seeking subscales are thrill and adventure-seeking (TAS), experience-seeking (ES), disinhibition (Dis) and boredom-susceptibility (BS). The sample reported is for all first price auction observations.

alternative forms of sensation-seeking can be investigated by focusing on each of these subscales.

Table IV reports the Spearman rank correlations of these measures with the three risk-tolerance parameters derived from the first price auction. The overall sample exhibits a significant correlation between risk tolerance and TAS, Dis and BS. Males exhibit significant correlations for Dis and BS. Furthermore, unlike the results reported thus far, the risk-aversion estimates for females display a significant correlation with TAS.

The results so far are based on risk-aversion parameters estimated for each subject. As an alternative, we can look at estimates for each subject group as a whole. While no theoretical basis exists for such aggregation, it does provide a statistical means for comparing overall behavioral differences.

For our first price auction sample, we modified the regression in Equation (4) to include variables reflecting the auction size and individual-specific traits. In particular, dummy intercept and slope variables were added to the regression equation to distinguish between auctions involving four ($N = 4$) and six ($N = 6$) bidders. Similar intercept and slope parameters were included using the various biochemical/psychometric measures as the relevant independent variables. (The measures were standardized with zero mean and unit standard deviation to allow for comparisons across regressions.) These regressions across J subjects and T_F auctions are represented by:

$$b_{jt} = \alpha_1 + \alpha_2(X_j) + \alpha_3(\delta_j^N) + \beta_1(v_{jt}) + \beta_2(X_j v_{jt}) + \beta_3(\delta_j^N v_{jt}) + \varepsilon_{jt}; \quad (5)$$

$$t = 1, \ldots, T_F; \; j = 1, \ldots, J,$$

where:

X_j = the standardized biochemical/psychometric measure (i.e., MAO, Gen, Si, TAS, ES, Dis or BS) and

$\delta_j^N = 0 \; (N = 4)$ or $1 \; (N = 6)$.

Table V presents the results of the estimation of Equation (5) with weighted-least-squares for the male and female subgroups using each of the behavioral traits. It is useful to focus on the β_1, β_2 and β_3 regression coefficients. β_1 and β_3 capture the aggregate level of risk aversion for a given auction size, while β_2 reflects the dependence of risk aversion on a particular characteristic.

Of the 14 β_2 coefficients reported, 12 have a sign consistent with the hypothesis of this study; all are statistically significant. Only one coefficient (females with MAO as the independent variable) is significant with the opposite sign. For males, all coefficients are significant and of the predicted sign, consistent with the stronger results found for this group in the earlier analyses. In terms of the overall level of risk aversion, males and females tend to bid in a similar fashion in auctions with four bidders (i.e., comparable β_1 coefficients), while females tend to be more risk-averse in auctions with six bidders (i.e., higher β_3 coefficients).

These results, combined with the other parametric and non-parametric analyses, indicate that the risk-tolerance parameters derived from the first price auction exhibit a significant dependence on the measures of neurochemical activity and sensation-seeking. Consistent with the original hypothesis, high MAO levels, low levels of sensation-seeking, non-impulsivity and introversion tend to be associated with more risk-averse behavior, providing support for a correlation between behavioral traits and economic preferences. Quantifiable differences in economic behavior are evident for both males and females.

Table V First Price Auction Regressions*

X_j	Obs.	α_1	α_2	α_3	β_1	β_2	β_3	R^2
Males								
MAO	3300	0.0028	−0.0045	−0.0014	0.9118	0.0139	0.0269	0.9879
		(1.64)	(−4.43)**	(−0.66)	(307.66)**	(7.94)**	(7.25)**	
Gen	4350	0.0017	−0.0007	−0.0027	0.9125	−0.0108	0.0281	0.9892
		(1.28)	(−0.84)	(−1.58)	(381.28)**	(−7.74)**	(9.27)**	
Si	3675	0.0038	−0.0010	−0.0039	0.9113	0.0075	0.0326	0.9884
		(2.46)**	(−1.11)	(−2.00)**	(333.72)**	(4.46)**	(9.34)**	
TAS	4350	0.0016	−0.0006	−0.0019	0.9135	−0.0065	0.0280	0.9888
		(1.21)	(−0.82)	(−1.08)	(374.71)**	(−5.12)**	(8.99)**	
ES	4350	0.0020	0.0002	−0.0023	0.9154	−0.0036	0.0263	0.9885
		(1.44)	(0.25)	(−1.35)	(376.20)**	(−2.51)**	(8.43)**	
Dis	4350	0.0014	−0.0011	−0.0023	0.9139	−0.0088	0.0261	0.9890
		(1.07)	(−1.39)	(−1.32)	(380.32)**	(−6.11)**	(8.54)**	
BS	4350	0.0015	−0.0003	−0.0024	0.9160	−0.0103	0.0246	0.9889
		(1.10)	(−0.31)	(−1.37)	(384.48)**	(−6.49)**	(8.01)**	
Females								
MAO	2725	−0.0026	−0.0009	0.0004	0.9124	−0.0102	0.0542	0.9950
		(−1.02)	(−1.35)	(0.16)	(215.47)**	(−8.43)**	(11.80)**	
Gen	3500	−0.0025	0.0022	0.0009	0.9150	−0.0144	0.0593	0.9940
		(−1.12)	(1.81)*	(0.40)	(241.87)**	(−6.72)**	(14.77)**	
Si	2900	−0.0027	−0.0007	0.0023	0.9110	0.0178	0.0490	0.9896
		(−1.19)	(−0.58)	(0.90)	(230.24)**	(8.09)**	(11.03)**	
TAS	3500	−0.0026	0.0002	0.0015	0.9151	−0.0072	0.0566	0.9939
		(−1.18)	(0.21)	(0.66)	(239.17)**	(−3.72)**	(13.91)**	
ES	3500	−0.0022	0.0020	0.0005	0.9138	−0.0116	0.0615	0.9939
		(−1.01)	(1.62)	(0.21)	(240.18)**	(−5.38)**	(15.16)**	
Dis	3500	−0.0021	0.0022	0.0008	0.9130	−0.0119	0.0599	0.9939
		(−0.97)	(2.05)**	(0.35)	(241.24)**	(−6.42)**	(14.89)**	
BS	3500	−0.0022	0.0008	0.0010	0.9128	0.0003	0.0592	0.9938
		(−0.98)	(0.71)	(0.43)	(238.29)**	(0.17)	(14.50)**	

* Based on Equation (5). Significance is reported at the 0.05 level (**) and the 0.10 level (*)

Implications

Our survey of existing risk-tolerance assessment techniques showed that a great deal of effort has gone into characterizing the physiological and psychological makeup of investors. However, for all the sophistication and creativity that have been brought to bear on this problem, the critical issue of why individuals have different preferences has not been adequately addressed. For this reason, our empirical analysis has concentrated on unique biochemical and psychological factors and their role in an individual's decision-making process.

While a biochemical basis for economic behavior represents a new research frontier, it is supported by prior investigations relating behavioral traits to biological factors. In particular, psychological and medical research in areas generally described as "behavioral biology" or "behavioral physiology" has established a relation between personality characteristics such as sensation-seeking and extroversion and various components of the complex set of human neurochemical systems (MAO being one of many such factors).

These behavioral traits, which can be ascertained through psychological testing, have many parallels with economic notions of financial risk-taking. For example, thrill and adventure-seeking (a form of sensation-seeking) reflect an individual's propensity to engage in risky activities (e.g., sky diving and mountain climbing). Thrill and adventure-seeking individuals have relatively low MAO levels, as do individuals who exhibit a willingness to take financial risks.

Our results demonstrate that, along with neurochemical activity, financial risk tolerance is significantly related to sensation-seeking and extroversion. Individuals who exhibit higher degrees of various forms of sensation-seeking and those who are less introverted are more willing to accept financial risk. The results form the basis of a consistent biological and behavioral framework that can provide an attractive vantage point from which to view and assess economic behavior.

From a theoretical perspective, this research sheds new light on a continuing debate between psychologists and economists centering on individual decision-making. Psychologists often argue that individuals' choices are primarily determined by factors unique to the particular decision setting, while economists assume that some individual-specific mechanism plays a common role in all economic decisions. The finding that measurable individual traits underlie economic behavior lends support to the economists' view of the decision-making process.

From a more practical standpoint, a biological/psychological basis for economic preferences may allow for the development of improved methods of assessing individual economic risk aversion. For instance, client-specific risk tolerances could be assessed using improved psychological measures that are known to be correlated with both biochemical and economic attributes. The existence of a fundamental common thread may also provide insights into differences in individuals' economic preferences and risk tolerances and how these change over time. Of course, the magnitude and consistency of these differences play an important role in the asset allocation process. While this entire line of research is still in its infancy, the prospects for new developments and new insights into economic behavior are very exciting.[25] ■

Footnotes

1. See H. K. Baker and J. A. Haslem, "Toward the Development of Client-Specified Valuation Models," *Journal of Finance*, September 1974.
2. M. E. Blume and I. Friend, *The Changing Role of the Individual Investor* (New York: John Wiley & Sons, 1978) and T. H. McInish, "Individual Investors and Risk-Taking," *Journal of Economic Psychology*, 1982.
3. A reference to this line of reasoning can be found in R. D. Milne, "Determination of Portfolio Policies: Individual Investors," in J. L. Maginn and D. L. Tuttle, eds., *Managing Investment Portfolios: A Dynamic Process* (New York: Warren, Gorham & Lamont, 1983).
4. See G. Farrelly and D. LeBaron, "Assessing Risk Tolerance Levels: A Prerequisite to Personalizing and Managing Portfolios," *Financial Analysts Journal*, January/February 1989.
5. R. W. Kaiser, "Individual Investors," in Maginn and Tuttle, *Managing Investment Portfolios, op. cit.*
6. This questionnaire, which requires clients to evaluate their feelings toward a broad array of descriptive phrases (such as "fear of losses" and "rewards for taking chances") is reproduced in D. LeBaron, G. Farrelly and S. Gula, "Facilitating a Dialogue on Risk: A Questionnaire Approach," *Financial Analysts Journal*, May/June 1989.
7. See A. M. Lipper and M. J. Busby, "The Traditional Asset Classes," W. G. Droms, "Investment Risk and the Individual Investor—Part I," and M. M. Barnewall, "Psychological Characteristics of the Individual Investor," all in *Asset Allocation for the Individual Investor* (Charlottesville, VA: Institute of Chartered Financial Analysts, 1987).
8. W. L. Fouse, "Asset Allocation" and K. A. Condon, "Asset Mix Model," in *Asset Allocation Decisions in Portfolio Management* (Charlottesville, VA: Institute of Chartered Financial Analysts, 1982).
9. B. D. Fielitz and F. L. Muller, "The Asset Allocation Decision," *Financial Analysts Journal*, July/August 1983.
10. W. F. Sharpe, "Integrated Asset Allocation," *Financial Analysts Journal*, September/October 1987, contains a more complete consideration of both the tactical and strategic implications of the asset allocation approach. Sharpe provides an excellent explanation of how information about an investor's risk tolerance can be translated into a "risk penalty" measure and then combined with capital market variables to achieve an optimal portfolio selection in "The Risk Factor: Identifying and Adapting to the Risk Capacity of the Client," in *Asset Allocation for Institutional Portfolios* (Charlottesville, VA: Institute of Chartered Financial Analysts, 1987).
11. W. V. Harlow and K. C. Brown, *The Role of Risk Tolerance in the Asset Allocation Process: A New Perspective* (Charlottesville, VA: Research Foundation of the Institute of Chartered Financial Analysts, 1990).
12. These results are found in M. Zuckerman, J. C. Ballenger, D. C. Jimerson, D. L. Murphy and R. M. Post, "A Correlational Test in Humans of the Biological Models of Sensation Seeking, Impulsivity, and Anxiety," in M. Zuckerman, ed., *Biological Bases of Sensation Seeking, Impulsivity, and Anxiety* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1983).
13. D. Fulker, S. B. W. Eysenck and M. Zuckerman, "A Genetic and Environmental Analysis of Sensation Seeking," *Journal of Research in Personality*, 1980 and A. Nies, D. S. Robinson, K. R. Lamborn and R. P. Lambert, "Genetic Control of Platelet and Plasma Monoamine Oxidase Activity," *Archives of General Psychiatry*, 1973.
14. M. Zuckerman, M. S. Buchsbaum and D. L. Murphy, "Sensation Seeking and Its Biological Correlates," *Psychology Bulletin*, 1980 and M. Zuckerman, "Sensation Seeking and Risk Taking," in C. E. Izard, ed., *Emotions in Personality and Psychopathology* (Plenum Press, 1979).
15. These results are summarized in M. Zuckerman, S. Eysenck and H. J. Eysenck, "Sensation Seeking in England and America: Cross-Cultural, Age, and Sex Comparisons," *Journal of Consulting*

Footnotes concluded on page 80.

historical simulation that yields dismal results; such models are rejected before they see the light of day. Furthermore, some over-zealous practitioners succumb to the temptation to use *ex post* simulations in which a model is tested on the same data used to develop the model, because stellar simulations are more likely to attract investor interest.

Furthermore, portfolio construction considerations might result in a gap between simulation and execution. Structured simulations often recommend very lopsided portfolios, resulting in excessive industry or factor exposure. Portfolio managers are frequently compelled to moderate these structural biases, often muting strategy performance.

The authors do not suggest that simulations are useless. Properly conducted, they can lead—and have led—to profound insights and successful innovations. But biases in design (e.g., *ex post* simulations as described above) and theoretic strategies that cannot be traded introduce real crises of expectations. Some simulations must be taken with a grain of salt, others with a whole shaker-full.

8. G. L. Beebower and R. J. Surz, "Analysis of Equity Trading Execution Costs" (Center for Research in Security Prices Seminar, November 1980).

Harlow and Brown footnotes concluded from page 62.

and Clinical Psychology, 1978; D. S. Robinson, J. M. Davis, A. Nies, C. L. Ravaris and D. Sylvester, "Relation of Sex and Aging to Monoamine Oxidase Activity of Human Brain, Plasma and Platelets," *Archives of General Psychiatry*, 1971; and Zuckerman, Buchsbaum and Murphy, "Sensation Seeking and Its Biological Correlates," *op. cit.*

16. Sharpe, "The Risk Factor," *op. cit.*
17. V. L. Smith, "Microeconomic Systems as an Experimental Science," *American Economic Review*, December 1982.
18. W. Vickery, "Counterspeculation, Auctions, and Competitive Sealed Tenders," *Journal of Finance*, March 1961.
19. The theoretical development of the first price sealed bid auction can be found in J. C. Cox, B. Roberson and V. L. Smith, "Theory and Behavior of Single Object Auctions," in V. L. Smith, ed., *Research in Experimental Economics* (Greenwich, CT: JAI Press, 1982) and J. C. Cox, V. L. Smith and J. M. Walker, "Theory and Individual Behavior of First Price Auctions" (Working paper, University of Arizona, 1987).
20. Complete details of all experimental procedures are available from the authors upon request.
21. Each of the four subscales represents responses to 10 question items, scored on the basis of the number of relevant responses (0 to 10). The Gen scale is the sum of the four subscales, hence ranges in value from 0 to 40. See M. Zuckerman, *Sensation Seeking: Beyond the Optimal Level of Arousal* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1979).
22. S. R. Hathaway and J. C. McKinley, *The Minnesota Multiphasic Personality Inventory*, rev. (New York: Psychological Corp., 1951).
23. See Zuckerman et al., "A Correlational Test," *op. cit.*
24. See J. C. Cox et al., "Theory and Individual Behavior of First Price Auctions," *op. cit.*
25. Financial support for this project was provided by The Research Foundation of the Institute of Chartered Financial Analysts, the University of Arizona Foundation (grant program of the Office of the Vice President for Research) and the Economic Science Laboratory at the University of Arizona. The opinions and analyses presented, however, are those of the authors, and not necessarily those of Salomon Brothers Inc, The Research Foundation or the University of Arizona Foundation.