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Personality differences in patterns of risk taking on a gambling task

Christodoulou, Christopher, Ph.D.

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U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

PERSONALITY DIFFERENCES IN PATTERNS OF RISK TAKING ON A GAMBLING TASK

by

CHRISTOPHER CHRISTODOULOU

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1/19/94
Date

Chair of Examining Committee

1-20-94
Date

Executive Officer

Jeffrey J. Rosen, Ph.D.

Malvin Janal, Ph.D.

John McDonald, Ph.D.

Arthur J. Spielman, Ph.D.

William King, Ph.D.

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

Abstract

PERSONALITY DIFFERENCES IN PATTERNS OF RISK TAKING ON A GAMBLING TASK

by

CHRISTOPHER CHRISTODOULOU

Advisor: Professor Jeffrey J. Rosen

People are known to differ in their patterns of risk taking. Some gamblers, for example, tend to make riskier bets after losing as opposed to after winning, even when each outcome is independently determined. While this betting pattern has been called the "gambler's fallacy," not all gamblers display it. In fact, some display the opposite (Leopard, 1978; Wagenaar, 1988).

The present investigation attempted to examine some of the reasons underlying such individual differences from the perspective of Cloninger's (1986, 1987a) unified biosocial personality theory. It was hypothesized that there was an overlap between variables important for decision making and the personality dimensions of this theory. Models of decision making typically include measures of loss, gain, and uncertainty/probability, (e.g., Kahneman & Tversky,

1979). Cloninger's personality dimensions are Harm Avoidance, Reward Dependence, and Novelty Seeking. In addition, a four factor version of the theory includes the dimension of Persistence, which may relate in part to the "framing," or contextual, effects which are also thought to affect decision making (Tversky and Kahneman, 1981).

In a preliminary study, Cloninger's Tridimensional Personality Questionnaire (TPQ) was administered to 428 undergraduate students in order to ascertain its usefulness in the present college population. The results largely replicated Cloninger's own normative data. A factor analysis resulted in the four personality dimensions listed above.

The relationship between personality and risky decision making was then examined in 127 undergraduates who completed the TPQ and performed a computerized gambling task. Results indicated that each personality dimension was independently correlated with specific patterns of risky decision making. In addition, a multiple regression indicated that the combination of independent dimensions and their interactions accounted for a considerable portion (40 to 50 percent) of the variance in gambler's fallacy betting patterns. Interpretations of the data were then presented, limitations of the study discussed, and future studies proposed.

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I. INTRODUCTION

Of the multitude of characteristics that distinguish individuals, some of the most intriguing relate to risk taking. For example, given the choice between a relatively safe option (e.g., one's present job, home, or relationship) and a more uncertain and risky alternative (e.g., a new job, home, or relationship), one outcome is certain. Some people will and some people will not take the risky option. Similarly, some people choose to risk significant sums of money on games of chance (e.g., lotteries, poker, football pools), while others would never dream of doing so. The present investigation attempts to examine some of the personality characteristics that may relate to such differences in risk taking.

A. Overview

Decision making is an integral part of life. Whether we are crossing the street, climbing the Andes, or choosing a career, there is always a path not taken (at least for the moment), and a choice made. Even in simple circumstances, there is the choice of whether to act or not. The importance of decision making is underscored by the variety of disciplines which find it of interest. Psychologists, economists, philosophers, and political scientists are all concerned with the study of decision making (e.g., Douglas & Wildavsky, 1982; Kahneman & Tversky, 1979; Rosenberg, 1988; Yates & Stone, 1992).

The widespread effort to understand this topic is not simply due to disinterested intellectual curiosity. Many researchers are no doubt interested, at least in part, because decisions matter. Fortunes can be made, elections won, or lives saved, if the "right" decisions are made. If not, all can be lost. While every decision is not so momentous, the study of this topic is clearly of practical importance.

The process of decision making is complicated by the presence of uncertainty. Lacking clairvoyance, one can not be fully certain of all the consequences of a choice. Even the act of choosing a can of cola from a machine can be fraught with uncertainty regarding receipt of the soda, correct labelling, accurate pricing, consistent taste, and product safety. When uncertainty surrounds a decision that matters, the situation is generally considered "risky," particularly when a possible loss is involved (Yates & Stone, 1992).

Despite the functional importance of making appropriate decisions, research has found that choices made in risky situations are often less than rational (e.g, Neumann & Politser, 1992, p. 29; Tversky & Kahneman, 1981). This may stem in part from individual differences in the appreciation of risk. The assessment of risk appears to include subjective, rather than exclusively objective, factors. As stated by Yates and Stone (1992), "what is considered a loss is peculiar to the person concerned, and so is the significance of that loss and its chance of occurring" (p. 5).

If risk assessment is to some degree subjective, it should not be surprising that individuals often differ from one another in the choices they make, even under similar circumstances. Gamblers, for example, display a variety of betting patterns. Many increase the size of their wagers after losing (even when betting outcomes are relatively independent of one another). While this pattern is known as the "gambler's fallacy," not all gamblers display it. In fact, some bet more while winning than while losing (Wagenaar, 1988, p. 30). The reasons for this sort of variability are not well understood. In fact, throughout the literature on risky decision making, there has been relatively little focus on individual differences, though a number of authors have recently suggested that greater emphasis be placed upon examining this potential source of variance (Bromiley & Curley, 1992; Schneider & Lopes, 1986, Yates, 1992).[1]

The present investigation attempted to address the issue of individual differences by examining risky decision making from the standpoint of Cloninger's (1986, 1987a) unified biosocial theory of personality. Cloninger's theory appears relevant because the personality dimensions he identified are somewhat similar to variables thought to be important in decision making. Models of decision making, as implied by earlier comments, typically include the dimensions of loss, gain, and uncertainty/probability, (e.g., Kahneman & Tversky, 1979). Cloninger's dimensions are based upon tendencies to respond to particular environmental circumstances. The dimensions are: **Novelty Seeking** (novel stimuli or cues of potential reward or potential relief from punishment), **Harm Avoidance** (aversive stimuli), and **Reward Dependence** (signals of reward, particularly social reward). In addition, a four factor version of the theory includes the dimension of **Persistence**, which is defined as the maintenance of behavior previously associated with reward or relief from punishment. While

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[1] Studies which have examined individual differences will be reviewed at a later point in the introduction (e.g., Dickerson, Cunningham, Legg, & Hinchy, 1991; Kogan & Wallach, 1964; Schneider & Lopes, 1986; Wagenaar, 1988; Zuckerman, 1979). For further discussion of individual differences, see Bromiley & Curley, 1992, p. 125; Fischoff, 1992; Yates, 1992, p. 323.

Persistence formed part of the original Reward Dependence dimension, it has been purported to comprise an additional separate dimension (e.g., Waller, Lilienfeld, Tellegen, & Likken, 1991). Data from the present investigation appeared to support this view. Persistence may relate in part to the "framing," or contextual, effects which are also thought to affect decision making (Tversky and Kahneman, 1981).

The following sections will expand upon the introductory comments above by examining relevant literature in both decision making and personality. Efforts will be made to integrate data from these two domains. Arising out of this integration are the issues of the present investigation, which in turn lead to a set of guiding hypotheses.

B. Decision Making

The ubiquity of choice has lead an number of theorists to emphasize its central place in psychology (e.g., Miller, Galanter, & Pribram, 1960/1986, p. 62; Rachlin, 1989, p. 119). In one of the seminal contributions to cognitive psychology, "Plans and the Structure of Behavior," Miller, Galanter, and Pribram (1960/1986) stated that, "so long as people are behaving, <u>some</u> Plan or other must be executed. The question thus moves from <u>why</u> Plans are executed to a concern for <u>which</u> Plans are executed," and this is the "problem of choice" (p. 62). From the behavioral perspective, Rachlin (1989) stated that all voluntary behavior can be conceived of as choice behavior, that even a single operant can be viewed as "a choice between responding and not responding" (p. 119).

Despite the ubiquity and importance of choice, previous research has made it clear that people are limited in their decision making abilities (Neumann & Politser, 1992, p. 28). For example, people's choices can often be dramatically altered by subtle changes in the way that the alternatives are presented (Tversky & Kahneman, 1981; this issue will be expanded upon below). The recognition of this imperfection is reflected in the development of three related branches of decision making research (Fischhoff, 1992, p. 138). The first is **normative** theory. The emphasis here is upon the creation of appropriate procedures for making decisions. The second is **descriptive** theory, which describes how people actually make decisions. The third is **prescriptive** theory, which attempts to bridge the gap between the first two areas and help people make better decisions (see Fischhoff, 1992, p. 138, for references).

Judgement and choice involve complex cognitive processes. The process of decision making is not simply a matter of forming an objective internal representation of reality and then proceeding to make a choice. Instead, internal representations are subjective, arising from an interaction between the individual and his or her environment. For example, a gift of $10 would probably be valued less by a prince than by a pauper. The subjective nature of decision making is also underscored by the important work of Tversky and Kahneman (e.g., 1981), which makes it clear that individuals can be influenced simply by the way in which a decision problem is presented. The presentation, by altering the context or framing the situation, can significantly impact decision making.

B1. Subjective Losses and Gains

In deciding between two alternatives, one interesting question is the degree to which one is preferred over the other (Rachlin, 1989). Almost everyone would agree that $20 is preferable to 10$. They would probably also agree that $1,010 is better than $1,000. However, the degree (the strength) of preference for $20 over $10 tends to be greater than the preference for $1,010 over $1,000. While both situations involve a difference of $10, the difference is of more consequence in the first situation than in the second. Similarly, a $10 dollar discount is more likely to influence the purchase of a $30 pair of pants than a $30,000 car. The idea that equal differences between alternatives are not always equally appreciated, has been understood for some time. The mathematician Daniel Bernoulli (1738/1954) and the economist Jeremy Bentham (1823/1968) pointed out that the subjective value people place upon most goods increases with an additive increase in amount (e.g., + $10), but at a rate that tapers off as the person accumulates more of the good. Thus, returning to the first example, the subjective increase in value from $10 to $20 is more than that from $1,000 to $1,010. Likewise, a raise of $2.00 an hour is likely to be appreciated more by a worker who currently receives $8.00 an hour, than by one who receives $80.00. The subjective value (known as "**utility**") that a person places upon a good may differ from its objective amount. People tend to display decreasing sensitivity to changes in amount as the overall amount is additively increased.[2]

The subjective value of an alternative in a decision situation depends not only upon the accumulation of goods, but also upon the outcome to which it is compared, the **reference outcome**, or **reference** (Kahneman & Tversky, 1979; Yates & Stone, 1992, p. 7). At the broadest level of analysis, an alternative that a person prefers to the

[2] This relationship between subjective value and objective amount is analogous to that found in psychophysics between subjective perceptual sensitivity and stimulus intensity (Rachlin, 1989, p. 82, Stevens, 1957).

reference is considered a gain, and an alternative that is less preferred to the reference is a loss. Compared to a reference of $10, an alternative of $20 would be considered a gain, and one of $5 would be a loss. Yates and Stone (1992) point out that a variety of references are possible and that the choice is up to the individual. References can be based upon past or present circumstances, or upon future expectations. The past and present circumstances can be those of the individual or those of others in similar situations. The future expectations can be those of the individual or of others important to the individual (e.g., parents, or a spouse). The references can be based upon a minimum standard, an average attainment, or the best of all possible worlds.

It is easy to see that a change of reference can make the difference in how an alternative is perceived. For example, a year end bonus of $3000 would be considered a gain if compared to a person's present wealth. But the person would probably consider the $3000 a loss if he/she had been expecting $5000. In a recent series of studies, Diener and his colleagues (Diener, Colvin, Pavot, & Allman, 1991) found that affective states can serve as a contextual reference. They found that an experience of intense positive affect made later experiences feel more negative, in part because the latter were compared to the former.

Consistent with the latter results. Kahneman and Tversky (1979) argue that individuals change their subjective value references over time as they adapt to the changing circumstances of their lives. The latter authors compare the process to that involved in perception. A given temperature can be considered hot or cold depending upon the temperature to which the individual has adapted. Likewise, "the same level of wealth, for example, may imply abject poverty for one person and great riches for another - depending upon their current assets" (p. 277).

The subjective nature of value is also evident in the variety of types of losses and gains that can be considered for any alternative. The choice of what to eat for lunch might entail considerations of time, money, taste, cardiac functioning, and physical attractiveness (the latter relating to either the food or the person).

The description of value above has been primarily derived from a cognitive perspective, in which the estimation of value is an internal intermediate state that takes place before a decision is made. However, behaviorists also view value as both subjective and relative. Rachlin (1989, p. 157) states that value is the "key subjective variable" in behavioral theory. From this perspective, reinforcement is analogous to gain, and punishment to loss. Rachlin also states that Premack's (1971) relativistic theory of reinforcement, or some modification of it, is generally accepted as the best solution to defining reinforcement (Rachlin, 1989, p. 123). Premack views all reinforcers as being associated with consummatory responses (e.g., food with eating, water with drinking). The relative value of reinforcers is determined in situations where individuals are given the choice between consummatory responses. The response chosen is presumed to be the more highly valued. In this fashion, reinforcers can be placed upon a scale of value. A consummatory act that is more highly valued can be used to reinforce one which is less valued. Each alternative provides a reference for others. Value on Premack's scale, however, is not entirely stable. Deprivation and satiation can alter value of an alternative. For example, the value of a reinforcer can be increased by depriving the subject of the opportunity to engage in it over a period of time. Premack (1971, p. 139) found that among rats, drinking water was preferred to running on a wheel when rats were water deprived for 23 hours, but that running was preferred to drinking otherwise.

B2. Subjective Uncertainty

Decision making would be far easier were it not for uncertainty. Unfortunately, this factor accompanies the vast majority of life's decisions. Uncertainty assumes practical importance because of its relevance for gains and losses. The outcome of a coin toss is trivial unless there is some sort of significant expected consequence (a gain and/or loss) for the individual considering it.

Situations in which uncertainty exists are often thought of as "risky." While there is some disagreement as to the definition of risk, Yates and Stone (1992, p. 4) argue that there is a common underlying construct to most conceptions of the term, and that it is based upon the common dictionary definition of risk as, "the possibility of loss" (loss itself is to some extent subjectively determined, as discussed above). They further refine the term by proposing three critical elements: 1) potential losses, 2) the significance of those losses, and 3) their uncertainty. While gains would appear to be left out of the matter, the earlier discussion of losses and gains should make it evident that losses are only losses in reference to some other more desirable outcome, a gain. It is therefore reasonable to see risk as arising from a combination of loss, gain, and uncertainty.

There are actually a variety of forms of uncertainty surrounding a decision situation. Consider the following examples adapted from Yates and Stone (1992, pp. 11-16).

There is uncertainty about the kinds of outcomes that are possible, uncertainty about whether a particular outcome will occur (this is often estimated as a probability, e.g., 25%), and uncertainty about the quality of a particular probability estimate. Each of these aspects is subjectively perceived. Each will be discussed in turn in the following paragraphs.

People generally do not take into account all of the possible outcomes of their decisions, especially outcomes that are of very low probability. A person deciding to eat a can of soup may not consider the possibility of food poisoning. A person moving to a new city may not ponder the development of lifelong friendships. A person visiting a popular urban landmark may not anticipate the possibility of terrorism. Specialized knowledge, previous experience, and emotional disposition are only some of the subjective factors which make some people better anticipators than others, at least under certain circumstances. Some are paid for their abilities, employed as insurance agents, risk analysts, or genetic counsellors.

Even when a particular outcome is anticipated as a possibility, there is still uncertainty as to whether it will in fact occur. Estimates of probability can be used in such cases to quantify the level of uncertainty surrounding a particular outcome. A number of methods make use of probability estimates in an attempt to help individuals make rational decisions under such conditions. Consider the following example (adapted from Rachlin 1989, p. 93). A person is offered an opportunity to buy a lottery ticket with a 1/1,200,000 chance to win $1,000,000 at a cost of $1. The expected value of choosing to buy the ticket is the expected amount of money that would be gained or lost by buying a very large number of such tickets. This can then be compared with the expected value of not buying a ticket. The expected value of each choice equals the sum of its associated outcomes multiplied by the probability of the outcome's occurrence. The expected value of buying the ticket equals -$0.17 (-$0.17 = (1/1,200,00 x $1,000,000) + (1/1 x -$1.00)). The expected value of not buying the ticket equals 0 (0 = (1.00 x 0); though to be more complete one would also include the value of what was done with the $1.00 instead). Based upon expected value, no one should ever buy a lottery ticket. The popularity of lotteries powerfully disconfirms this conclusion, and indicates that other, and perhaps subjective, processes are at work.[3]

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[3] The substitution of utility for amount, as discussed above in the section on losses and gains, only makes the choice to buy a lottery ticket less inviting. If an individual's sensitivity to changes in amount decreases as the overall amount increases, then the utility of winning $1,000,000 would be worth less than its dollar amount. This would mean that the expected utility of buying a ticket would be even less than its expected value.

Another form of uncertainty surrounds the firmness of a probability estimate. For example, an estimate that is based upon many observations of relevant circumstances is better than one based upon just a few observations, all else being equal. Yet individuals, including psychologists, have been shown to be somewhat lacking in sensitivity to such differences in the quality of information (Kahneman and Tversky, 1972).[4]

Just as uncertainty is subjectively experienced, so is the related concept of familiarity. In an interesting series of experiments, Langer (1975) found that the manipulation of a number of variables related to familiarity could affect betting confidence. Based upon the premise that increased familiarity increases feelings of control in skill-based situations, she increased aspects of subjects' familiarity during chance-based decisions (e.g., choosing a lottery ticket) and induced in them the "illusion

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[4] For example, the following problem was presented to Stanford University students:

> A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50% of all babies are boys. The exact percentage of baby boys, however, varies from day to day. Sometimes it may be higher than 50%, sometimes lower.
>
> For a period of 1 year, each hospital recorded the days on which (more/less) than 60% of the babies born were boys. Which hospital do you think recorded more such days? (p. 443).

The majority of subjects responded that both hospitals would have about the same number of such days, despite the fact that there should be larger fluctuations in the smaller hospital's birth rate.

of control." These aspects included time spent thinking about the task, familiarity with the stimuli (e.g., letters of the alphabet vs. novel visual symbols), and practice in responding (even though practice was unrelated to success on the task since it was truly chance-based).

B3. Losses and Gains are Often Treated Differently

Losses and gains are often treated differently in decision making. Discussion of this issue was delayed until this point because uncertainty is considered one of the determinants of the difference. Consider the following examples from Tversky and Kahneman (1981, p. 453, problems 1 and 2). Two groups of subjects were given the following scenario:

> Imagine that the U.S. is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs are as follows:

One group of subjects was given the following choice (Problem 1):

> If Program A is adopted, 200 people will be saved.
>
> If Program B is adopted, there is 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved.

The second group of subjects was given the following choice (Problem 2):

> If Program C is adopted 400 people will die.
>
> If Program D is adopted there is 1/3 probability that nobody will die, and 2/3 probability that 600 people will die.

It can be seen that the two problems are identical, except that problem 1 is framed as 'saving lives,' and problem 2 as 'avoiding death.' However, this framing produced powerful effects. In problem 1, the prospect of surely saving 200 people from the disease was preferred by most people (72 percent) to the 1/3 chance of saving all 600. In problem 2 the certain death of 400 people was less preferred (22 percent) than the 1/3 chance that no one will die. This intriguing pattern of results is a vivid example of a broad and robust observation that most people tend to be more willing to take risks to avoid losses (like death), than to obtain gains (like saving lives) (Kahneman & Tversky, 1984, p. 342).[5]

The tendency for choices involving risky gains to be the mirror image of those involving risky losses of the same size, has been termed the "reflection effect" by Kahneman and Tversky (1979, p. 268). For example, they found that in hypothetical decisions 80 percent of individuals preferred a sure win of 3000 Israeli pounds to an 80 percent chance of winning 4000 (median monthly income for an Israeli family at the time was 3000 pounds). In contrast, only 8 percent of subjects preferred a sure loss of 3000 to an 80 percent chance of losing 4000 (It should clear from a discussion of these results that the "reflection effect," does not flawlessly describe the relationship between decisions for losses and gains, but rather provides an approximation).

[5] Interestingly, this pattern can be reversed when people are dealing with highly unlikely outcomes. In such cases, most people tend to be risk seeking with regard to improbable gains, like those involved in buying a lottery ticket, and risk averse with regard to improbable losses, such as those avoided by buying insurance policies (Kahneman & Tversky, 1984, p. 345). Even such cases, however, are consistent with the notion that losses and gains are treated differently by most people.

Similar patterns can also be discerned in real life situations. Kahneman and Tversky (1984, p. 346) present an example from the world of business and politics. They cite Thaler (1980) who noted that lobbyists for the credit card industry insisted that any price difference between cash and credit card purchases be labelled as a "cash discount" rather than a "credit card surcharge." Kahneman and Tversky note that the two labels create different frames of reference for the price difference, frames which in turn have important effects upon consumer behavior. Labelling the credit card price as a surcharge, implies that the cash price is normal, and that the credit card price involves a <u>loss</u> of additional money. In contrast, labelling the cash price as a discount, implies that the credit card price is normal, and the cash price is a <u>gain</u> in the form of money saved. "Because losses loom larger than gains, consumers are less likely to accept a surcharge than to forego a discount" (p. 346).

Another relevant real world example is a phenomenon known as "escalation," which describes a tendency to be risk seeking in order to avoid losses. In an escalation situation, an individual (or an organization) becomes overly committed to a losing course of action (e.g., Staw and Ross, 1989). Faced with mounting losses, efforts to maintain the present course of action are escalated. Rather than *changing course, the present strategy is continued with* increased effort. This course of action often results in throwing good money after bad.

The "gambler's fallacy," a primary focus of the present investigation, is another example of the way in which people often treat losses and gains differently. The phenomenon refers to the tendency of many gamblers to increase risk taking after losing, even when betting outcomes are relatively independent of one another. Even though the objective odds of winning in most games of chance (e.g., blackjack, roulette) are basically the same whether one has just won or lost, many gamblers choose to make larger and/or riskier bets just after losing. Real life and laboratory studies tend to confirm the presence of the gambler's fallacy pattern among many gamblers (Edwards, 1954; Leopard, 1978; Morgan, 1983, Wagenaar, 1988), though this tendency is far from universal (the issue of individual differences is of central to the present investigation and will be discussed in greater detail in a later section) (Leopard, 1978; Wagenaar, 1988).[6]

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[6] It is implied in the above discussion that negative outcomes are often treated as more consequential than those which are positive (though this pattern is certainly not universal, *either across all situations or people).* Why might this be the case? The answer may lie in the functional importance (utility) of their attendant emotions. Frijda (1988) made such an argument in positing "the law of hedonic asymmetry", which states that individuals always habituate to pleasure, but pain persists as long as the adverse conditions. He regarded this law as necessary

B4. Positive and Negative Affect as Separate Dimensions

The fact that losses and gains are treated differently in decision making may indicate that evaluations of each arise from separate systems which only later tend to combine in our awareness and behavior. Consistent with this view are findings that positive and negative emotions (which often accompany gains and losses) may be separable. Watson and Tellegen (1985) found evidence that positive affect and negative affect form two independent factors, rather than opposite sides of a single dimension. In a reanalysis of a large number of earlier studies of self-reported mood, they found that positive and negative affect consistently emerged as the first two factors (from orthogonal and oblique solutions). They operationalized these dimensions on the

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because "emotions exist for the sake of signaling states of the world that have to be responded to or that no longer need response and action. Once the 'no more action needed' signal has sounded, the signaling system can be switched off; there is no further need for it" (p. 354). Survival demands that highly aversive stimuli remain in focus. Frijda qualified his statements, however, by stating that the hedonic law is not unavoidable, making the point that the intensity and duration of emotions are subject to the effects of framing (e.g., positive emotions can be rekindled through recollection).

This general view has also been expressed by others. Sokolov's (1963) classic work indicated that painful stimulation can lead to a "defensive reaction" which is nonhabituating, as opposed to the "orienting" and "adaptation reflexes" which accompany novel and other sorts of stimuli, and to which habituation occurs (p. 546). Coombs and Avrunin (1977), in their theory of preference, go even further than Frijda and say that "good things satiate and bad things escalate" (p.224).

Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988). Positive affect is composed of the following adjectives: attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong, active. Negative affect is measured by the following: distressed, upset, hostile, irritable, scared, afraid, ashamed, guilty, nervous, jittery. These dimensions were basically uncorrelated with one another, and differentially correlated with other aspects of life. For example, perceived stress was related to negative affect only, while social activity was more highly related to positive than to negative affect (Watson, 1988).[7]

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[7] It should be noted, however, that the independence of the dimensions depends upon the choice of descriptors; not all positive and negative adjectives are the same, and not all are independent of one another. Diener and colleagues have found that some positive and negative mood terms form a single dimension called hedonic level (Diener, Larsen, Levine, & Emmons, 1985; Larsen & Diener, 1985; this dimension has been called Pleasantness-Unpleasantness by others, e.g, Meyer & Shack, p. 692; Watson & Tellegen, 1985, p. 233). The positive end of this dimension is represented by words such as happy, joyful, and pleased, while the negative end includes unhappy, depressed, and blue. Diener's second dimension is affect intensity, which involves the strength of emotional reaction to both positive and negative events, and is independent from hedonic level. It is to some extent similar to Cloninger's personality dimension of Novelty Seeking. For further discussion of this approach to organizing affect see Meyer & Shack, p. 692; Watson & Tellegen, 1985, p. 233. See also a recent criticism of Diener's view (Cooper & Conville, 1992).

C. Personality

C1. Individual Differences in Decision Making

Casual observers are aware that people differ from one another both in their emotional and behavioral responses to situations. Studies finding differences in choice during decision making situations provide support for this view. Phenomena such as the reflection effect and the gambler's fallacy, while common, are not found among all individuals (e.g., Leopard, 1978; Schneider & Lopes, 1986, Wagenaar, 1988). For example, Leopard (1978) found in a laboratory experiment that approximately 2/3 of subjects significantly varied their risk taking behavior according to the immediately preceding series of wins or losses. Most who did alter their pattern tended to display the gambler's fallacy by increasing their risk taking with an increasing number of consecutive losses, but others displayed other patterns, including the exact opposite. In a naturalistic study of casino blackjack gamblers, Wagenaar (1988, p. 30) found that only about half changed their bets in accordance with previous outcomes. Approximately half of those who changed displayed the gambler's fallacy, while the others displayed the opposite pattern of betting more while on a winning streak.

Explanations have been proposed both for the gambler's fallacy and for its opposite, streak betting. For example, Tversky and Kahneman (1971) stated that the gambler's fallacy stems from a mistaken belief about the laws of chance, a belief termed the "law of small numbers." When a gambler perceives that the proportion of wins or losses in a short series has strayed from the overall expected ratio in an infinitely long series, he/she expects a corrective bias in the other direction. For example,

> the gambler feels that the fairness of the coin entitles him to expect that any deviation in one direction will soon be canceled by a corresponding deviation in the other. Even the fairest of coins, however, given the limitations of its memory and moral sense, cannot be as fair as the gambler expects it to be. (p. 106)

Regarding streak betting, Wagenaar (1988) stated that personal interviews with gamblers displaying the pattern revealed that they believe in periods of good and bad luck. "If one is winning, one should increase one's bets in order to use the period of good luck. When one is losing, bets should be decreased to a minimum, because one might experience a period of bad luck" (p. 30).

The above explanations attempt to characterize group behavior, but they do not specify which individuals will display which gambling pattern. In fact, throughout the literature on risky decision making, there have been relatively few attempts to explain individual differences (For a discussion of this issue, see Yates, 1992, p. 323; Bromiley & Curley, 1992, p. 125; Fischoff, 1992. Exceptions include Kogan & Wallach, 1964; Schneider & Lopes, 1986). Much of the research on individual differences which has been done has focussed upon the relationship between decision making and demographic variables such as age, gender, race, marital status, occupation, socioeconomic status, and culture (see recent reviews by Bromiley & Curley, 1992; Fischoff, 1992). However, a finding that one of these factors is related to risk taking does not explain why that should be the case. A number of authors have suggested that greater emphasis be placed upon explanatory factors (Bromiley & Curley, 1992; Fischoff, 1992; Schneider & Lopes, 1986, Yates, 1992, p. 323).

C2. Personality and Decision Making

The goal of the present investigation was to examine whether differences in patterns of risky decision making are associated with differences in the evaluation of key variables such as gain, loss, and uncertainty. Similar approaches have been taken by a number of other researchers. For example, Lopes (1984; 1987, p. 275) hypothesized that there are two motivations at work in risky decision making. One is the desire for security (safety), and the other the desire for potential. Risk averse people are motivated by the former, and tend to pay most attention to the worst possible outcomes in a situation. Risk seekers, in contrast, are motivated by the desire for potential, and attend most to the best possible outcomes. A study of two highly selected groups of subjects, each chosen to represent one of the two extremes, provided support for this view (Schneider & Lopes, 1986).[8] In a choice among pairs of hypothetical multioutcome lotteries (i.e., each lottery contained more than two possible outcomes, e.g., the possibility of winning $0, $13, $26,...$200) risk averse subjects tended to prefer lotteries which guaranteed a minimal gain to those which did not, even if the latter offered larger maximum possible wins. However, risk seekers tended to prefer lotteries with the highest possible gains, even if such gains were relatively improbable.

A similar motivational theory has been posited by Atkinson, McClelland, and their colleagues (e.g., Atkinson, 1958; Atkinson & Litwin, 1960; McClelland, 1958).

[8] 30 subjects were selected for each group from an initial sample of 1382. They were selected based upon their responses to five Kahneman and Tversky (1979) type hypothetical decision problems involving the choice between a risky gain and a sure gain. Risk averse subjects chose the sure gain all five times. Risk seekers chose the risky choice at least four out of five times.

Individuals are posited to be motivated by two separate desires, achieving success and avoiding failure. According to this model, the appeal of an alternative is dependent upon the person's particular levels of each motivation. The theory predicts and empirical evidence has supported (though, more clearly for skilled than chance tasks) the contention that

> subjects whose achievement motive is higher than their motive to avoid failure will prefer intermediate risks: They desire challenging tasks at which success is possible. Subjects with a higher failure-avoidance motive relative to the achievement motive tend to prefer either high- or low-risk tasks. They want either success or failure to be ensured, removing the onus of failure from themselves" (Bromiley & Curley, 1992, p. 98).

For example, on a ring toss game, individuals with relatively higher achievement motives tended to toss from an intermediate distance, while those higher in failure-avoidance were more likely to toss from close up or from far away (Atkinson & Litwin, 1960).

Zuckerman's trait of sensation seeking provides another related perspective on risky decision making (1990). The trait is characterized as the need for varied, novel, intense, and complex experiences and sensations, and the willingness to take physical and social risks for the sake of such experience (1990, p. 313). Zuckerman suggested that sensation seeking and its opposite, sensation avoidance, represent the two alternative behavioral responses to novel stimuli which evolved as a function of their adaptive value for survival and reproductive fitness. Sensation seeking is represented by approach behavior directed towards obtaining food, shelter, and mates, while sensation avoidance involves withdrawal (avoidance) behaviors such as freezing, huddling, and flight (p. 314).

The Sensation Seeking Scale, a measure of Zuckerman's concept is in its fifth revision (SSS V) (Zuckerman, 1979). It is composed of four subscales: Thrill and Adventure Seeking, Experience Seeking, Disinhibition, and Boredom Susceptibility. Though they are all considered to be indicative of sensation seeking, the subscales are not highly correlated with one another, with levels ranging from .06 to .48 (Zuckerman, Eysenck, & Eysenck, 1978). The heterogeneity of the subscales calls into question the notion of a single trait of sensation seeking as measured by the SSS V.

Despite the above results, sensation seeking, or at least some of its subscales, have been related to a variety of risky activities such as multidrug use, physically dangerous sports, greater sexual activity, and volunteering for unusual experiments (Campbell, Tyrrell, & Zingaro, 1993; Horvath & Zuckerman, 1992; see review by Zuckerman, Buchsbaum, & Murphy, 1980). However, with regard to real gambling behavior, the picture is less supportive (reviewed by Dickerson, Hinchy, & Fabre, 1987, p. 674). A number of studies have found that gamblers do not differ from normals in mean level of sensation seeking (Anderson, & Brown, 1984; Dickerson, et al., 1987). Among gamblers, studies have found that sensation seeking was related to larger bet size (Anderson & Brown, 1984, Dickerson, et al., 1987), but not to persistence in gambling when losing (Dickerson, Cunningham, Legg, & Hinchy, 1991).

Atkinson (Atkinson, & Litwin, 1960), Lopes (1987), and Zuckerman (1990) all present motivational accounts of risk taking, and all mention both positive (achieving success - Atkinson, potential - Lopes, approach - Zuckerman) and negative (avoiding failure - Atkinson, security - Lopes, withdrawal - Zuckerman) components. There appear to be differences, however, in the implicit relationships between the components. Zuckerman (1990) views sensation seeking and sensation avoidance as "extremes of a continuous behavioral trait dimension" (p. 314). Implicit in Zuckerman's statement is a view of positive and negative components as forming a single dimension of value. Lopes

(1987) appears to agree on this general point, stating that her hypothesized positive and negative motives form a single factor (p. 275).[9] Atkinson, in contrast, by measuring each motive separately and thereby allowing for any combination of the two to be present in a particular person, appears to imply that the two are separate (Atkinson & Litwin, 1960).

In addition to trait dimensions such as those discussed above which relate specifically to decision making, other more general personality traits have also been related to such behavior. One of the most influential theories of personality is that H. J. Eysenck (Eysenck & Eysenck, 1985). While the theory has been modified over the years (see Brody, 1988, p. 103) the current view is that there are three broad unrelated dimensions of personality (which are measured by the Eysenck Personality Questionnaire - EPQ): Extraversion, Neuroticism, and Psychoticism. Each is comprised of more specific characteristics. Individuals high in Extraversion are "sociable, lively, active, assertive, sensation-seeking, carefree, dominant, surgent, and venturesome" (Brody, 1988, p. 104). Those high in Neuroticism, have characteristics such as "anxious, depressed, tense, irrational, shy, moody, and emotional" (Brody, 1988, p. 104). Persons high is Psychoticism are

[9] However, she entertained the possibility that the two were separable in an earlier article (Lopes, 1984, p. 482)

described as "aggressive, cold, egocentric, impersonal, impulsive, antisocial, unempathic, creative, and tough-minded" (Brody, 1988, pp. 103-104).

The relationship of Eysenck's dimensions to gambling appears to be somewhat complex. For example, Roy and his colleagues found that pathological gamblers (meeting DSM III criteria) had higher Psychoticism and Neuroticism scores than controls (Roy, Custer, Lorenz, & Linnoila, 1989). However, other studies by this group found that pathological gamblers were higher than normals on indices of noradrenergic functioning (Roy, et al., 1988) and that these indices were positively correlated with the Extraversion scale among the gamblers (Roy, De Jong, & Linnoila, 1989). A recent study of normals by a separate group found that none of Eysenck's dimensions were related to level of involvement in gambling or persistence when losing (Dickerson, et al., 1991).

C3. The Big Five

While Eysenck's theory has certainly been influential in the field of personality, it is also true that there is no shortage of alternatives (e.g., Gray, 1983; Tellegen, 1985; John, 1990). John (1990) recently characterized the state of personality assessment in the following way.

"Researchers, as well as practitioners in the field of personality assessment, are faced with a bewildering array of personality scales from which to choose, with little guidance and no overall rationale at hand" (p. 66). One popular approach to integrating the field, and the one supported by John, is the use of a descriptive model called the "Big Five" (e.g., see recent reviews by Digman, 1990; John, 1990). The Big five personality factors were empirically derived from the analysis of a relatively exhaustive set of natural-language terms (starting with unabridged dictionaries; and including independent sets of terms used by different investigators) which people use to describe themselves and others. This "lexical" approach was guided by the "assumption that native speakers would have evolved words for all important individual differences" (McCrae & Costa, 1989, p. 23). While there remain some minor disagreements regarding labelling and interpretation, especially regarding the fifth factor (McCrae & Costa, 1985a; John, 1990), the dimensions have been largely replicated by numerous investigators (e.g., Norman, 1963; McCrae & Costa, 1985a), and in other cultures and languages (e.g., Japan, The Philippines, Hong Kong; Bond, 1979; Church & Katigbak, 1989).

The most common labels for the Big Five are those of Norman (1963), and they are as follows: Surgency, Agreeableness, Conscientiousness, Emotional Stability, and Culture. John (1990, p. 80) reported prototypic, highly loading terms for high and low levels of each dimension. Persons high on factor 1, Surgency (another common term for this factor is **Extraversion**, and that will be the label used here in this paper) were referred to as talkative, assertive, active, and energetic. Those low in factor 1 were quiet, reserved, and shy. High levels of factor 2, **Agreeableness**, involved the terms sympathetic, kind, appreciative, and affectionate. Low levels included terms such as fault-finding, cold, unfriendly, and quarrelsome. Persons high on **Conscientiousness**, factor 3, were called organized, thorough, planful, and efficient. Those who are low were described as careless, disorderly, frivolous, and irresponsible. For high levels of factor 4, Emotional Stability (low levels often called **Neuroticism**, and that will be the label used here), there were no terms which loaded highly, though stable and calm (factor loadings of .39 and .35, respectively) came closest. In contrast there were a number of highly loading items for persons low in the fourth factor, including tense, anxious, nervous, and moody. Highly loading terms for high levels of the last factor, **Culture** (also called Openness to Experience and/or Intelligence), were typified by imaginative, wide interests, intelligent, and original, while some of the terms low on the last factor were commonplace, narrow interests, simple and shallow.[10]

While there is substantial agreement regarding the Big Five as a description of personality, there is a lack of explanation of their underlying processes and structures (Digman, 1990, p. 432; John, 1990, p. 95, Revelle, 1987, p. 437). The difficulty is much the same as that mentioned above for demographic variables. The Big Five model is largely atheoretical in nature. Derived from empirical observation, it describes surface manifestations of individual differences primarily from the view of the lay observer. It describes what dimensions appear to be important to people. In contrast, little is known about how or why they are important (Revelle, 1987, p. 437; but see Buss, 1991).[11]

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[10] A helpful mnemonic device for recalling the Big Five was suggested to John (1990, p. 95-96) by Robert McCrae. It relies upon an anagram for the word "ocean", suggesting an OCEAN of personality dimensions:

E: Extraversion, Energy, Enthusiasm (I)
A: Agreeableness, Altruism, Affection (II)
C: Conscientiousness, Control, Constraint (III)
N: Neuroticism, Negative Affectivity, Nervousness (IV)
O: Openness, Originality, Open-Mindedness (V)

[11] There has been some recent movement in the direction of explaining why the dimensions are important. Buss (1991) posits that from an evolutionary standpoint, the Big Five represent important dimensions of the social landscape to which humans need to attend and act upon. They provide information with important ramifications for survival and reproductive success, such as: "Who is high or low in the social hierarchy? . . . Whom can I trust? Whom will betray my trust? . . . Whom can I depend upon when in need? With whom should I mate?" (p. 472). However, even if the

C4. Comparing Models of Personality

At the present time the Big Five model can serve as a descriptive framework within which to examine other models of personality (McCrae & Costa, 1987, p. 89). It provides a common language to which other models can be compared. Using the Big Five as a framework, it is possible to examine commonalities between different models at the phenotypic level. Similarities are most apparent for factors 1 (Extraversion) and 4 (Neuroticism). A number of researchers emphasize the importance of three general dimensions (rather than five), two of which can be reconciled with factors 1 and 4.[12] There is less agreement, however, on the third dimension (Gray, 1987a; Tellegen, 1985; Zuckerman, Kuhlman, & Camac, 1988; see discussions of this issue by Cloninger, Przybeck, & Svrakic, 1991, p. 1047; Digman, 1990, p. 429;

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dimensions are proven to be important, there is still the matter of understanding how the dimensions arise, the mechanisms and structures underlying the Big Five. For example, the evaluation of whom to trust may be depend upon general systems of information processing, which are not specific to the processing of information about human beings.

[12] The choice of a number of factors at the descriptive level depends to some extent upon the particular aims of the theorist (Zuckerman, Kuhlman, Camac, 1988, p. 96). A large number of specific factors is preferable in predicting behavior in particular situations, while a smaller number of factors provides a broader, more general perspective upon individual differences. Many theorists, particularly those from a biopsychological perspective, prefer a broad three factor solution to the Big Five.

John, 1990, p. 91). The following paragraphs summarize a few of these theories.

Returning to Eysenck's (1981) model, his dimensions of Extraversion and Neuroticism have been found to be quite similar to Big Five factors 1 and 4, respectively. There is less clarity with regard to Psychoticism, though it displayed weak to moderate negative correlations with the Big Five dimensions of Agreeableness and Conscientiousness (McCrae & Costa, 1985b).

Zuckerman's three dimensional model is similar to that of Eysenck's (Zuckerman, Kuhlman, Camac, 1988). Based upon the examination of a large number of personality questionnaires, he concluded that Eysenck's scales characterize each of the three dimensions relatively well (though examination of the data reveals that EPQ Extraversion and Neuroticism did contain weak, approximately .30, secondary loadings on each other's factor; p. 102). While, EPQ Psychoticism was clearly and cleanly loaded on the remaining factor, the overall makeup of the factor lead Zuckerman to posit an alternative conceptualization of the dimension, which he named Impulsive Unsocialized Sensation Seeking, P-ImpUSS for short. This factor is characterized as incorporating psychopathy, antisocial behavior, social deviance, and nonconformity (p. 104).

In contrast to Eysenck, Zuckerman, and the Big Five model itself, Gray (1982, 1983) suggested an alternative to the dimensions of Extraversion and Neuroticism. He noted, for example, that anti-anxiety drugs (such as benzodiazepines, barbiturates, and alcohol) affect both dimensions. These drugs increase scores on Extroversion while reducing them on Neuroticism. This led Gray to believe that Eysenck's dimensions do not reflect the underlying biological sources. He hypothesized that one of the biological sources is a dimension called Trait Anxiety (not surprising in light of the evidence regarding antianxiety drugs). A person high on the latter trait would be regarded as both Introverted and Neurotic. Gray proposed that Eysenck's dimensions of Extroversion and Neuroticism be rotated 45% to reflect the biological source dimensions of Trait Anxiety and a second orthogonal factor called Impulsivity. A person high in the latter would be described as Extroverted and Neurotic.[13]

Gray deemed that rotation of the dimensions was justified because factor analysis, from which Eysenck's dimensions arose, can only indicate the number of

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[13] More recently, Gray (1987, p. 186) has suggested a more complex rotation, in which he additionally relates his factors to Eysenck's third dimension of Psychoticism. A person high in Trait Anxiety is not only Neurotic and Introverted, but also low in Psychoticism. A person high in Impulsivity, is not only Neurotic, and Extroverted, but also high in Psychoticism.

independent factors, but not their location in space. Meyer and Shack (1989) compare this problem to,

> the confusion early cartographers would have faced had they not had knowledge of magnetism. In this situation it would have been agreed that the Earth could usefully be conceptualized on a two-dimensional plane. Without benefit of a compass, however, there would have been considerable disagreement as to what the essential or basic coordinates to this two-dimensional space should be. (p. 692)

Given the lack of a single, obvious, universally agreed upon criterion such as magnetism in the field of personality, Gray felt justified in using evidence such as drug effects to select an appropriate rotation.

Gray's dimensions of Trait Anxiety and Impulsivity are said to result from individual differences in sensitivity to conditioned signals of punishment and reward, respectively. Each is mediated by an underlying neurophysiological system. Sensitivity to reward signals is mediated by Behavioral Activation System (BAS), while sensitivity to signals of punishment is mediated the Behavioral Inhibition System (BIS). Gray (1987a) also posited a third dimension of personality, which is currently nameless, but which nonetheless results from sensitivity to unconditioned punishment, and is mediated by a third system called the

Fight/Flight System. Gray did not apologize for the namelessness of his last dimension, a dimension for which he said there are no good names at present (p. 185). This is a telling contrast between his biological approach and the lexical approach guiding the Big Five. Gray has not developed a questionnaire operationalizing his concepts.

Tellegen's (1985) model is most similar to Gray's (1987a), but it appears to have developed as a result of the integration of Tellegen's own work on emotions (Watson & Tellegen, 1985, see above). His personality model posits the existence of three independent broad dimensions (more specific traits are also described in this hierarchical model) called **Positive Emotionality, Negative Emotionality,** and **Constraint**; measured by the Multiple Personality Questionnaire - MPQ). The first two are said to be conceptually similar to Gray's Impulsivity and Trait Anxiety, respectively. Tellegen, however, objects to Gray's use of the term Impulsive to describe the Behavioral Activation System which is sensitive to signals of reward. Tellegen (1985) feels that Positive Emotionality is a better term for this dimension, and reserves the term impulsivity as a marker of low Constraint, his third dimension (p. 699). Recalling the discussion of emotions above, note the independence of positive and negative dimensions in both of Tellegen's models. Positive and negative personality traits, as well as emotional states, are seen as separate.[14] While Tellegen's two personality dimensions are thus conceptually more similar to Gray's than to Eysenck's, Tellegen (1985) found that Positive Emotionality and Negative Emotionality were substantially correlated with Eysenck's dimensions of Extroversion, and Neuroticism, respectively. This congruence, along with other evidence regarding the correspondence of mood state and personality trait measures, lead Tellegen to conclude that despite Eysenck's labels, Eysenck's two scales are actually better described as measuring Positive and Negative Emotionality.[15] Tellegen's third dimension is Constraint. Persons high on this latter dimension are cautious and restrained. They refrain from risky adventures and accept

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[14] In support of Tellegen's conception of relatively independent positive and negative emotional traits, there is evidence that traits of Optimism and Pessimism are separate, but related dimensions, as opposed to opposite ends of a single dimension. The two display differential relationships with measures of mood and personality (Marshall, Wortman, Kusulas, Hervig, & Vickers, 1992).

[15] The work of other researchers also bears upon this issue. Meyer and Shack (1989), examining the convergence of mood and personality, found that Extroversion converged with positive affect, and Neuroticism converged with negative affect (using mood measures slightly different, but similar to Watson & Tellegen's, 1985, PANAS). In addition, Larsen and Ketelaar (1991) presented experimental evidence that Extroverts (compared to introverts) are more responsive to positive mood induction, and Neurotics (compared to stable subjects) are more responsive to negative mood induction, though both dimensions were related to both types of mood induction.

the strictures of conventional morality. Constraint is negatively correlated with Eysenck's Psychoticism scale.

C5. Cloninger's Unified Biosocial Theory of Personality

Cloninger's unified biosocial theory of personality (1986, 1987a), the focus of the present investigation, bears some similarity to models reviewed above, particularly those of Gray and Tellegen. It contains three primary personality components. Cloninger posited that there are three genetically independent dimensions which mediate adaptive responses to particular types of stimuli. **Novelty Seeking** is defined as a tendency to respond with intense excitement to novel stimuli, or cues for potential rewards or potential relief of punishment. This tendency leads to frequent exploratory activity. **Harm Avoidance** is hypothesized to be a tendency to respond intensely to signals of aversive stimuli, and to learn to passively avoid punishment, novelty, and frustrative non-reward. **Reward Dependence** is proposed to be a tendency to respond intensely to signals of reward (especially social reward) and to maintain behavior previously associated with reward or with relief from punishment. Each of the dimensions is neurologically mediated by a separate brain system. Novelty Seeking is hypothesized to be mediated by Behavioral Activation, Harm Avoidance by Behavioral Inhibition, and Reward Dependence by

Behavioral Maintenance. At this level of generality the conceptual overlap with Gray and Tellegen is obvious. The following paragraphs attempt to further elucidate the particulars of the model. More specific comparisons of Cloninger's and other models will then be discussed.

C6. Genetic versus Phenotypic Structure of Personality

In developing his model, Cloninger (1986, 1987a) like Gray (1987a) and others (e.g., Meyer & Shack, 1989), made the point that factor analysis limits the number, but not the particular rotation of dimensions (p. 574). Cloninger, like the others, argued that traditional rotations such as Eysenck's were incorrect (see the earlier discussion of rotation in the section on Gray's theory). Faced with the problem of providing an adequate criterion for rotation (a magnetic compass for personality), Cloninger chose a biological one. "Genes and the biological systems that underlie personality cannot be arbitrarily rotated" (Cloninger, 1990, p. 241). However, "the phenotypic structure" (p. 241). This is because phenotypic behavior results not only from genotypic factors, but also reflects the effects of social learning and environmental factors. Cloninger's personality dimensions, while said to be inherited separately (e.g., Sigvardsson, Bohman, & Cloninger, 1987, p. 929), are expected to interact at the behavioral level because the same stimulus can trigger incompatible reactions from more than one system. For example, a novel stimulus may trigger both novelty seeking and harm avoidance. Such a situation would be hypothesized to induce approach from the novelty seeking system, and avoidance from the harm avoidance system. Harm avoidance is hypothesized by Cloninger to lead to a decrease in exploration of unfamiliar situations (i.e., reducing novelty seeking), and passive avoidance of punishment and non reward (i.e., reducing reward dependence). In addition, novelty seeking is hypothesized to lead to the initiation of unfamiliar activities which are potentially rewarding, thereby reducing the likelihood of maintenance of familiar activities which have been rewarded in the past (i.e., reducing reward dependence). The interaction of these three systems is hypothesized to provide an explanation of both normal personality and maladaptive traits such as anxiety disorders (Cloninger, 1986) and antisocial behavior (Sigvardsson, Bohman, & Cloninger, 1987).

Cloninger argued that other personality researchers have often failed to take into account the difference between phenotype and genotype, and thus do not adequately represent the underlying causal genetic factors. With regard to Eysenck's model, a recent multivariate item analysis of a large twin sample ($\underline{N}$ = 2903), found that

Psychoticism as measured on the EPQ was not heritable. While there were common genetic influences on items from the scale, they appeared to relate to a predisposition toward 'paranoid' behavior and attitudes (Heath, Eaves, & Martin, 1989, p. 886; Heath & Martin, 1990). With regard to the Big Five, Cloninger cites a study by Bergeman and colleagues indicating that Agreeableness and Conscientiousness showed little or no genetic transmission from parent to child (Cloninger, 1990, p. 242). The latter finding, however, cannot be fully evaluated because it appears that the Bergeman study, despite being submitted for publication in 1989, and mentioned in another article as in press in 1990, does not appear to have been published as of yet.

Given these and other limitations of models such as Eysenck's and the Big Five, Cloninger (1986, 1987a) developed an alternative, the unified biosocial theory of personality, synthesizing data from a variety of sources. The separate inheritance of each of the three dimensions which is predicted by his theory has not yet been tested in family studies (Cloninger, 1990, p. 249, though a study by Heath appears to be in progress based upon comments by Cloninger, Przybeck, & Svrakic, 1991, p. 1050), but there is evidence to support the utility of the overall model (e.g, Nixon, & Parsons, 1989; Sigvardsson, Bohman, & Cloninger, 1987). For example, ratings of 11 year old Swedish boys on

Cloninger's three dimensions were predictive of violent criminal activity in adulthood (Sigvardsson, et al., 1987).[16] Supporting the predictive validity of the model, such behavior was associated with high ratings of Novelty Seeking, and low scores on Harm Avoidance and Reward Dependence.[17]

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[16] In this retrospective study, scores on the three dimensions were applied to records of childhood interviews without prior knowledge of later outcomes. Violent criminal activity was based upon accumulated criminal convictions for such infractions by age 27.

[17] Phylogenetic arguments have also been marshalled in support of the model (Cloninger & Gilligan, 1987). Cloninger points to evidence that each dimension of the model evolved separately. Harm Avoidance has the most primitive origin of the three, as manifest in the sensitization response of almost all animals after exposure to an unpredictable aversive stimulus. This phenomenon involves an enhancement or facilitation of the reaction to an unidentifiable threat to the survival of the animal. Novelty Seeking or exploratory behavior was the next to evolve (e.g., found in mollusks such as snails and octopi). Novelty Seeking is associated with advancement in sensory and motor capabilities, enabling the animal to explore its environment over a wider range. Reward Dependence was the last to evolve, emerging as the ability to maintain behavior that had been previously rewarded despite frustration. This behavior, first seen in reptiles, has adaptive value when resources are scarce or there is intense competition.

Data regarding neurotransmitter systems are an integral part of Cloninger's model. The biochemical underpinnings of each personality dimension are recognized as complex, involving communication between multiple brain areas through several neurotransmitters in combination with comodulatory peptides and hormones. However, a single monoamine is assigned a principle neuromodulatory role in each personality dimension (Cloninger, 1986, 1988). The behavioral activation system underlying Novelty Seeking is principally modulated by dopamine. The behavioral inhibition system of Harm Avoidance is served by serotonin. Norepinephrine is assigned to behavioral maintenance and Reward Dependence. Just as the genetically separate dimensions are said to interact at the behavioral level, they are also hypothesized to do so at the level of neurophysiology (Cloninger, 1991, p. 199).

A full examination of the neurophysiological and phylogenetic data is beyond the scope of the present paper (see Cloninger, 1986, 1988, 1991, Cloninger & Gilligan, 1987).

C7. The Tridimensional Personality Questionnaire (TPQ)

In an effort to operationalize the model, Cloninger (1987a) developed the Tridimensional Personality Questionnaire (TPQ). Because of predicted interactions among the personality dimensions at the behavioral level, care was taken to create questions that were theoretically expected to minimize such effects. In effect, questions were chosen to evaluate behaviors expected to be found in individuals who are deviant on one dimension and average on the others (Cloninger, 1987a, p. 580). Currently in its fourth revision (Cloninger, 1987b), the questionnaire consists of one hundred true-false items, spread relatively evenly among the three dimensions. Each dimension is composed of four subscales (see Table 1). Following Cloninger's convention, the scales will be referred to in the remainder of the text by the following abbreviations: NS for Novelty Seeking, HA for Harm Avoidance, and RD for Reward Dependence.

Normative data were recently published for the latest version of the TPQ based upon a national area probability sample of 1019 male and female, black and white American

Table 1: Tridimensional Personality Questionnaire (TPQ) Scales and Subscales*

Novelty Seeking (NS)

NS1: exploratory excitability vs stoic rigidity (9 items)

NS2: impulsiveness vs reflection (8 items)

NS3: extravagance vs reserve (7 items)

NS4: disorderliness vs regimentation (10 items)

NS = NS1 + NS2 + NS3 + NS4 (34 items)

Harm Avoidance (HA)

HA1: anticipatory worry vs uninhibited optimism (10 items)

HA2: fear of uncertainty vs confidence (7 items)

HA3: shyness with strangers vs gregariousness (7 items)

HA4: fatigability and asthenia vs vigor (10 items)

HA = HA1 + HA2 + HA3 + HA4 (34 items)

Reward Dependence (RD)

RD1: sentimentality vs insensitiveness (5 items)

RD2: persistence vs irresoluteness (9 items)

RD3: attachment vs detachment (11 items)

RD4: dependence vs independence (5 items)

RD = RD1 + RD2 + RD3 + RD4 (30 items)**

* directly quoted from Cloninger, 1991, p. 1048.

** Note: two of the 100 TPQ items were deemed inappropriate by Cloninger and are excluded from the scoring.

adults, with an oversample of black subjects (Cloninger, et al., 1991). Results were generally reported separately for each of the four subgroups, but tended not to vary a great deal. Alpha coefficients indicated moderate to strong internal consistency for the three dimensions. Six month test-retest reliability was moderately high (data available only for a subset of white subjects).

The reliability of RD and its subscales tended to be lower than that of the other dimensions. Cloninger explained these results by noting that the RD scale had fewer items than the other two dimensions (30 vs. 34 each), and that RD subscales tended to be shorter (Sentimentality and Dependence have 5 items), tended to have high endorsement rates skewing distributions (especially Sentimentality), and smaller variances (unweighted mean SD of subscales across subject groups: RD = 1.58, NS = 1.79, HA = 1.99).

NS was weakly to moderately negatively correlated with age and with Social Desirability. The correlation with the latter indicates a possible problem with the validity of the scale (because some people may not be responding honestly). However, partialing out age reduced by about 50% the variance in NS accounted for by Social Desirability, lessening any threat to the validity of the NS scale.

C8. Factor Structure of the TPQ

Pearson correlations among the dimensions were weak, as predicted. A three factor principle components analysis (factors were rotated obliquely by PROMAX) of the TPQ subscales explained approximately 50% of the variance and resulted in fairly clear and consistent HA and NS factors across subject groups (Cloninger, et al., 1991). However, the results for RD were less clear, with the Persistence (referred to as P in the remainder of the text) subscale tending to load weakly on the overall factor, except among black men where it loaded moderately.[18] In a four factor solution (explaining approximately 10% more variance), RD separated into two parts. Except among black men, P formed a fourth factor, separate from the other RD subscales. This fourth factor also included a variable negative loading (-.31 to -.59) of Fatigability (HA4) and a weaker positive loading (.31 to .42) of Exploratory Excitability (NS1). However, this pattern was only found in three of the four subject subgroups (white men, white women, and black women). In black men, P remained in the overall RD factor, while the subscale Dependence formed the major component of a fourth

[18] The results for the black male subgroup should be viewed with some caution. It was the smallest in the overall sample, with 136 subjects versus 326 for white males, 350 for white women, and 207 for black women. In addition, while men regardless of race tended to be less likely to return the questionnaires than women, stratified random sampling across gender was only possible among white subjects, due to procedural difficulties.

factor. It should also be noted that in correlations among RD subscales all four subgroups displayed either a weak relationship between P and the other subscales, or none at all.[19] These correlations were higher for men than women, but the highest, among black men, was only .18 (Cloninger, 1988, p. 99).

To explain difficulties with the factor structure of RD, Cloninger brought up a number of points. He cited the issues of reliability regarding the RD scale (see above). He stated that the weak correlations pointed to the importance of experiential factors in the development of personality traits like persistence at hard work (Cloninger, 1988, p. 99). Later he stated that reinforcement schedules in natural settings may not be consistent across traits, such that an individual may be positively reinforced for maintaining close social relationships, but not for working hard (Cloninger, personal communication, March, 1989, cited by Waller, et al., 1991, p. 18). More recently, Cloninger and his colleagues admitted that the construct validity of RD was unclear, and questioned whether P should be considered a fourth factor or integrated into the other two dimensions (Cloninger, et. al., 1991, p. 1056).

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[19] Correlations were presented for only three, rather than four of the Reward Dependence subscales: Sentimentality, Persistence, and Attachment, apparently reflecting an earlier modification of the questionnaire.

Research examining the TPQ's factor structure in samples from a number of nations has also called into questioned the factor structure of RD, though these same studies have generally validated the NS and HA dimensions (Heath, personal communication cited in Cloninger, et. al., 1991; Kozeny, Kubicka, & Prochazkova, 1989; Svrakic, Przybeck, & Cloninger, 1991; Waller, et al., 1991). In a large U.S. adult sample (N = 1,236), a factor analysis of the subscales using an earlier, but conceptually similar, version of the TPQ (version 2), indicated that P formed a separate fourth factor, with little contribution from other subscales (Waller, et al., 1991). In a sample of Yugoslavian university students, factor loadings of TPQ subscales in a three factor solution showed that P loaded weakly on the overall RD factor (Svrakic, et al., 1991) (factors were rotated by varimax and then obliquely by promax; p. 201). They were unable, however, to isolate P as a fourth factor in this sample (Cloninger, et al., 1991, p. 1056). In a sample of 804 Czechoslovakian adults, a factor analysis of the subscales of an earlier version of the TPQ using a three factor solution indicated that P loaded negatively on a factor with three of the NS subscales (Impulsiveness, Extravagance, Disorderliness), though it also loaded on the RD factor (Kozeny, et al., 1989, p. 1256). An as yet unpublished study of a large sample of Australian twins, using a shortened version of the questionnaire, found evidence that P may form a separate heritable dimension (Heath, a personal communication cited in Cloninger, et al., 1991 p. 1050). In sum, the role of P in RD is clearly questionable (at least with regard to the way that the RD scale has been operationalized thus far; see Cloninger, et al., 1991, p. 1056), and may form a separate fourth factor. These issues were examined in a study of the TPQ in the present subject pool which will be presented in a later section.

C9. Comparing Cloninger's Model with Others

Now that Cloninger's theory has been more fully explained, including its operationalization on the TPQ, its relationship to other models can be examined in a bit more detail. Because the present investigation examines the utility of Cloninger's dimensions at the behavioral level (i.e., relationships with gambling), the discussion which follows primarily focuses on comparisons at that level, rather than addressing biologically causal mechanisms (for more on the latter, see Cloninger, 1986, 1988, 1991; Gray, 1987b; Nurnberger, 1988; Roy & Linnoila, 1988). Using the Big Five as a descriptive (phenotypic) framework, Cloninger's model, like those discussed earlier (see the section, "Comparing Models of Personality"), appears most similar on factors 1 (Extraversion) and 4 (Neuroticism). A person high in NS would be described as Extroverted and Neurotic, based upon correlations with Eysenck's EPQ. A person high on HA would be regarded as both Introverted and Neurotic (Cloninger, 1988, p. 100).

Cloninger's first two dimensions therefore appear to involve a rotation of Eysenck's dimensions, similar to that hypothesized by Gray (1982, 1983). NS is similar to Gray's Impulsivity, and HA is similar to Trait Anxiety. In other respects, however, Gray and Cloninger's models differ. For example, Impulsivity does not appear to include a response to novelty as does NS. Impulsivity does involve sensitivity to conditioned signals of reward, but this only partially overlaps with Cloninger's view. Cloninger divides the reward system into two parts: incentive motivation and reinforcement. Incentive motivation is centered in the NS dimension and involves activation induced by signals of possible reinforcement. Reinforcement, associated with RD, involves the maintenance of behavior and resistance to extinction (Cloninger, 1986, p. 215). In addition, Gray's Fight/Flight dimension, which involves sensitivity to unconditioned punishment, has no unitary counterpart in Cloninger's model.

Empirical studies have not yet examined the relationship between Cloninger's model and Zuckerman's

Sensation Seeking Scale. Sensation Seeking appears similar to NS in some respects. Zuckerman characterized his dimension as the need for varied, novel, intense, and complex experiences and sensations, and the willingness to take physical and social risks for the sake of such experience (1990, p. 313). Sensation Seeking can be seen to involve an element of danger, and Zuckerman (1988) noted that other measures of harm avoidance are strongly and negatively related to his trait. In contrast, Cloninger's NS and HA dimensions have been found to be largely independent of one another (Cloninger, et al, 1991; Waller, et al, 1991). Cloninger conceptualizes Sensation Seeking as a composite of high NS, low HA, and possibly low RD (Cloninger, 1986, p. 187).

Cloninger (1986, 1987a) and Tellegen's (1985) models are both hierarchical, and correlations between the TPQ and Tellegen's MPQ have been examined at the level of general dimensions (Cloninger, 1988, p. 100) and specific subscales (Waller, et al., 1991, p. 13). Both studies used earlier versions of the TPQ. NS was primarily negatively correlated with Constraint, and weakly positive correlated with Negative Emotionality. NS subscales tended to correlate most highly with the Control subscale of the Constraint dimension. These results are generally consistent with the concept of NS as related to behavioral disinhibition (Waller, et al., 1991, p. 12).

Correlations of HA with Tellegen's MPQ were also examined. HA on the whole was primarily negatively correlated with Positive Emotionality, with weaker secondary positive correlations on Negative Emotionality and Constraint. HA subscales were all negatively correlated with Well Being and Social Potency (Positive Emotionality subscales), and positively correlated with Stress Reaction (from Negative Emotionality). Only one of the TPQ HA subscales (Fear of Uncertainty) was particularly correlated with MPQ Harm Avoidance, the latter a subscale of MPQ Constraint. Even TPQ Fear of Uncertainty displayed a higher correlation with MPQ Stress Reaction than with MPQ Harm Avoidance. The pattern of subscale results led Tellegen and colleagues to posit that Cloninger's HA scale is more a measure of Negative Emotionality than Constraint (Waller, et al., 1991, p. 19). Harm Avoidance in Tellegen's model attempts to measure avoidance of risky and adventurous activities, while Cloninger's HA includes Anticipatory Worry (HA1), Fear of Uncertainty (HA2), Shyness with Strangers (HA3), and Fatigability (HA4). In all, it seems reasonable to question whether TPQ HA is more emotional than behavioral, whether it is more a measure of a negative emotion than of inhibition (through constraint or passive avoidance) of a behavioral response.

The relationship between RD and the MPQ again tended to call into question the structure of Cloninger's third TPQ dimension (see earlier discussion under the section "Factor Structure of the TPQ"). Overall RD was found to be weakly correlated both with Positive Emotionality and Constraint.[20] Using an earlier version of the TPQ with only two RD subscales, Waller and colleagues (Waller, et al., 1991) found that the TPQ Social Sensitivity subscale was highly correlated with the MPQ Social Closeness subscale, while TPQ P was highly correlated with MPQ Achievement. These results support the concept underlying each of the two TPQ subscales. However, other results did not support the unity of the RD dimension. The two TPQ subscales did not correlate at all with each other's counterpart on the MPQ (the same could be said of the two MPQ subscales). In addition, a rotated inter-battery factor analysis (while resulting in clear NS and HA factors) led to a separation of RD into two factors. Social Sensitivity and Social Closeness formed one, and P and Achievement formed the other. The above data, as well as that reviewed earlier

[20] The correlation with Positive Emotionality was only found in a general population sample, but not in a sample of medical students (Cloninger, 1988, p. 100).

regarding the factor structure of the TPQ, argue that P should be regarded as a separate fourth factor on the TPQ.

Cloninger's theory is an ambitious one whose adequacy can be judged on many levels (e.g., descriptive, neurophysiological, genetic) (see Gray, 1987b, pp. 378-379). Its appeal in the present investigation was the apparent overlap with variables important in decision making, HA with loss, RD with gain, and NS with uncertainty. It was hoped that this overlap would lead to significant associations between the TPQ and gambling behavior. This issue will be examined more closely below.

Before applying the TPQ in the present context, however, a study was undertaken to examine its utility among the available population of college undergraduates. It was hoped that the descriptive statistics would replicate previous studies. In addition, given the uncertain nature of the RD dimension, it was hoped that the factor structure of the TPQ could be further clarified.

II. TPQ REPLICATION STUDY

A. Method

A1. Subjects

Subjects consisted of 428 students from the City University of New York. Subjects were volunteers from undergraduate psychology classes. Most participated during in-class exercises (67%), and the rest took part during non-class time (33%). In a few of the classes, instructors offered students extra credit for participation in the study (34%), but for the majority (66%) no credit was given. Rates of participation in each class tended to be high (approximately 90%), but were lower (50-60%) for two large lecture hall classes with over 100 students (other classes had 40 or fewer students), who participated after class in return for extra credit. The class to class differences mentioned above did not appear to make an appreciable difference to the factor structure and so the reported scores are those of the total sample.

Of the 428 total subjects, 127 also performed a gambling task (described in detail at a later point). The participation rate of the latter was approximately 90% (not all classes were given the opportunity to participate in the gambling task), with the exception that from the two larger classes, eight subjects were chosen in an attempt to round out the number of subjects with particular combinations of above and below average TPQ dimension scores. In order to better characterize the 127 gambling task subjects, they are compared in the following results to their 301 peers who did not did not perform the task.

Demographic characteristics were measured by self report. The overall sample had a mean age of about 26 years, contained more females than males, and was racially diverse (see **Table 2**). The two subsamples both also fit that general description, though there were some differences (see **Table 3**). The subjects who participated in the gambling task tended to be more likely to report being hispanic, while the other group was more likely to report "other" for race. The subjects who did not participate in the gambling task also tended to be less likely to report demographic information.

A2. The Tridimensional Personality Questionnaire (TPQ)

The Tridimensional Personality Questionnaire (TPQ) is currently in its fourth revision (Cloninger, 1987b). The questionnaire consists of one hundred true-false items, spread relatively evenly among the three dimensions of NS,

Table 2: Demographic Characteristics of the Total Subject Sample.

	Total Sample (N=428)
Age in years:	
mean	25.6
Standard Deviation	7.4
% missing cases	17.9%
Gender:	
% female	57.2%
% male	29.5%
% missing cases	13.3%
Race:	
% black	31.6%
% hispanic	24.7%
% caucasian	17.4%
% other race	12.3%
% missing cases	14.0%

Table 3: Demographic Characteristics of the Gambling Task and Non-Gambling Task Subject Samples.

	Gambling Task Sample (N = 127)	Non-Gambling Task Sample (N = 301)
Age in years:		
mean	26.5	25.1
Standard Deviation	6.8	7.7
% missing cases	7.9%	22.1%
Gender:		
% female	63.8%	54.5%
% male	36.2%	26.7%
% missing cases	0.0%	18.8%
Race:		
% black	35.4%	30.0%
% hispanic	34.6%	20.5%
% caucasian	21.3%	15.8%
% other race	7.1%	14.5%
% missing cases	1.6%	19.1%

HA, and RD. Each dimension is composed of four subscales (see Table 1; see earlier description of the task in the Introduction). Each item in a dimension which was scored positively was given a score of 1.0, while negative items were given a score of 0.0. In addition, missing data was assigned a score of 0.5.

A3. Procedure

Potential subjects were asked to participate in a study by answering a true-false questionnaire (the TPQ) designed to measure attitudes, opinions, interests, and feelings. All information was kept strictly confidential, participation was completely voluntary, and subjects could withdraw at any time. Those subjects in classes where extra credit was offered by the instructor were informed of that fact, while the rest were informed that participation or non-participation would in no way affect academic standing. In some cases, subjects filled out the TPQ in class, while in others they completed the task outside of class. All subjects were informed that they would be able to learn about their own results (in private) following the completion of the questionnaire.

A4. Data Analysis

Two types of analyses were performed on the data. First, descriptive statistics were derived and comparisons were made with Cloninger's national U.S. sample (Cloninger, et al., 1991). Secondly, the dimensional structure of the TPQ was examined with a series of principle components analyses on the TPQ subscales. Factors were rotated obliquely using OBLIMIN on SPSSX. Oblique (rather than orthogonal) rotation was chosen in order to allow for the possibility that the factors might correlate with one another, based upon Cloninger's hypothesis that shared environmental influences might lead to mild correlations between the dimensions at the phenotypic level (Cloninger, 1987a, p. 575; Waller, Lilienfeld, Tellegen, & Lykken, 1991, p. 8). The solution was initially limited to 3 factors, based upon Cloninger's original assumption of the tridimensional structure of personality (Cloninger, 1987a). A four factor analysis was also undertaken, in order to examine whether P would form a fourth independent personality dimension (e.g., Cloninger, et. al., 1991; Waller, et. al., 1991).

B. Results and Discussion

B1. Descriptive Statistics

The means and standard deviations of the sample and subsamples (gambling task, non-gambling task) are presented in **Table 4** (statistics for Reward Dependence are presented with and without the P subscale. Reward Dependence without the P subscale is referred to as RDM). The two subsamples were generally similar except that the subjects who did not participate in the gambling task were perhaps a little higher in HA than was the other group.

Also presented in **Table 4**, for comparison purposes, are the data for Cloninger's national area probability sample of 1,019 subjects (Cloninger, et al., 1991). Only the overall means across race and gender are presented because the present sample included a large number of hispanics, a group not represented in Cloninger's study, and because no effort was made in the present study to generate equivalent random samples of each racial group. Comparing the total present sample ($\underline{N}$ = 428) with Cloninger's, it is evident that the two

Table 4: Subject Characteristics on the Tridimensional Personality Questionnaire (TPQ). A comparison of the present sample with that of Cloninger's.*

	Present Sample							
	Total Sample (*N* = 428)		Non-Gambling Task Sample (*N* = 301)		Gambling Task Sample (*N* = 127)		Cloninger's Sample (*N* = 1019)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
NS	16.2	5.5	16.1	5.5	16.6	5.3	12.9	4.9
HA	13.6	6.7	14.1	6.8	12.2	6.5	12.1	5.7
RD	18.6	4.6	18.6	4.6	18.6	4.6	18.6	3.9
RDM	12.9	3.9	12.8	3.9	13.0	3.9	13.1	NA
P	5.7	2.0	5.7	2.0	5.6	2.0	5.5	1.9

Note. NS = Novelty Seeking
HA = Harm Avoidance
RD = Reward Dependence
RDM= Reward Dependence Modified, by excluding the Persistence subscale
P = Persistence

* (Cloninger, Przybeck, & Svrakic, 1991) Data for Cloninger's sample based upon an unweighted mean of scores presented separately for male and female blacks and whites.

samples were roughly equal, though HA was higher by one and a half points, and NS by three points in the present sample. Because both samples were large, each difference was significant (for HA, t=4.33, p<.05; for NS, t=11.28; p<.05). The difference for HA was small and rather inconsequential.[21]

The difference on NS may have been partly due to age and education differences between the samples. The mean age of Cloninger's sample was 43.9 (SD = 17.6, unweighted mean across race and gender), while the present sample was approximately two decades younger, with a mean of 25.6 years (SD=7.4 years, 17.9% missing cases). Cloninger found that, "Novelty Seeking scores declined approximately 1 point per decade" (Cloninger, et. al, 1991, p. 1053). Thus, age alone probably accounts for a large proportion of the obtained difference between samples.

In addition, Cloninger found a weak significant relationship between NS and level of education (r = .19, p < .001) among white, but not black respondents (Cloninger, et al., 1991). While the mean level of education was not indicated in Cloninger's study, and was not directly

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[21] There was also a significant difference between subjects in the sample who played the gambling task and those in the non-gambling sample. Those in the gambling sample were less harm avoidant than those in the other sample (t=2.11, p<.05). There were no other significant differences between these two samples.

measured in the present sample, it is likely that the present sample of undergraduates had a higher average level of education, and this may have mildly contributed to a difference between the two samples on NS.

In summary, the means and standard deviations for the present sample of subjects on the TPQ were generally consistent with expectations, and these results lend support to the use of the questionnaire in this population.

B2. TPQ Factor Structure

The dimensional structure of the TPQ was assessed with a series of principle components analyses performed on the TPQ subscales. In order to obtain a more stable assessment of the factor structure, these analyses were performed on the total subject sample ($\underline{N}$ = 428).[22]

Factors were rotated obliquely using OBLIMIN on SPSS-X (SPSS-X User's Guide, 1988). The OBLIMIN procedure allows non-orthogonal factors to be produced. The decision to use an oblique rotation was guided by Cloninger's (1987a) remarks that the dimensions might be mildly correlated at the level of behavior (phenotype) even though they are

[22] Analysis of the gambling and non-gambling subgroups produced largely similar results. Both resulted in a fourth factor comprised primarily of P.

hypothesized to be inherited independently (genotype), and even though an attempt was made to design the TPQ so as to measure each dimension separately. Oblique rotation follows the convention of Cloninger's factor analyses of the TPQ, as well as those of others (Cloninger, et al., 1991, Waller, et al., 1991). For comparison, orthogonal rotation (SPSS VARIMAX) was also used in the present study, and the obtained factors were quite similar to those for oblique rotation (described below), indicating that the TPQ successfully resulted in dimensions that were roughly independent of one another (see **Tables 1X** and **2X** in Appendix B for VARIMAX results).

Based upon Cloninger's original assumption of the tridimensional structure of personality, the initial solution was limited to 3 factors (Cloninger, 1987a). The three factor pattern matrix solution (Tabachnick & Fidell, 1983, pp. 393-394) presented in **Table 5A** indicates that the subscales formed factors roughly corresponding to HA, NS, and RD, respectively. While the size of factor correlations indicate that they were independent of one another (see **Table 5B**), two of the subscales were not particularly well defined. Exploratory Excitability (NS1) was moderately related to its overall scale, NS, but was also mildly to moderately negatively related to HA. Persistence (RD2, abbreviated in the text as P) was equally, but not strongly,

Table 5: Oblique Three Factor Tridimensional Personality Questionnaire (TPQ) Solution.

A. Three Factor TPQ Pattern Matrix Solution, based upon 428 CUNY undergraduate psychology students.

	Factor 1	Factor 2	Factor 3
NS1	-.397	.570	.
NS2	.	.784	.
NS3	.	.611	.
NS4	.	.748	.
HA1	.802	.	.
HA2	.711	.	.
HA3	.776	.	.
HA4	.702	.	.
RD1	.	.	.681
RD2 (P)	.	-.387	.378
RD3	.	.	.720
RD4	.	.	.710

Note: Only loadings with absolute values > .30 are shown.
NS = Novelty Seeking
HA = Harm Avoidance
RD = Reward Dependence
P = Persistence

B. Three Factor Correlation Matrix

	Factor 1	Factor 2	Factor 3
Factor 1	1.000		
Factor 2	- .057	1.000	
Factor 3	- .052	.004	1.000

associated with both RD (positively) and NS (negatively). In order to examine whether P would form a fourth independent personality dimension (e.g., Cloninger, et. al., 1991; Waller, et. al., 1991) a four factor solution was also produced (see **Table 6A**). Examination of the pattern matrix solution indicates that a fourth factor was indeed produced, and that it was basically characterized by the P subscale, though it was also mildly negatively associated with Extravagance (NS3), as well as Fatigability and Asthenia (NS4). The first three factors were basically similar to the three factor solution, except for the absence of any contribution from P (RD2) to factors 2 and 3. The factor correlation matrix (**Table 6B**) indicates that the four dimensions were relatively independent of one another.

In summary, the results appeared to support Cloninger's (1987a) original model, with the exception that P appeared to form a separate independent fourth dimension, a finding generally consistent with the results of investigations (Heath, personal communication cited in Cloninger, et. al., 1991; Kozeny, Kubicka, & Prochazkova, 1989; Svrakic, Przybeck, & Cloninger, 1991; Waller, et al., 1991). Because of the emergence of a fourth factor, the RD dimension will be broken down into two parts, <u>Persistence (P)</u>, and <u>Reward Dependence Modified (RDM)</u>. The latter is equal to the sum of the remaining three RD subscales.

Table 6: Oblique Four Factor Tridimensional Personality Questionnaire (TPQ) Solution.

A. Four Factor TPQ Pattern Matrix Solution, based upon 428 CUNY undergraduate psychology students.

	Factor 1	Factor 2	Factor 3	Factor 4
NS1	-.361	.592	.	.
NS2	.	.811	.	.
NS3	.	.483	.	-.333
NS4	.	.818	.	.
HA1	.845	.	.	.
HA2	.669	.	.	.
HA3	.812	.	.	.
HA4	.646	.	.	-.334
RD1	.	.	.689	.
RD2 (P)	.	.	.	.898
RD3	.	.	.772	.
RD4	.	.	.706	.

Note: only loadings with absolute values > .30 are shown.

B. Four Factor Correlation Matrix

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1.000			
Factor 2	- .125	1.000		
Factor 3	.012	.097	1.000	
Factor 4	- .056	- .140	.057	1.000

III. GAMBLING STUDY

A. Introduction

A1. Development of the Gambling Task

A computerized gambling task was developed to study the relationship between the TPQ and betting. The primary objective was to develop a controlled task in which the variables of gain, loss, and uncertainty could be studied. A simple repetitive 50%-50% win-loss task was created. The task is much like betting on the flip of a coin where the subject simply chooses how much to wager on each trial. The task allows for the measurement of patterns of gambling (e.g., the gambler's fallacy) by examining how the size of bets changes following wins and losses. The choice of 50/50 probability of winning and losing makes it equally likely that a series of wins versus a series of losses will result, making it easier to judge similarity and differences in subjects' responses to the two types of outcomes. By holding probability constant, there is only one way to increase risk, by increasing bet size. Choosing a less probable alternative with a larger possible win is not an option on the present task.

The task involved 250 trials, allowing for a reliable measure of betting patterns. In addition, the large number of trials allowed for the examination of betting changes over the course of the task, as the task novelty wanes. This would be expected to relate to the NS dimension (specifics of this issue will be presented below).

A2. Research Hypotheses for the Gambling Study

If a pair of gamblers differed in their sensitivity to loss, how might that affect their pattern of gambling? Would they both be equally likely to exhibit a pattern like the gambler's fallacy, and try to recoup their losses by making riskier bets after losing than winning? What if the pair differed in their sensitivity to winning, or to change and novelty in the environment? How might that affect their behavior? These were the sorts of questions that were examined.

The initial research hypotheses were as follows. High NS individuals were predicted to be more risk taking (i.e., make larger bets) than those lower in NS, particularly early on in the game, when the task is most novel. This was expected because high NS subjects have been characterized as tending to respond with intense excitement to novelty and cues for potential rewards and relief from punishment. Such tendencies are said to lead "to frequent exploratory activity in pursuit of potential rewards as well as active avoidance of monotony and potential punishment" (Cloninger, 1987a, p. 575). The gambling task provided an opportunity to engage in such exploratory behavior, particularly early on, before its novelty waned.

High Harm Avoidant subjects were predicted to be more sensitive to loss than other individuals, but their response to losing was expected to differ depending upon their level of NS. Those high in NS were expected to take an <u>active</u> stance against losing. They were predicted to try to actively recoup their losses by betting large amounts to win back what they had just lost, thus displaying the gambler's fallacy pattern of betting. In contrast, high Harm Avoidant subjects who were low in Novelty seeking were expected to try to <u>passively avoid</u> further loss by making small bets, and thus be less likely to display a gambler's fallacy pattern.

At the beginning of the present investigation, RD was considered a unitary dimension consisting of sensitivity to signals of reward and the tendency to maintain previously rewarded behavior in the face of frustration (i.e., persistence). Thus, the original research hypothesis was that higher RD individuals would display more consistent patterns of betting than those lower in RD. In other words, high RD subjects were expected to be less affected by the consequences of previous betting outcomes (at least on a trial to trial basis), and thus less likely to show a pattern like the gambler's fallacy.

In light of the results of the factor analytic study, it was decided that P should be treated as an independent fourth dimension, separate from the rest of the original RD subscales. Subjects high in P would therefore be predicted to display the pattern heretofore attributed to the original RD dimension (i.e., more consistent patterns of betting). The revised Reward Dependence dimension (RDM) is then left solely as a measure of sensitivity to signals of reward, and would therefore be expected to be positively associated with bet size, particularly following wins. Relatively large bets following wins would make subjects higher in RDM less likely to show a betting pattern like the gambler's fallacy.

B. Method

B1. Subjects

Subjects consisted of 127 students from the City College of New York (CCNY). They were given $5.00 with which to gamble, and allowed to keep their winnings.

Specific demographics of this young, racially diverse, male and female subject group were presented earlier, as were details regarding the generally high participation rates (see the Subject section of the TPQ Replication Study).

Subjects were drawn from undergraduate psychology courses, and most participated during voluntary in-class exercises (108 subjects). It was emphasized to these prospective subjects that the decision to participate and performance during the study would in no way affect academic standing. In two classes the instructors offered students extra credit for participation in the study (19 subjects). To this latter group of prospective subjects, it was emphasized that performance during the study would in no way affect academic standing (though they would of course receive credit for having chosen to participate). The issue of class credit did not appear to affect the overall results, and data have been combined.

B2. The Gambling Task

The gambling task basically consisted of a series of 250 two outcome gambles, with an overall probability of winning and losing of 50%. Risk taking was measured in the task by the size of the bets chosen by subjects.

The order of wins and losses was the same for all subjects. This fixed sequence across subjects was chosen to reduce variability between subjects that might result from different orders and numbers of wins and losses. A random series of 125 wins and losses was chosen for the first half of the trials, and the second half of the trials were a mirror image of the first (all losses became wins and vice versa), thus ensuring an even number of wins and losses, and a relatively even number of consecutive win and consecutive loss sequences. The 250 outcome series included sequences of up to 6 consecutive wins, and 6 consecutive losses.

The gambling task was run on an IBM PS2 Model 30 computer using a program specifically devised for the study. At the beginning of each betting trial, the monitor displayed the following information: 1) the 50/50 probabilities of winning and losing; 2) the amount won or lost on the immediately preceding trial; 3) the amount presently in the bank account; 4) the difference between the present total and the starting bank account of $50.00 (which in reality was equivalent to 1/10 of that amount, or $5.00); 5) the series of 10 wagering alternatives ranging from $0.50 to $5.00, differing in increments of $0.50. Each wagering alternative was associated with a number key ("1" through "9" plus "0") at the top of the computer keyboard. After a bet was chosen, a two second lag occurred, and then the monitor displayed: 1) the amount won or lost; 2) instructions to press the space bar to move on to the next betting trial. The delay was used to pace the task and to convince the naive subject that the computer had actually played out the gamble (Leopard, 1978).

B3. Procedure

Subjects were tested in groups of usually between 10 and 20 persons. They were informed that the purpose of the study was to examine individual differences in risky decision making. The experimenter emphasized the importance of truthful and accurate responses on the TPQ for the validity of the results, and that participation was completely voluntary. Subjects were then given an informed consent form to examine, while the experimenter read it aloud (see Appendix A). Any questions regarding the procedure were then addressed. Most subjects filled out the TPQ before completing the gambling task (112 subjects). However, this order was counterbalanced in a small group of subjects (15). This difference in order did not appear to appreciably affect the results and the data from both groups have been combined in the results.

Subjects were escorted to the personal computer laboratory for the gambling task. Each subject was seated in front of a computer. They were told to imagine that they had taken a trip to Atlantic City, that they had $50.00 with which to gamble, and that they had decided to play the following game. They were told that the game involved a series of 50/50 gambles. The game was compared to flipping a coin. They were told that about half of the time they would win, and about half of the time they would lose.

Subjects were informed that they would be initially credited with $50.00 in their bank account, and that at the completion of the task they would receive 1/10 of the final bank total in cash. For example, a player finishing with the same amount with which he/she started, would receive $5.00. Subjects were told that they would be paid if and only if they completed the session. All subjects were willing to complete the task.[23]

The task was introduced with four practice trials. Subjects were informed that these bets would not contribute to their bank total. They were instructed to press the space bar in order to begin the practice trials. The experimenter then pointed out the contents of the screen at the beginning of a betting trial (as described above). They

[23] Due to a lack of time, one person did not complete the task. He/she was given winnings as of the last trial completed, and his/her betting scores were computed based upon the only the trials completed.

were then instructed to make a practice wager by pressing down the number key associated with the amount of their choice. The experimenter ascertained that each subject had successfully placed a wager and answered any questions regarding the operation of the computer as the subjects made three more practice wagers.

The order of wins and losses during the practice session was different for subjects seated adjacent to one another. This precaution was taken because during this introductory period, the entire class was betting almost simultaneously, and subjects occasionally noted the outcomes of their bets aloud. Once the actual gambling procedure had begun, differing speeds of responding and differing bet sizes ensured that it would be highly unlikely for subjects to perceive identical, simultaneously experienced, gambling outcomes with others in the class.

Subjects were informed that the actual task would end after a large unspecified number of trials so that they would not count trials in order to anticipate the end. Subjects then played the gambling task. Subjects continued betting for 250 trials, or until their bank account dipped below the maximum bet size ($5.00). The latter criterion was chosen because bank accounts of less than the maximum bet size would limit the size of bets and thus obscure the primary variables of interest, the measures of relative bet size following wins and losses.

B4. Measures of Betting

A variety of betting measures were derived for each subject. First, mean bet size was determined for bets made immediately following particular sequences of wins or losses. Those sequences were as follows: 1 consecutive win (1win), 2 consecutive wins (2win), 3 or more consecutive wins (3win+), 1 consecutive loss (1loss), 2 consecutive losses (2loss), 3 or more consecutive losses (3loss+). It was decided to combine consecutive sequences of 3 or more wins (losses) because of the increasingly rare occurrence of longer sequences, and the reduced reliability of measures based upon so few data points. Means for each of the chosen sequences were based upon all such trials completed by that particular subject. The mean was unweighted so that the more frequent shorter consecutive sequences would not completely overwhelm the determination of the resulting average. Means for the entire task were computed, as were means for the first half only. The latter were used because the contribution of NS was predicted to be most important earlier on in the task when it was most novel.

In addition, more general betting averages were also determined: bet size following wins, bet size following losses, and overall bet size. Bet size following wins was based upon an unweighted mean of each of the three win sequences. Means were unweighted so that each sequence could contribute equally to the determination of the overall mean. Bet size following losses was computed analogously from the three loss sequences. Overall bet size was determined by an unweighted mean of all six win and loss sequences.

Overall bet size measures were also computed for each of the five 50 trial periods of the 250 trial task (e.g., 1-50, 51-100, etc.) in order to more closely examine the predicted effects of NS. These measures were simply based upon an unweighted mean of the 50 trials within that series, regardless of previous outcome, because there were too few occurrences of each outcome in a 50 trial series to compute reliable estimates.

Finally, measures of relative bet size were also computed in order to determine <u>changes</u> in an individual's bets due to particular previous outcomes. Such changes were measured during winning streaks, during losing streaks, and for losses versus wins. For winning streaks, betting after 1win was divided by that after 3win+ (hereafter referred to as 1win/3win+). For losing streaks, betting after 3loss+ was divided by that after 1loss (abbreviated 3loss+/1loss). For losses versus wins, betting after losing was divided by betting after winning (abbreviated loss/win).

These relative bet size measures were the primary focus of the present investigation since they represent methods of operationalizing the gambler's fallacy. In each case, higher scores indicate a greater degree of the gambler's fallacy. An individual can display the gambler's fallacy by betting more while on a losing streak, less while on a winning streak, and/or more while losing than winning. Of the three measures, loss/win betting is conceptually the most important in the present study. It is the only one of the measures which simultaneously examines performance across both losses and wins, to which the different TPQ dimensions, especially HA and RDM, respectively, should be differentially sensitive.

It should be pointed out that each of the three betting ratios measures the gambler's fallacy as a continuous variable, rather than a dichotomous one. Often, the gambler's fallacy is thought of being either present, or not. For example, either risk taking increases after losses compared to wins, or it does not. Measuring the gambler's fallacy as continuous variable would be expected to improve the sensitivity of measurement.

B5. Methods of Data Analysis

In order to assess the adequacy of Cloninger's model it was necessary to examine the <u>independent</u> contribution of each TPQ dimension to betting behavior. Remember that in this model each personality dimension, while presumed to be genetically independent, interacts with the others at the behavioral level. For example, while sensitivity to novelty and harm are thought to be independently inherited, a behavioral response to a new environmental stimulus may invoke both dimensions (i.e., because the stimulus is both new and possibly dangerous). Two methods were used to examine independent contributions: semipartial correlations, and "pure sample" correlations.

Semipartial (or part) correlations. A semipartial correlation refers to the unique independent relationship of a variable to an outcome, after removing (partialling out) the relationship between the relevant variable and other nonrelevant variables (Cohen, & Cohen, 1983, pp. 88-90; Kerlinger, & Pedhazur, 1973, pp. 93-99). For example, the semipartial correlation of NS to betting represents that part of the relationship which remains after removing whatever relationship NS shares with other personality dimensions. It is the independent contribution of NS to the explanation of all the variability associated with betting.[24] Note, however, that because the dimensions are basically independent of one another (see factor analytic study above), there should be little overlap, and little difference between the semipartial and basic Pearson r correlations of each dimension with betting.

When examining the entire subject pool, including those with extreme scores on more than one personality dimension, the semipartial correlation of a single TPQ dimension provides a picture of its unique overall relationship across all levels of the other scales. However, this particular measure is not specifically sensitive to a conditional relationship between the relevant dimension and betting, one which changes at different levels of the other dimensions. A conditional relationship involves an interaction between TPQ dimensions in relationship to betting.[25] Recall that

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[24] A partial correlation coefficient would differ in that it would also exclude (partial out) whatever variance in betting that was due to nonrelevant personality dimensions, thus reducing the amount of variance for which the relevant one would have to account. Semipartial correlations were chosen here in an attempt to model the more complicated situation in which all betting variability remains to be explained.

[25] Cohen and Cohen (1983, p. 302) point out that interaction of two variables in a multiple regression is often confused with the simple additive combination of their separate effects. Two variables are said to additively combine to affect an outcome when the relationship of each variable to the outcome is not dependent

such a conditional relationship was predicted in the present study. The relationship between HA and betting was expected to depend upon the level of NS. When NS was high, HA was expected to be positively correlated with the gambler's fallacy (specifically, with an increase in bets while on a losing streak). When NS was low, HA was expected to display a negative correlation with that betting pattern. In such a case the semipartial correlation of HA across all levels of NS would probably be weak or nonexistent (though it would depend upon the relative strength of the relationships under the different conditions).

Interactions can be examined with semipartial correlations, and such analyses were carried out in the present study (see below). However, the initial objective was to measure the separate, unique contribution of each TPQ dimension, and when interactions are present, the semipartial correlations for each individual scale can be misleading.

"Pure sample" correlations. The possibility of interactions between TPQ dimensions makes it important to take into account an individual's level on each of the dimensions. Not surprisingly, Cloninger (e.g., 1987a) has

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upon the level of the other variable. The semipartial correlation of each single variable would remove the additive effect of the other.

been careful in this respect. When describing the typical behavioral attributes of one TPQ dimension, he consistently indicates that the description holds for individuals with average levels on each of the other nonrelevant dimensions. Persons who score close to average on a nonrelevant attribute are least likely to be affected by it. For example, someone who scores near the mean on HA is neither overly nor underly concerned about possible threats in the environment, as compared to other persons. By focussing on individuals who are average on nonrelevant dimensions, it becomes possible to specify the unique, hypothesized contribution of a single TPQ dimension.

This sort of approach was also taken in the present study. Certain correlations were carried out on selected "pure samples" of subjects which excluded those with extreme scores (more than one standard deviation above or below the mean) on nonrelevant personality dimensions. For example, NS was examined in analyses that excluded subjects with extreme scores on the other dimensions (HA, RDM, and P). Restriction of range on nonrelevant dimensions was intended to reduce their possible contribution to individual differences in gambling, including the possibility of interactions between relevant and nonrelevant dimensions. The only dimension upon which a pure sample was allowed to fully vary was the relevant dimension of that specific analysis (NS in the example above). In the present study, these "pure samples" came closest to representing the simple situation in which only one personality variable at a time can contribute to individual differences in behavior. Such samples were therefore thought to be appropriate for examining basic hypotheses specific to each dimension individually.

The examination of restricted samples of subjects, of course, has its own drawbacks. Reduction in sample size reduces the power of the analyses, thus requiring stronger correlations for significant results.

While it is technically possible to perform semipartial correlations on smaller pure samples, and thus combine the two techniques, this was not done. In a pure sample the restriction of the range of values for nonrelevant dimensions causes the correlations of those dimensions to be less accurate. It would be unwise to partial out such questionable correlations. In the analyses that follow, semipartial correlations control only variables with unrestricted range. Pearson r correlations were performed when range was restricted in the pure samples.

Comparison of pure sample and semipartial correlations. Both pure samples and semipartial correlations represent methods of examining the independent contributions of the TPQ dimensions, but they differ in important ways. While both control for extraneous variables, their methods are not equivalent and should not be expected to lead to identical results. The pure samples achieve control by a restriction of range on nonrelevant personality dimensions. The range to which they were restricted (average levels) was not random, but specifically chosen because of Cloninger's (1987a, p. 580) contention that these personality dimensions can interact in their effect upon behavior. By examining persons average on a nonrelevant dimension (e.g., harm avoidance), one can assume that they will not be overly nor underly sensitive to that aspect of the environment (e.g., signals of harm). It should be emphasized, however, that if the relevant and nonrelevant dimensions interact, then the results for a pure sample would not generalize to the overall subject sample. The results of a pure sample are conditional; they are dependent upon average levels on all the other dimensions. In such samples one may examine how a personality characteristic operates in relative isolation, with reduced interference from, or interaction with, other dimensions. As such the pure sample analyses were deemed most appropriate for examining the initial hypotheses for each of the TPQ dimensions, since these hypotheses are best examined in the simpler conditions in which interactive contributions from extraneous factors have been minimized.

In contrast, the semipartial correlations focus upon the more complex situation in which all TPQ dimensions can vary fully. Unlike the pure sample correlations, they are based upon all subjects, including those with extreme scores on more than one personality dimension. The semipartial analyses attempt to remove statistically whatever overlap exists between the relevant and nonrelevant dimensions across the entire range of all the dimensions. In contrast to the pure samples, the results of these analyses are not specific to a particular subgroup of subjects. Rather, they reflect the overall sample as a whole.

As stated earlier, when interactions are present the semipartial correlation of a single dimension can be misleading. Therefore, exploratory analyses were used to examine the semipartial correlations of interactions between dimensions. The analyses involved stepwise multiple regression in which interactions entered into the equation if, and only if, they added significantly ($p <= .05$) to the explanation of betting variance over and above the separate additive contribution of each of the individual dimensions (Cohen & Cohen, 1983, p. 305).[26]

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[26] It would not be appropriate to reverse the order and enter the interactions before the main effects. Generally an interaction will be correlated with each of its components, quite substantially in many cases. Since, interactions arise out of each of the individual variables from which they are composed (e.g., an AxB interaction arises from A and B, respectively), partialling out an interaction from the semipartial correlations of each of its

Both semipartial and pure sample analyses were analyzed using the REGRESSION procedure on an SPSS mainframe statistical analysis software package (SPSS-X User's Guide, 1988).

C. Results

C1. Description of Observed Betting Patterns

The overall pattern of betting produced by subjects on the gambling task exemplified the gambler's fallacy. Subjects tended to bet more after losing than after winning. In addition their bets tended to change within a series of wins and within a series of losses. They tended to bet more after a consecutive series of losses (i.e., a losing streak) than after a single loss. They tended to bet less after a series of consecutive wins (i.e., a winning streak) than after a single win. Descriptive statistics are displayed in **Table 7**, and graphed in **Figure 1**. Data are also presented for each of the pure sample groups for each of the four TPQ dimensions (see **Tables 8 through 11**). The pure samples tended to resemble the larger total group with the exception that there appeared to be less of a differences from losses to wins in the pure P sample. Despite the general presence

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components would be "stealing their rightful variance" (Cohen & Cohen, 1983, p. 305).

TABLE 7: Bet size for all subjects (N = 127) immediately following consecutive sequences of losses or wins

Outcome Sequence	Median	Mean	Standard Deviation	Standard Error
6 Losses	2.75	2.61	1.51	.13
5 Losses	2.75	2.80	1.35	.12
4 Losses	2.83	2.78	1.24	.11
3+ Losses	2.81	2.73	1.13	.10
3 Losses	2.70	2.71	1.20	.11
2 Losses	2.57	2.59	1.18	.11
1 Loss	2.44	2.43	1.07	.10
1 Win	2.44	2.50	1.06	.09
2 Wins	2.05	2.20	1.07	.10
3 Wins	1.97	2.10	1.09	.10
3+ Wins	1.78	2.07	1.17	.10
4 Wins	2.00	2.07	1.16	.10
5 Wins	1.75	2.03	1.31	.12
6 Wins	1.75	2.09	1.46	.13

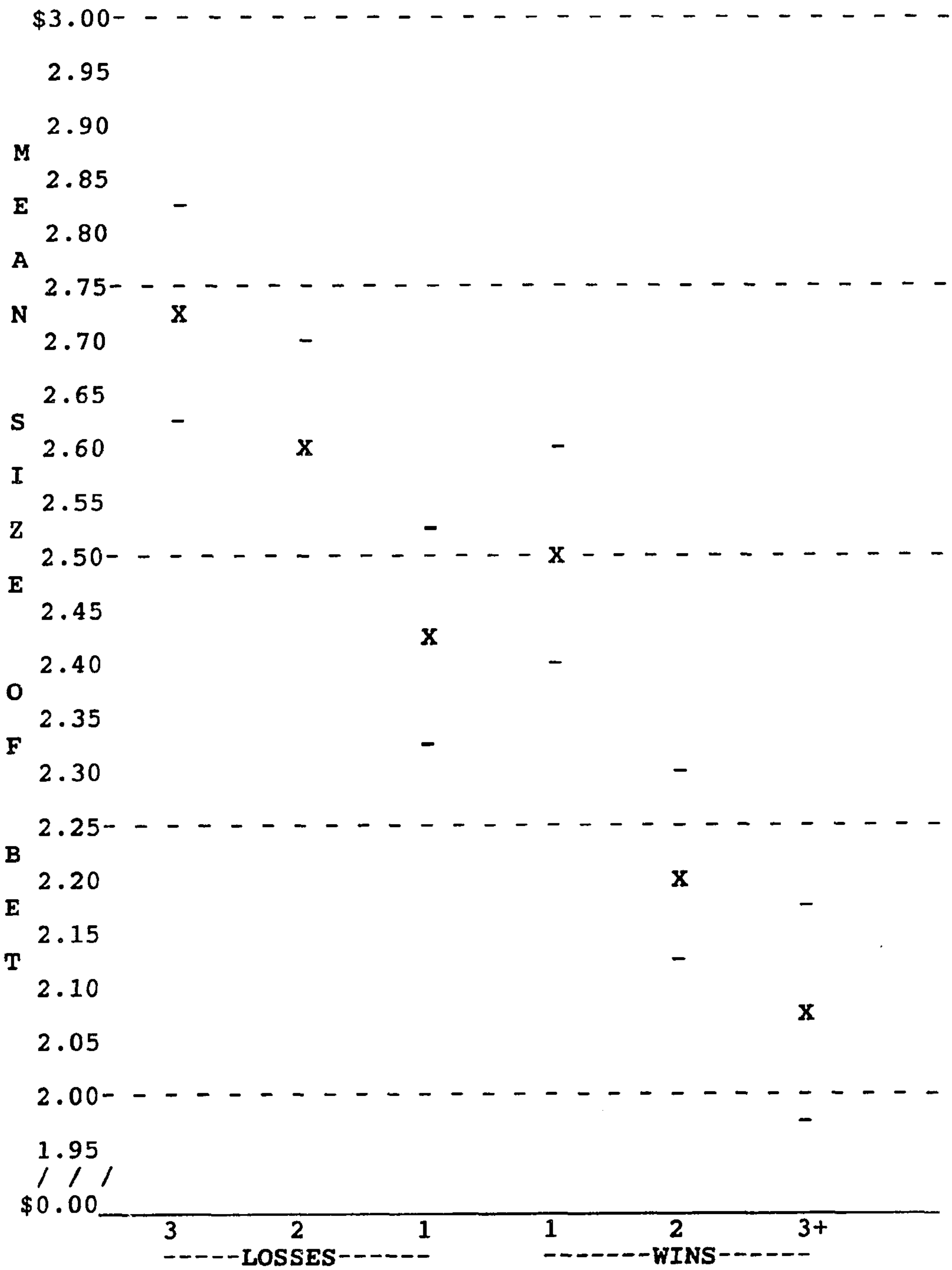

Figure 1: Mean bet size for all subjects (N = 127) immediately following consecutive sequences of losses or wins (Brackets represent estimated standard error of the mean)

TABLE 8: Bet size for the pure Novelty Seeking subject group (n = 38) immediately following consecutive sequences of losses or wins.

Outcome Sequence	Bet Size Measures		
	Median	Mean	Standard Deviation
3+ Losses	2.87	2.78	1.16
2 Losses	2.72	2.60	1.26
1 Loss	2.50	2.45	1.12
1 Win	2.41	2.46	1.11
2 Wins	2.22	2.22	1.13
3+ Wins	1.90	2.13	1.19

TABLE 9: Bet size for the pure Harm Avoidance subject group (n = 34) immediately following consecutive sequences of losses or wins.

Outcome Sequence	Bet Size Measures		
	Median	Mean	Standard Deviation
3 or more consecutive Losses	2.91	2.72	1.04
2 consecutive Losses	2.72	2.57	1.20
1 Loss	2.50	2.42	1.06
1 Win	2.55	2.49	1.00
2 consecutive Wins	2.17	2.23	1.03
3 or more consecutive Wins	2.01	2.17	1.14

TABLE 10: Bet size for the pure Reward Dependence Modified subject group ($\underline{n}$ = 37) immediately following consecutive sequences of losses or wins.

	Bet Size Measures		
Outcome Sequence	Median	Mean	Standard Deviation
3+ Losses	2.91	2.70	1.00
2 Losses	2.72	2.63	1.13
1 Loss	2.54	2.46	.98
1 Win	2.53	2.40	1.01
2 Wins	2.12	2.16	.93
3+ Wins	2.01	2.03	1.07

TABLE 11: Bet size for the pure Persistence subject group ($\underline{n}$ = 32) immediately following consecutive sequences of losses or wins.

	Bet Size Measures		
Outcome Sequence	Median	Mean	Standard Deviation
3 or more consecutive Losses	2.85	2.63	1.02
2 consecutive Losses	2.80	2.69	1.17
1 Loss	2.78	2.54	1.05
1 Win	2.72	2.59	1.09
2 consecutive Wins	2.40	2.39	1.07
3 or more consecutive Wins	2.28	2.38	1.17

of the gambler's fallacy, the standard deviations indicate that there was ample variability between subjects,supporting the idea that the present gambling task can be used as a tool with which to examine personality differences.

C2. Overview of the Analyses

The analyses examining the relationship between the TPQ dimensions and betting behavior are divided into three parts. First, Pearson correlations on the pure samples evaluate the initial hypotheses. Second, using pure sample correlations and total sample semipartial correlations, exploratory analyses examine additional contributions of each TPQ dimension to each of the betting behaviors. Third, interactions between dimensions are examined using semipartial correlations on the total sample.

C3. Examining the Initial Hypotheses

Novelty Seeking (NS). The initial hypothesis regarding NS was that the dimension would be positively related to bet size, particularly early on while the task was most novel.

A pure NS sample of subjects was examined for the independent relationship of NS to mean bet size (regardless

TABLE 12: Correlations of Novelty Seeking (NS) with mean bet size during different 50 trial periods in the gambling task, for the pure NS sample subjects.

Trials	Pure NS Sample Subjects Completing 201 trials	All Possible pure NS Sample Subjects
1 - 50	.323* (n=32)	.323** (n=38)
51 - 100	.257 (n=32)	.269* (n=38)
101 - 150	.075 (n=32)	.103 (n=37)
151 - 200	.109 (n=32)	.111 (n=34)
201 - 250	.091 (n=32)	.091 (n=32)

KEY
* p <= .10
** p <= .05
*** p <= .01

of previous outcome), during the five different 50 trial periods in the gambling task (see Table 12). For those 32 subjects who completed at least 201 gambling trials (so as to have participated in the fifth trial period of 201-250), the results indicate that there was a trend towards a positive correlation between NS and higher mean bets during the first period (r = .323, p <= .10). The removal of the restriction regarding trials completed (i.e., the restriction of only including those subjects who completed more than 200 trials), lead to a nearly identical correlation for this larger group of subjects (n = 38), but the result was now significant (r = .323, p <= .05). In addition, there was also a trend towards a positive correlation during the second period among this larger group of subjects (r = .269, p <= 10). An overall examination of the correlation coefficients indicated a general reduction in the size of correlations for NS over time. Consistent with the initial hypothesis, the results indicated that NS was related to increased bet size, but only towards the beginning of the task. It is interesting to note that NS was unique among the personality dimensions in displaying this decreasing relationship to bet size over the course of the task. It alone displayed a significant result solely in the first period (see Tables 3X and 4X in Appendix B)

Harm Avoidance (HA). The initial hypothesis was that subjects high in HA would be sensitive to losses, but that their response would depend upon their level of NS. Those who were high in NS were predicted to make larger wagers after losing in order to actively win back what they had lost, while those low in NS would bet less after losing in order to passively avoid further loss.

A restricted sample of subjects was examined for the independent relationship of HA to betting patterns in subjects who were either above or below the mean of NS. The sample was restricted to those subjects within one standard deviation of the mean on RDM and P, thus forming a "semi-pure" sample, in which subjects could freely vary only upon NS and HA, the variables of interest. Correlations between HA and betting were determined separately for subjects above versus below the mean on NS, in order to test the initial prediction.

Correlations based upon bets placed over the entire task are presented in **Table 13**, while **Table 14** examines only those during the first half. Results were similar in both tables, but correlations tended to be strongest during the first half, when the task was most novel, and the

TABLE 13: Correlations of Harm Avoidance (HA) with gambler's fallacy measures for subjects above and below average on Novelty Seeking (NS), among subjects who are average on the remaining TPQ dimensions.

Measures of the Gambler's Fallacy	Level of Novelty Seeking: Below Mean ($\underline{n}$=28)	Above Mean ($\underline{n}$=26)
3+ Losses / 1 Loss	-.181	.335*
1 Win / 3+ Wins	.111	.032
Losses / Wins	-.025	.064

KEY
* p <= .10
** p <= .05
*** p <= .01

TABLE 14: Correlations of Harm Avoidance (HA) with gambler's fallacy measures for subjects above and below average on Novelty Seeking (NS), during the 1st half of the task only, among subjects who are average on the remaining TPQ dimensions.

Measures of the Gambler's Fallacy	Level of Novelty Seeking: Below Mean ($\underline{n}$=28)	Above Mean ($\underline{n}$=26)
3+ Losses / 1 Loss	-.274	.397**
1 Win / 3+ Wins	.104	.314
Losses / Wins	-.178	.135

KEY
* p <= .10
** p <= .05
*** p <= .01

contribution of NS appeared most important. Therefore, the following discussion focusses upon the results from the first half of the task. Results tended to support the initial hypotheses. Among the group high in NS, HA was correlated with an increase in bet size during losing streaks ($r = .397$, $p <= .05$), an indication of the gambler's fallacy. Among those low in NS, the sign of the correlation was negative (as expected), but not significant ($r = -.274$, $p > .05$). Thus, the results supported one aspect of the hypothesized interaction of HA and NS; those who were high on both characteristics tended to display the gambler's fallacy to a greater extent than other people.

Reward Dependence Modified (RDM). The initial hypothesis regarding the original RD dimension (i.e., a prediction of increased stability in bet size), pertained primarily to P, which will be treated as a separate dimension. RDM is basically left as a factor involving increased sensitivity to rewards. As such one would expect increased bets following wins.

A pure RDM sample of subjects ($\underline{n} = 37$) was examined for the independent relationship of RDM to bet size (See Table 15). Strongly consistent with the nature of the revised dimension, RDM was positively correlated with bet size

TABLE 15: Correlations of Reward Dependence Modified (RDM) with different types of bets, for the pure RDM sample subjects.

	(RDM) Reward (n=37)
Bets after Specific Outcomes	
3+ Losses	.
2 Losses	.
1 Loss	.
1 Win	.420***
2 Wins	.396**
3+ Wins	.326**
Bets after Winning &/or Losing	
Losses	.
Wins	.399***
All Bets	.296*
Measures of the Gambler's Fallacy	
3+ Losses / 1 Loss	.
1 Win / 3+ Wins	.
Losses / Wins	-.403***

KEY

* $p <= .10$
** $p <= .05$
*** $p <= .01$

following one, two, and three or more consecutive wins (r = .420, $p <= .01$; r = .396, $p <= .05$; r = .326, $p <= .05$, respectively). This pattern of results lead to a negative correlation between RDM and the loss/win ratio (r = -.403, $p <= .01$). This indicates that subjects higher in RDM were less likely to display this form of the gambler's fallacy.

Persistence (P). The initial hypothesis regarding the original RD dimension pertained primarily to P. Subjects high in P were predicted to maintain a more consistent pattern of betting, less affected by the consequences of previous bets. Such subjects should therefore be less likely to display the gambler's fallacy.

A pure P sample of subjects (n = 32) was examined for the independent relationship of P to measures of the gambler's fallacy (see **Table 16**). P was found to be significantly negatively correlated with one of the measures. While the average subject tended to reduce the size of their bets while on a winning streak, individuals high in P tended not to reduce them as much (r = -.402, $p <= .05$), maintaining a more consistent level of bet size (see **Tables 7 and 11**).

TABLE 16: Correlations of Persistence (P) with measures of the gambler's fallacy, for the pure P sample subjects.

Measures of the Gambler's Fallacy	(P) Persist (n=32)
3+ Losses / 1 Loss	.
1 Win / 3+ Wins	-.402**
Losses / Wins	.

KEY

*	$p <= .10$
**	$p <= .05$
***	$p <= .01$

C4. Exploratory Analyses of Individual TPQ Dimensions

Following the generally supportive initial analyses, exploratory analyses attempted to further examine the relationship between each TPQ dimension and each of the betting measures. Pure samples for each dimension were examined first. These results are summarized in **Table 17**. In addition to those results which were part of the initial hypotheses, certain other information emerged. First, HA was found to be positively associated with the tendency to reduce bets while on a winning streak, a variant of the gambler's fallacy ($r = .345$, $p <= .05$). This result had not been predicted, but it probably should have been, as a reduction of this kind allowed high HA subjects to <u>avoid losing</u> all that they had just won on the previous bet. Second, further light was shed on the finding in the initial analyses that P was associated with more stable betting while on a winning streak. This effect appeared to result from larger than average bets after a series of wins, rather than smaller bets after a single win. Finally, NS did not appear to play any significant role in pure samples during the entire task nor in the first half, though trends toward increased mean bet size were more numerous during the first half (see **Table 18**). Recall that NS was significant for overall mean bet size during the first 50 trials (see **Table 12**).

TABLE 17: Correlations of individual TPQ dimensions with different types of bets, for pure sample subjects.

	(NS) Novelty (n=38)	(HA) Harm (n=34)	(RDM) Reward (n=37)	(P) Persist (n=32)
Bets after Specific Outcomes				
3+ Losses	.	.	.	.
2 Losses	.	.	.	.
1 Loss	.	.	.	.
1 Win	.	.	.420***	.
2 Wins	.268*	.	.396**	.352**
3+ Wins	.	.	.326**	.387**
Bets after Winning &/or Losing				
Losses	.	.	.	.
Wins	.	.	.399***	.322*
All Bets	.	.	.296*	.
Measures of the Gambler's Fallacy				
3+ Losses / 1 Loss	.	.	.	.
1 Win / 3+ Wins	.	.345**	.	-.402**
Losses / Wins	.	.	-.403***	.

KEY

* p <= .10

** p <= .05

*** p <= .01

TABLE 18: Correlations of individual TPQ dimensions with different types of bets, for pure sample subjects, during the 1st half of the task.

	(NS) Novelty (n=38)	(HA) Harm (n=34)	(RDM) Reward (n=37)	(P) Persist (n=32)
Bets after Specific Outcomes				
3+ Losses	(.182)	.	.	.
2 Losses	(.208)	.	.	.
1 Loss	.308*	.	.	.
1 Win	.299*	.	.337**	.
2 Wins	.298*	.	.370**	.350**
3+ Wins	.290*	.	.	.373**
Bets after Winning &/or Losing				
Losses	.	.	.	.
Wins	.310*	.	.345**	.327*
All Bets	.296*	.	.292*	.305*
Measures of the Gambler's Fallacy				
3+ Losses / 1 Loss	.	.	.	.
1 Win / 3+ Wins	.	.299*	.	-.318*
Losses / Wins	.	.	-.357**	.

KEY

* p <= .10

** p <= .05

*** p <= .01

Similar exploratory analyses were also carried out for the entire sample using semipartial correlations (Tables 19 and 20). One interesting characteristic of the latter analyses was that all TPQ dimensions except P tended to correlate with the gambler's fallacy in the form of the loss/win ratio, though NS displayed only a trend. Because of the relative independence of each semipartial correlation, the multiple regression of NS, HA, and RDM together correlated more strongly with loss/win than any single dimension alone ($R = .381$, $p <= .01$).

Comparison of the pure sample and semipartial analyses lead to a number of observations. First, associations for semipartial analyses tended to be weaker than those of the pure samples, which is reasonable given the greater control afforded by "pure" samples. Another general observation was that significant results in the semipartial analyses tended to involve losses, while those in the pure samples tended to involve wins. This had not been predicted and its meaning remains unclear at present.

A third observation involved the relationship that each TPQ dimension displayed with measures of the gambler's fallacy. Recall that overall, subjects tended to bet more while on a losing streak (as measured by the ratio of bets at 3 or more losses/1 loss), less while on a winning streak

TABLE 19: Semipartial correlations of individual TPQ dimensions with different types of bets, for all subjects (N = 127).

	(NS) Novelty	(HA) Harm	(RDM) Reward	(P) Persist
Bets after Specific Outcomes				
3+ Losses	.146*	.	-.157*	.
2 Losses	.	.	.	.
1 Loss	.	.	.	.
1 Win	.	.	.	.
2 Wins	.	.	.	.
3+ Wins	.	.	.	.
Bets after Winning &/or Losing				
Losses	.	.	.	.
Wins	.	.	.	.
All Bets	.	.	.	.
Measures of the Gambler's Fallacy				
3+ Losses / 1 Loss	.	.149*	-.234***	.
1 Win / 3+ Wins	.	.	.	.
Losses / Wins	.144*	.232**	-.246***	.

KEY

* p <= .10
** p <= .05
*** p <= .01

TABLE 20: Semipartial correlations of individual TPQ dimensions with different types of bets, for all subjects (N = 127), during the 1st half of the task.

	(NS) Novelty	(HA) Harm	(RDM) Reward	(P) Persist
Bets after Specific Outcomes				
3+ Losses	(.143)	.	(-.130)	.
2 Losses	.	.	.	.
1 Loss	.	.	.	.
1 Win	.	.	.	.
2 Wins	.	.	.	.
3+ Wins	.	.	.	.
Bets after Winning &/or Losing				
Losses	.	.	.	.
Wins	.	.	.	.
All Bets	.	.	.	.
Measures of the Gambler's Fallacy				
3+ Losses / 1 Loss	.	.	-.194**	.
1 Win / 3+ Wins	.	.	.	.
Losses / Wins	(.125)	.239***	-.233***	(-.081)

KEY

* p <= .10

** p <= .05

*** p <= .01

(1 win/3 or more wins), and more while losing than winning (loss/win) (see Table 7). Each of the three is a behavioral indication of the gambler's fallacy. The TPQ dimensions differed in the consistency of their relationships with the gambler's fallacy in general. RDM and HA were consistent across pure sample and semipartial analyses, while NS and P were not. RDM and HA displayed significant correlations in both sets of analyses, consistently positive for RDM and consistently negative for HA (though the specific measure of the gambler's fallacy which was involved was not always the same). In particular, whereas the average individual bet more after losing than winning (loss/win), this tendency was reduced in persons with high scores on RDM (pure sample, Table 17; semipartial, Table 19); high RDM persons tended to bet relatively more after winning (pure sample), relatively less after a losing streak (semipartial). HA consistently displayed an opposing pattern, positively correlating with the gambler's fallacy. High HA subjects bet even more than the average subject after losing than winning (semipartial, Table 19), even less after a winning streak (pure sample, Table 17). To summarize, <u>HA was positively</u> related to the gambler's fallacy, while <u>RDM was negatively</u> related.

In contrast, both NS and P did not display consistent correlations with the gambler's fallacy across the pure sample and semipartial analyses. NS displayed one positive trend, only in the semipartial analyses, with loss/win (Table 19). P was negatively correlated, only in the pure sample (Table 17). High P subjects tended not to reduce their bets while on a winning streak as much as low P subjects.

For additional comparison, Pearson correlations on the entire subject group were also examined (Table 21). The strength of corresponding associations in the Pearson r and semipartial analyses were roughly similar, implying that there was a relationship of each TPQ dimension to betting that was relatively independent of the other personality characteristics.

C5. Exploratory Analyses of Interactions between Dimensions

Further exploratory analyses examined interactions between TPQ dimensions. Interactions were examined only in semipartial analyses of the entire sample of subjects, not in the pure samples for each TPQ dimension. Interactions do not occur in pure samples because only one dimension is allowed to vary.

The focus of the analyses was upon two-way interactions involving either NS or P or both. This was because each had displayed main effects in the semipartial analyses which

TABLE 21: Correlations of individual TPQ dimensions with different types of bets, for all subjects (N = 127), during the 1st half of the task.

	(NS) Novelty	(HA) Harm	(RDM) Reward	(P) Persist
Bets after Specific Outcomes				
3+ Losses	.	.	-.152*	.
2 Losses	.	.	.	.
1 Loss	.	.	.	.
1 Win	.	.	.	.
2 Wins	.	.	.	.
3+ Wins	.	.147*	.	.
Bets after Winning &/or Losing				
Losses	.145*	.	.	.
Wins	.	.	.	.
All Bets	.	.	.	.
Measures of the Gambler's Fallacy				
3+ Losses / 1 Loss	.	.	-.195**	.
1 Win / 3+ Wins	.	.	.	.
Losses / Wins	(.125)	.251***	-.240***	-.166*

KEY

* p <= .10
** p <= .05
*** p <= .01

were inconsistent with those from their respective pure samples. Despite significant pure sample results (NS with larger bets at the beginning of the task, P with consistent bet size while on a winning streak), each was nonsignificant in the semipartial analyses (though NS displayed a trend). It was hoped that the presence of interactions in semipartial analyses would help to resolve these differences in results.

The analyses focussed only upon the three measures of the gambler's fallacy, and in particular upon the loss/win betting ratio. The analyses involved stepwise multiple regression in which two-way interactions entered into the equation if, and only if, they added significantly ($p <= .05$) to the prediction of gambler's fallacy measures above and beyond the contribution of the main effects of each of the four individual dimensions (Cohen & Cohen, 1983).

One interesting discovery was that very high and very low levels of P tended to exaggerate the main effects of other dimensions. It was deviation from the mean (either above or below) which was of consequence. In other words, it was not P, but the <u>absolute value of the Z-score for P</u> which appeared to be important. The results of two-way interactions involving the absolute Z-score value of P (abbreviated AP) and the Z-scores of NS, HA, and RDM are presented in Tables 22 (over the entire task) and 23 (first half of the task only). To illustrate that both very high and very low levels of P both had the same sorts of results, analyses were also run separately on subjects above the mean and below the mean on P. The results for subjects below average in P are presented in Tables 24 (entire task) and 25 (first half only), whereas those for subjects above average in P are presented in Tables 26 (entire task) and 27 (first half only). While there were more significant effects in the analyses for the below average P subjects than for those above average, both sets of analyses indicate significant interactions involving AP.

The results were somewhat complex, but exhibited the following general patterns. First, the two-way interactions generally did increase the variance accounted for in gambler's fallacy measures (note the many significant two-way interactions in Tables 22-27). While the semipartial correlations were often weak (e.g., .2 to .3), a number of the overall multiple regression coefficients were quite substantial (e.g., for loss/win in Table 23, R=.679), accounting for 40 to 50 percent of the variance in betting. Second, among the three gambler's fallacy measures, correlations tended to be strongest and most often significant for the loss/win betting ratio (Tables 22-27). Third, correlations tended to be stronger during the first

TABLE 22: Semipartial correlations of TPQ interactions with gambler's fallacy measures for all subjects (N = 127) (individual TPQ dimensions were entered into the multiple regression before the interactions).

TPQ Dimensions	Gambler's Fallacy Measures: 3+ Losses / 1 Loss	1 Win / 3+ Wins	Losses / Wins
AP x NS			.201***
AP x HA	.232***		.339***
AP x RDM			*
NS x HA			
NS x RDM			-.150**
Multiple R	.362***		.581***

KEY * p <= .10
** p <= .05
*** p <= .01

TABLE 23: Semipartial correlations of TPQ interactions with gambler's fallacy measures during the first half of the task for all subjects (N = 127) (individual TPQ dimensions were entered into the multiple regression before the interactions).

TPQ Dimensions	Gambler's Fallacy Measures: 3+ Losses / 1 Loss	1 Win / 3+ Wins	Losses / Wins
AP x NS	.166**		.243***
AP x HA	.275***		.385***
AP x RDM	-.182**		-.179***
NS x HA			
NS x RDM			-.166**
Multiple R	.472***		.679***

KEY * p <= .10
** p <= .05
*** p <= .01

TABLE 24: Semipartial correlations of TPQ interactions with gambler's fallacy measures for subjects BELOW average in Persistence (n = 62) (individual TPQ dimensions were entered into the multiple regression before the interactions).

TPQ Dimensions	Gambler's Fallacy Measures: 3+ Losses / 1 Loss	1 Win / 3+ Wins	Losses / Wins
AP x NS			.406***
AP x HA	.403***		.379***
AP x RDM			
NS x HA			
NS x RDM			
Multiple R	.570***	.387**	.668***

KEY * p <= .10
** p <= .05
*** p <= .01

TABLE 25: Semipartial correlations of TPQ interactions with gambler's fallacy measures during the first half of the task for subjects BELOW average in Persistence (n = 62) (individual TPQ dimensions were entered into the multiple regression before the interactions).

TPQ Dimensions	Gambler's Fallacy Measures: 3+ Losses / 1 Loss	1 Win / 3+ Wins	Losses / Wins
AP x NS	.210**		.421***
AP x HA	.409***		.470***
AP x RDM	-.254***		*
NS x HA			
NS x RDM			
Multiple R	.694***		.763***

KEY * p <= .10
** p <= .05
*** p <= .01

TABLE 26: Semipartial correlations of TPQ interactions with gambler's fallacy measures for subjects ABOVE average in Persistence (n = 65) (individual TPQ dimensions were entered into the multiple regression before the interactions).

TPQ Dimensions	Gambler's Fallacy Measures: 3+ Losses / 1 Loss	1 Win / 3+ Wins	Losses / Wins
AP x NS			
AP x HA			.290***
AP x RDM			-.212**
NS x HA			
NS x RDM			
Multiple R			.461***

KEY * p <= .10
** p <= .05
*** p <= .01

TABLE 27: Semipartial correlations of TPQ interactions with gambler's fallacy measures during the first half of the task for subjects ABOVE average in Persistence (n = 65) (individual TPQ dimensions were entered into the multiple regression before the interactions).

TPQ Dimensions	Gambler's Fallacy Measures: 3+ Losses / 1 Loss	1 Win / 3+ Wins	Losses / Wins
AP x NS		.300***	
AP x HA			.367***
AP x RDM			*
NS x HA			
NS x RDM			
Multiple R		.432***	.590***

KEY * p <= .10
** p <= .05
*** p <= .01

half of the task (Tables 23, 25, & 27) than over the entire task (Tables 22, 24, 26). Fourth, despite the relative strength of the loss/win correlations, results for all three gambler's fallacy measures were alike (see Tables 22 through 27) in that whenever two or more of the gambling measures were significantly correlated with a particular aspect of personality, the correlations were always consistently positive or consistently negative (e.g., the overall multiple R for each gambler's fallacy measure was consistently positive).

Interactions involving NS and AP were similar. Both appeared to modify the strength (but not the direction) of the independent correlations of other dimensions. In other words, both high levels of NS and extreme levels of P (very high and very low) tended to increase the initial tendencies of other dimensions. As mentioned above, for example, the initial tendency of RDM was for higher levels of RDM to be associated with lower levels of the gambler's fallacy (e.g., people higher in RDM tended to bet relatively more after winning than losing, compared to persons lower in RDM). This tendency was mildly more likely in the presence of high levels of NS than low levels of NS (Table 23, NSxRDM, $r=-.166$, $p<=.05$). This initial RDM tendency was also more likely for extreme rather than average levels of P (Table 23, APxRDM, $r=-.179$, $p<=.01$). In contrast, the initial tendency of HA was for higher levels of HA to be associated with higher levels of the gambler's fallacy (e.g., people high in HA tended to bet relatively more after losing than winning, as compared to persons low in HA). This tendency was more likely in the presence of extreme levels of P rather than average levels of P (Table 23, APxRDM, $r=.385$, $p<=.01$). NS did not interact significantly with HA in this set of analyses, but recall that it did in results mentioned earlier (Table 14).

In addition to interactions with HA and with RDM, NS and AP also interacted with one another, leading to positive correlations with measures of the gambler's fallacy (e.g., Table 23, APxNS, $r=.243$, $p<=.01$). An attempt to explain and integrate all of the results is presented in the following discussion.

D. Discussion

D1. Examination of Initial Hypotheses

The purpose of the present investigation was to examine the relationship between personality and risky decision making. In order to examine this relationship, the suitability of the chosen measures was first demonstrated. With regard to personality variables, a factor analysis of

Cloninger's TPQ in the present population of college students produced four independent factors (i.e., Novelty Seeking <NS>, Harm Avoidance <HA>, Reward Dependence Modified <RDM>, and Persistence <P>), with means and distributions generally consistent with Cloninger's national sample (Cloninger, et al, 1991; See earlier remarks in the Results and Discussion of the TPQ Replication Study). With regard to decision making, the gambling task created for the present study produced an overall gambler's fallacy pattern as measured across subjects. The gambler's fallacy was evidenced on the task by larger average bets after losing than winning, larger bets after many losses than one loss, and larger bets after one win than many wins. Both the decision making and personality variables contained enough variability between subjects such that correlations between the two types of measures were not restricted by range.

Results were generally supportive of the three original hypotheses for the gambling study. First, as predicted NS was found to be associated with increased bet size only during the beginning of the task, when it was most novel. Second, subjects higher in HA were found to be more likely to increase their bets while on a losing streak, but only if the subjects were also above average in NS. Such persons had been predicted to increase their bets in order to actively win back what they had just lost. However, it had also been predicted that subjects high in HA, but below average in NS, would be more likely to reduce their bets while losing (in order to passively avoid further loss), and this result was not found to be significant. Third, as predicted P was associated with increased consistency of bet size regardless of previous outcome, though the effect was significant only during winning streaks. A separate hypothesis was not made for RDM (because it was initially assumed that the RD scale was unitary and the initial hypothesis was more pertinent to P), though it was found that subjects higher in RDM tended to make larger bets after winning, a result which is consistent with the scale's conceptual basis (Cloninger, 1987a).

While all the TPQ dimensions were jointly implicated in the prediction of betting patterns, evidence supported the notion that each made a unique, independent contribution. First of all, analysis of the pure sample for each TPQ dimension resulted in significant effects (e.g., see results of initial hypotheses above), indicating that even in isolation every dimension was independently related to betting behavior. Further support came from an examination of the total sample pool. In the larger sample, there was a rough equivalence in the size of the semipartial and Pearson r correlations for each aspect of betting.[27] This comparison is relevant because the Pearson r for each dimension indicates its total overall correlation with betting, while the semipartial correlation indicates that part of its correlation which is independent of its relationship with each of the other dimensions. The rough equivalence of the two types of correlations indicates that the contribution of each dimension was largely independent. This provides support for Cloninger's (1987a) general assumption that the dimensions are independently generated and lends convergent validity to the results of the factor analysis of the TPQ which found four independent factors.[28]

In addition to an examination of initial hypotheses, exploratory analyses were also performed, focussing upon interactions between personality dimensions. These interactions added significantly to the variance accounted for in patterns of gambling. While individual correlations were often weak ($r<.3$), in combination the various TPQ dimensions and interactions among them were able to account for between 40 and 50 percent of the observed variance in

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[27] The specific semipartial analyses referred to here are those in which only the main effects of the four TPQ dimensions were entered into the multiple regression, but not their interactions. The latter will be addressed at a later point.

[28] The independence of the dimensions is hypothesized to originate genetically, an issue which is clearly beyond the scope of the present investigation.

gambler's fallacy patterns. This is a substantial amount of variance for a general personality questionnaire to predict of a specific behavioral measure. The examination of interactions between TPQ dimensions helped shape a tentative interpretation of the results. P played an important part in these interactions, and is therefore examined first in the following discussion of each individual TPQ dimension. Interactions are presented as they relate to the interpretation of each dimension individually. An integration of the major findings is then attempted, followed by a discussion of future studies.

In the following discussion it should be kept in mind that the guiding thesis of the present investigation was that decision making is to some extent subjective, and that the TPQ dimensions are related to this subjectivity. Each of the dimensions was hypothesized to relate to a specific subjective aspect of a decision making situation: HA to loss, RDM to gain, NS to uncertainty in the immediate environment, and P to framing.

D2. The Role of Persistence (P)

The initial expectation for the newfound dimension of P was that high P subjects would simply display more consistent sized bets from trial to trial, relatively unaffected by previous outcome, and would therefore be less likely to display the gambler's fallacy. As mentioned above, a test of the initial hypothesis in the pure P subject sample provided some support for this view. High P subjects tended to be more consistent than others in their bets while winning. In contrast to the pure sample results, however, there were no significant results for P in the overall subject sample.

The inconsistency of results lead to exploratory analyses of interactions between P and other TPQ dimensions. In these interactions it was found that extreme scores on P (very high or very low) were associated with an exaggeration of the initial tendencies of other dimensions. For example, extreme P scores appeared to accentuate the tendency of high HA subjects to display the gambler's fallacy, while at the same time, appeared to make high RDM subjects less likely to do so.

These analyses lead to the emergence of a broader characterization of the P factor, which retains the core of the original concept, provides a reasonable integration of the current results, and is related to concepts discussed by other researchers in decision making (e.g., Kahneman & Tversky, 1984; Rachlin, 1989; Tversky & Kahneman, 1981; Yates & Stone, 1992), personality (e.g., Mischel, 1984), and other fields of psychology (Skinner, 1969). The separation of P from the original RD dimension (reviewed earlier in detail) means that P is <u>not necessarily associated with reward</u>. This appears to make some intuitive sense; a person can exhibit persistence for a variety of reasons. For example, while one person might be persistent in order to seek rewards, another might be persistent in order to avoid harm. If P is untethered from RD, then it can be used for a broader variety of purposes. The person who consistently avoids an unpleasant situation is being persistent in a sense. He/she is being consistent and stable over time.

Just as persistence might be motivated by different factors, it might also be expressed in different ways. Behavior which remains the same from trial to trial is perhaps the simplest form of persistence. It is manifested in the present gambling task as a bet size which remains stable, regardless of previous outcomes. However, it is also reasonable to label as "persistent" the behavior of a person who consistently increases the size of his/her bets whenever losing (i.e., one who consistently displays a form of the gambler's fallacy).

Persistent behavior in whatever form tends to be regarded as evidence of some sort of internalized rule or strategy (at least from a cognitive perspective). Rules, strategies, and persistent behavior imply that the person possesses a long-term perspective of a particular situation. A pattern of behavior is maintained because it is viewed as most likely to lead to the outcome that the person desires in the long run (at least as compared to the other alternatives which the individual has considered). In other words, a strategy involves a way of framing a decision. The frame in this case involves a long-term perspective. Persistence, as exhibited in a pattern of behavior, is the implementation of a strategy over a period of time. As reviewed in the introduction, framing can have a significant impact on decision making (e.g., Kahneman & Tversky, 1984; Rachlin, 1989; Tversky & Kahneman, 1981; Yates & Stone, 1992).

This broader characterization of P, as being motivated by a variety of factors and taking a variety of forms, was able to provide a reasonable integration of the current results. In the simple case of the pure P sample, for example, there was little variability on HA, RDM, and NS. Because subjects were average on each of these dimensions, they were not particularly sensitive nor insensitive to harm, rewards, or novelty. There was little to motivate the development of specific internalized strategies in high P individuals. In addition, there was little that environmental stimuli could do to provide external constraint on the bets of low P subjects. It is understandable then, that the pure P sample displayed relatively little difference in mean bet size due to previous wins and losses (the size of the gambler's fallacy as measured across subjects was relatively small in the pure P sample). It might also be reasonable to expect that in this fairly simple context, higher levels of P would, as was found, act to further stabilize bet size across levels of wins and losses. In the pure P sample, the only outcomes which lead to any real change in bet size were wins, and P tended to reduce such changes. Stable betting from trial to trial can be viewed as the simplest default strategy of a high P person, in the absence of further motivation. In contrast, subtle interactions between P and the other dimensions might be expected to result from the more variable and complex context of the total subject sample.

Before attempting to explain the results for P in the larger subject sample (where it displayed interactions with other TPQ dimensions), it should first be noted that the organization of the present gambling task was highly structured and redundant, a simple repetitive succession of 50/50 bets.[29] As such, an individual with biased sensitivity to particular environmental signals could fairly

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[29] The structure, of course, was intentionally created for purposes of control, though it certainly introduces limitations, as discussed in a later section.

easily develop a basic strategy which could be useful throughout the largely invariant task.[30]

If the P dimension measures the tendency to use strategies, then subjects highest in P should hold an advantage over other people in developing and consistently using strategies, thus leading them to exaggerate the independent initial tendencies motivated by HA and RDM. This was in fact the pattern of results found in exploratory analyses among those subjects above average in P. Very high levels of P increased the tendency for high HA subjects to display the gambler's fallacy (e.g., to bet more after losing than after winning) and for low HA persons not to do so. At the same time P exaggerated the tendency for high RDM subjects not to display the pattern (e.g., not bet more after losing than after winning) and for low RDM persons to do so.

Interestingly, very low levels of P also lead to the same results, exaggeration of the independent tendencies of both HA and RDM. This pattern of results had not been expected, but it may have also resulted from the highly structured and redundant nature of the gambling task. If

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[30] The reasons why certain strategies might appeal to subjects with particular sensitivities will be discussed at a later point. The NS interactions with P were unique in certain respects, and their description and interpretation will be presented separately, in the section on NS.

very high P subjects are the most likely to form long-term internal strategies, then very low P subjects should be least likely to form them. Lacking such strategies, subjects lowest in P would be expected, by default, to be more affected by current environmental stimulation. Very low P subjects should be most likely to frame situations based upon short-term consequences. Because the gambling task was so highly repetitive, the exaggerated sensitivities would be expected to lead to consistent patterns of responding. In other words, among subjects extremely low in P, the structure of the immediate consequences of betting (winning and losing) should lead to consistent exaggerated patterns of behavior. This was the pattern found among the group of subjects below the mean in P. Subjects lowest in P displayed the most extreme patterns of betting. Low P subjects were most likely to display the gambler's fallacy when they also possessed high levels of HA, and least likely to do so when they had high levels of RDM.

In sum, the results indicated that both very high and very low levels of P tended to exaggerate the independent effects of HA and RDM. A reasonable synthesis emerged from the exploratory analyses. In the very high P subjects, the effects are thought to have resulted from internal strategies based upon a long-term view of the consequences of betting, while in very low P subjects, the effects are hypothesized to have been due to short-term environmental consequences and the structure they provided. Because the gambling task was so simple, structured, and repetitive, there was little difference between patterns of betting based upon repeated responses to immediate environmental consequences and betting patterns based upon a long-term strategy. Both extremes appear to have been similarly effective. Both short-term and long-term perspectives involve a way of framing a situation. The concept of framing and its relevance to betting patterns will be discussed in more detail following further review of the current results.

D3. Reward Dependence Modified (RDM)

With the removal of P from the original RD dimension, the modified factor, RDM, became fairly homogeneous. The remaining three subscales (Sentimentality, Attachment, and Dependence) all loaded highly on a single factor. The homogeneity of the remaining RD subscales is a fairly consistent finding in previous studies (Cloninger, 1988; Cloninger, et al., 1991; Kozeny, et al., 1989; Svrakic, et al., 1991; Waller, et al., 1991).[31]

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[31] Though, as reviewed in the introduction, some of the studies used slightly different versions of the TPQ (Kozeny, et al., 1989; Svrakic, et al., 1991; Waller, et al., 1991), and in one of the four subgroups in Cloninger's national sample, black males, the Dependence subscale appeared to form a separate factor

The results for RDM were fairly straightforward. They supported the hypothesis that the dimension involves response to signals of reward (Cloninger, 1987a). In the pure sample analyses, RDM was positively related to bet size following any series of wins, but had no relationship to bets following losses. Because of this pattern, RDM also varied inversely with the gambler's fallacy in the form of the loss/win ratio (no change in bet size while losing and larger bets while winning leads to reduction in the loss/win ratio) in the pure sample. The latter result was also evident in the larger overall sample, where RDM was also associated with the tendency *not* to increase bets while on a losing streak. The results in the simpler context of the pure RDM sample suggest that the negative relationship with the gambler's fallacy arose from an increased response to signals of reward, in the form of winnings on previous trials. This is consistent with the conceptual foundation of the RDM scales (Cloninger, 1987a).

(Cloninger, et. al., 1991). Regarding the latter, however, the number of individuals sampled in this subgroup was smaller than that of any of the others, males regardless of race were less likely to return the surveys, and stratified random sampling was not carried out on black subjects due to procedural difficulties in the study. Still, the issue of gender and ethnic differences would probably benefit from further study.

D4. Harm Avoidance (HA)

Whereas high levels of RDM were associated with a decrease in the gambler's fallacy, HA displayed a positive association. In the pure HA sample, those highest in HA tended to reduce the size of their bets while on a winning streak by the largest degree, as measured by the 1win/3win ratio. This pattern, a variant of the gambler's fallacy, was not predicted as one of the original research hypotheses, though perhaps it should have been. The reduction of bets while on a winning streak has the clear effect of avoiding the complete loss of recently acquired winnings (at least it avoids complete loss on the current bet). While the results are certainly not conclusive, it is reasonable that someone who responds intensely to signs of aversive stimuli (i.e., someone high in HA) would display such a pattern. It is hard to imagine why someone would act in this way if they were not concerned that what had just been won might now be lost. A person responding to signals of reward would most likely continue to make similar (if not larger) wagers while on a winning streak, as was found in the pure RDM sample. In the total sample, those highest in HA were most likely to display the gambler's fallacy as manifested in a larger loss/win ratio. All the results were therefore consistent in displaying a positive correlation between HA and the gambler's fallacy. Furthermore, it appears that this relationship arose from the tendency of high HA subjects to decrease bets while winning, a pattern which enables such subjects to somewhat passively avoid losing all of what they had just won.

Interactions between HA and other TPQ dimensions were also found. Interaction between HA and NS had been predicted. Among subjects with above average levels of NS, HA was positively associated with the tendency to increase bet size while on a losing streak. A similar interaction was also found between HA and extreme scores on P (either very high or very low), as mentioned above. While the nature of the interaction between HA and P was not exactly the same as between HA and NS, each reflects a similar sort of interaction. The implication of both results for HA is that under certain circumstances those who were highest in HA were the most likely to increase their risk taking (by increasing the size of their bets while on a losing streak). This type of result can be seen as indicative of a heightened sensitivity to aversive signals among high HA subjects, but it is more difficult to view it as passive avoidance. Instead, it appears to be an active attempt to win back what has just been lost.[32]

[32] It should be noted that the positive relationship between HA and increasingly large bets while losing was not a universal result. For example, it was not found among subjects below average in NS. Here, the correlation was negative (-.274 in the first half of the task), but not significantly so. A significant negative

Passive avoidance is a component of HA in Cloninger's model (1987a), but it does not appear to be a necessary component. Cloninger hypothesized that HA measures the "heritable tendency to respond intensely to signals of aversive stimuli, thereby learning to inhibit behavior to avoid punishment, novelty, and frustrative nonreward" (p. 575). Sensitivity to aversive signals therefore appears to form the primary source of the HA dimension, while passive avoidance is a secondary learned response to such signals. In addition, Cloninger strongly distinguished between genotypic and phenotypic levels in his model. The dimensions are genetically based and predicted to interact at the level of behavior (the latter point will be expanded upon below).

Waller and his colleagues have also questioned the necessity of passive avoidance for HA (Waller, et al, 1991, p. 19). Based upon a comparison of the TPQ with Tellegen's MPQ (Multiple Personality Questionnaire), they suggested that HA was not specifically a measure of behavioral inhibition (e.g., passive avoidance) as measured by the MPQ Constraint scale, but more a measure of Negative Emotionality. Cloninger's HA scale is composed of the subscales: Anticipatory Worry (HA1), Fear of Uncertainty (HA2), Shyness with Strangers (HA3), and Fatigability (HA4),

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relationship had been predicted.

which on the whole seem to focus more on a description of emotional concerns than upon behavior (or the inhibition of behavior indicative of passive avoidance). Tellegen's identically labelled measure of Harm Avoidance is a subscale of MPQ Constraint, and attempts to measure avoidance of risky and adventurous activities. Only one of Cloninger's HA subscales (Fear of Uncertainty) was particularly correlated with MPQ Harm Avoidance, and even it displayed a higher correlation with Stress Reaction (part of the Negative Emotionality scale). In general, interactions between subscales on MPQ Constraint subscales and TPQ HA were weak.

While passive harm avoidance does not appear to be a necessary component of HA, according to Cloninger's model (1987a) it does appear to be the only behavioral response to which HA should lead. Cloninger (1987a) stated that,

> environmental influences on harm-avoidant behavior are shared among the three dimensions. More specifically, in response to novel stimuli, the novelty-seeking dimension leads to active-approach behavior, whereas the harm-avoidance dimension leads to inhibited or passively avoidant behavior. The resulting behavior is the balance between these influences on active approach and passive avoidance. Likewise, in response to frustrative nonreward, reward dependence predisposes to

> continued reward-seeking behavior, whereas harm avoidance predisposes to extinction of behavior; again, the resulting behavior is the balance between these influences on maintenance and extinction (p. 575).

To the extent that increasing one's bets while on a losing streak is indicative of active avoidance, and to the small degree that HA was positively associated with such behavior, the present results are difficult to reconcile with a view of HA as solely responsible for passive avoidance. Nonetheless, the present results do appear to support the core concept underlying HA, which is a sensitivity to signals of aversive stimuli. Perhaps "Harm sensitivity" would be a better label for this dimension.

One argument which could be raised regarding the present study is that the subjects had no chance to display passive avoidance, since they were not given the option of not playing the gambling task. This is true, though in lieu of that option, high HA subjects could have chosen to bet less, which would have appeared more consistent with passive avoidance. Nonetheless, the lack of opportunity for passive avoidance does limit interpretation of the present results regarding HA. A future study will attempt to remedy this limitation (see below).

D5. Novelty Seeking (NS)

The results for NS indicated an intriguing dual role for this dimension. Like HA and RDM, NS is said to involve sensitivity, in this case sensitivity to novelty, in the form of rarity, surprise, or change in the immediate environment. The results for the pure NS sample tended to support this assumption. Like P, however, NS also appeared to serve as a frame for decision making, leading to a number of interesting interactions with other TPQ dimensions.

The initial hypothesis for NS as an independent dimension was that it would lead to larger bets early in the gambling task. In Cloninger's (1987a) model, NS was hypothesized to involve a tendency to respond with intense excitement to novel stimuli. Since any task is most novel at the beginning, NS was expected to have its impact there. This hypothesis was supported in the pure NS subject sample. The positive correlation of NS with bet size was significant only during the first 50 trials, and thereafter the size of the correlations tended to approach zero. It is interesting to note that NS was unique in displaying this pattern. None of the other dimensions displayed either the early significant correlation or the drop off in correlation size.[33]

In addition to the independent relationship of NS with bet size, NS also interacted with other TPQ dimensions. Among the group of subjects below average in NS, HA did not affect one's pattern of responding following losses.[34] In contrast, in the group above average in NS, people who were higher in HA tended to be more likely than others to make increasingly large wagers after repeatedly losing, thus displaying a form of the gambler's fallacy. Subjects high in both NS and HA had been predicted to wager in this way in order to quickly win back what they had just lost, thus <u>actively</u> avoiding loss.

The NS by RDM interaction was also examined. It too was found to be significant. Independently, RDM tended to be negatively related to the gambler's fallacy. This relationship was more pronounced at higher levels of NS, particularly as measured by the loss/win ratio.

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[33] P was the only other dimension which was significantly associated with bet size at all, a positive correlation coming during the second 50 trials.

[34] However, HA did display a <u>non</u>significant negative correlation with a reduction in bets following increasing numbers of losses.

To summarize, the interactions of NS were similar to those of P. Both tended to modify the degree of both the positive correlation of HA and the negative correlation of RDM with measures of the gambler's fallacy. The interpretation of NS which emerged from the analyses as a whole was generally consistent with Cloninger's (1987a) model. The model indicates that in addition to novelty, NS also involves sensitivity to cues for potential rewards or potential relief from punishment. The current interpretation is that high NS subjects tend to explore the present environment, seizing opportunities to actively approach potential rewards, or actively avoid potential harm. For a person high in RDM, the concern is upon gains, so the opportunity is taken to make relatively larger bets after winning than after losing. For a person high in HA, the concern is upon loss, so the opportunity is taken to actively avoid loss by making relatively larger bets after a losing streak in order to recoup immediately preceding losses. High NS is similar to low P in that both involve a short-term time frame. However, NS is hypothesized to involve the active emphasis upon the present moment, while in low P the lack of a long-term strategy leaves the individual in the present moment by default.

Absent from the discussion thus far has been the interaction of NS and P with regard to the gambler's fallacy. In the present discussion of the gambler's fallacy, NS and P have been primarily interpreted as frames of reference within which harm and reward are judged. Findings for NS and P, apart from their interaction with HA and RDM, therefore require explanation.

There were two such significant interactions between NS and P, and they were consistent in showing that high levels of NS and extreme levels of P (either very high or very low) were associated with an increased degree of the gambler's fallacy. In below average P subjects, those who were lowest in P and highest in NS, displayed the gambler's fallacy to the greatest extent, as measured by the loss/win ratio. In the group of subjects above average in P, those who were highest in P and highest in NS displayed the greatest degree of the gambler's fallacy while on a winning streak, during the first half of the task only, as measured by the 1win/3win ratio.

These interactions may have resulted from the tendency of high NS and extreme P to exaggerate the overall tendency of the present subject sample to display the gambler's fallacy. The similarity between high NS and low P in emphasizing the present moment has already been mentioned.

Therefore, it is not surprising that they would complement one another in exaggerating effects in the below average P group. The interaction in the above average P group, however, is somewhat more difficult to explain. To some extent high NS and high P might be thought of as opposites. The former emphasizes the present moment and the latter the long run. A person who is preoccupied with the present moment might have difficulty developing a long-term agenda. The present gambling task, however, may have been so simple and repetitive that this did not prove particularly problematic, and it may in fact have been beneficial to be sensitive to immediate environmental stimuli in speeding the development of a strategy (this interaction was significant only during the first half of the task). It should be clear, however, that the present comments are speculative, and that further study will be required to specify more fully the nature of these dimensions and their interactions.

D6. Time Frames and Decision Making

A number of researchers have pointed out distinctions relevant to short- and long-term time frames (e.g., Mischel, Shoda, & Rodriguez, 1989, Skinner, 1989). For example, Skinner (1969; see review by Reese, 1989) distinguished between "contingency-governed" and "rule-governed" behavior. Contingency-governed behavior is learned through its short-term consequences (e.g., reward and punishment). Learning of such behavior can be drastically reduced by even brief delays between response and consequence. The short-term time frame of such associations appears similar to that hypothesized for high NS and low P. In contrast, rule-governed behavior is learned primarily as language-based rules which do not require previous experience of consequences. Rachlin (1989) cited the example of a person learning the rule "stop at red lights and go at green lights" (p. 353) without having previously been in an accident or received a ticket. Rules and strategies are learned because they presumably reflect long-term contingencies which pertain to a situation. For example, running red lights will, sooner or later, lead to a negative outcome. Rule-governed behavior is similar to high P in the present study, though the necessity of language encoding, while certainly important, is not considered necessary in the present formulation of P.[35]

The work of Mischel appears to be particularly relevant to the present hypotheses (Mischel, et al., 1989). He and his colleagues have conducted a number of studies on the delay of gratification in young children. One method they used was to offer a child (mean age of about 4 years) a

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[35] It is possible that stable behavioral strategies might occur even in the absence of language, particularly in other animal species.

choice between a small immediate positive outcome (e.g., one marshmallow) and a larger delayed alternative (e.g., two marshmallows). The researchers then investigated various manipulations of the situation to examine their effect on the amount of time that children would wait for the larger prize. One finding was that children could wait much longer when the rewards were out of sight than when they were exposed. This powerful effect exemplifies what Mischel called "stimulus control," the power of the present environment to structure the behavior of individuals (Mischel, 1984, p. 353). It is hypothesized to correspond in the present study with the short-term time frame associated with high NS and low P. Such individuals tend to focus upon the immediate possibilities evident in the current situation.

Even under the stimulus control of the current environment, some flexibility may remain. In order to maintain experimental control, Mischel's basic procedure included stimuli that were chosen to be regarded as rewarding by young children. In addition, the room in which the children were placed was designed to be free from other distracting stimuli. As any teacher or parent knows, such control is not generally available in the outside world. Children and adults are usually in a position to choose the stimuli to which they will attend, and responses can be quite idiosyncratic. The presence of a large dog on a short leash might have had a variety of effects upon the behavior of individual children in Mischel's studies, possibly including crying and petting. In the present investigation, the subject's immediate environment could be viewed in a variety of ways, as potentially beneficial or harmful, thus the interactions found for NS and for low P with other dimensions are reasonable.

Stimulus control over the choices of children was not found to be all powerful in Michel's studies. For example, children were able to wait much longer when they thought about the exposed prize as a picture rather than a real reward, or when they thought of the exposed reward as a reminder of the long-term contingency or reason for delaying gratification (Mischel & Baker, 1975). These examples display the power of thoughts and strategies in helping individuals overcome the control of current stimulation. Their power, however, is not limited exclusively to escaping from the control of the current environment. Some strategies can even exacerbate short-term concerns. For example, delay was more difficult for children who were asked to focus on the arousing qualities of the rewards, such as the crunchy, salty taste of the pretzel for which they were waiting (Mischel, & Baker, 1975; Moore, Mischel, & Zeiss, 1976). Thus, Mischel and his colleagues found that thoughts and strategies could be put to a variety of uses. The tendency to spontaneously engage in such strategizing is hypothesized to underlie the dimension of P, which also appeared to be put to a variety of uses in the present study, depending upon the particular concerns of the individual (A future study will examine self-report questionnaires regarding the use of strategies in order to test this issue).

It is also interesting to point out that delay of gratification appears to be a stable characteristic (e.g., Shoda, Mischel, & Peake, 1990). The delay displayed by four year old children was positively correlated with outcomes more than 10 years later. Significant relationships were specifically found for the condition in which children were exposed to rewards without being given any instructions. Children in this condition had to spontaneously devise strategies to help themselves wait (e.g., covering their eyes with their hands so that they could not see the exposed rewards) (Mischel, et al., 1989). The ability to produce a long spontaneous delay in this situation was associated with "academic and social competence and the ability to cope with frustration and stress in adolescence" (Shoda, et al., 1990, p. 978).

D7. Integrating the Findings

As mentioned earlier, it is the present thesis that the process of decision making is to some degree subjective and that the TPQ dimensions are related to this subjectivity. Furthermore, each TPQ dimension is thought to play a specific role. As reviewed in the introduction, it has been recognized for centuries that the subjective value (known as "utility") that a person places upon a good may differ from its objective amount (Bernoulli, 1738/1954; Bentham, 1823/1968). For example, one is likely to enjoy one's first meal of the morning more than the fourth. The subjective value of most goods increases with amount, but at a rate that decreases as more of the good is accumulated (see Rachlin, 1989, p. 81).

In addition, individuals tend to treat losses and gains differently with regard to risk taking (e.g., the reflection effect, escalation situations, and the gambler's fallacy - see earlier mention of these in the introduction). As evidenced by Kahneman and Tversky's (1984) work, most people tend to be more risk taking when decision situations are framed as avoiding losses (like death) rather than obtaining gains (like saving lives), even when the situations and choices are objectively identical.[36]

In real life situations individuals tend to be free to frame their own decisions. In the present gambling task, chances of winning and losing were equal, allowing individuals to choose which type of outcome to emphasize. The gambler's fallacy can serve as a way of measuring an individual's relative emphasis on losses and wins, especially as measured by the loss/win betting ratio. It is hypothesized that high RDM subjects tended to frame around gains, while high HA subjects tended to frame around losses.

It is reasonable that subjects who continued making relatively large wagers after winning (versus after losing), tended to be higher in RDM. Such subjects were presumably more pleased by the idea of winning than other people, and thus made larger bets after wins, but they were not particularly disturbed by the thought of losing (assuming average HA levels). In all, they were less likely to display the gambler's fallacy.

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[36] Though, as mentioned in the introduction, this pattern can be reversed when people are dealing with highly unlikely outcomes, such as buying lottery tickets or insurance policies (Kahneman & Tversky, 1984, p. 345). Even such cases, however, are consistent with the notion that losses and gains are treated differently by most people.

In contrast, subjects higher in HA were presumably more upset by the thought of losing than other people, but were not particularly pleased by the idea of winning (assuming average RDM levels). More than other people, high HA subjects tended to bet less and less after consecutive wins. This may have been an effort to avoid losing what had just been won.

These formulations of HA and RDM share some similarity with those of previous researchers who have focussed upon decision making, including Atkinson (Atkinson, & Litwin, 1960), Lopes (1987), and Zuckerman (1990) (see earlier mention in the introduction). Each of these researchers has presented a motivational account of risk taking, and each mentioned both positive (achieving success - Atkinson; potential - Lopes; approach - Zuckerman) and negative (avoiding failure - Atkinson; security - Lopes; withdrawal - Zuckerman) components. In the present conceptualization, RDM and HA fit into this positive-negative distinction, respectively.

The present view is most similar to Atkinson's (Atkinson & Litwin, 1960). Lopes (1987) and Zuckerman (1990) appeared to imply that their positive and negative components were part of a single dimension of value, while

Atkinson measured each separately, as independent factors.[37] HA and RDM are assumed to be separate from one another for a number of reasons (see also the earlier discussion of the independence of all four dimensions). First of all, they formed two uncorrelated, independent factors on the TPQ. This meant that scores on HA were not related to scores on RDM. For example, subjects who were high on HA were no less likely to be high on RDM, and vice versa. Secondly, the two dimensions were each independently associated with gambling behavior, as has been discussed. These findings support the view that HA and RDM do not serve as opposite ends of a single continuum of value which extends from positive to negative. Rather, they appear to form two separate, independent dimensions of value which can combine additively to affect behavior, as they did in predicting the gambler's fallacy.[38]

While RDM and HA are hypothesized to separately value positive and negative events, respectively, NS is proposed to separately value novelty, in the form of rarity, surprise, or change in the immediate environment. As

[37] Though, as stated earlier, Lopes (1984) in an earlier article considered the possibility of a separation of positive and negative factors.

[38] The independence of positive and negative personality components has also been hypothesized by Tellegen (1985), as discussed in the introduction, though Tellegen did not focus particularly upon decision making.

predicted, NS was positively correlated with larger bets only at the beginning of the task. Unlike RDM and HA, however, NS is inherently a time dependent dimension. Its focus is upon what is new, and what is new does not remain so for long. It is conceivable therefore that NS may also act as a time frame within which decision situations are evaluated. This conception is tentatively proposed to account for the separate interactions NS displayed with RDM and HA, respectively. NS is hypothesized to have shortened the time frame for RDM and HA, focussing the high RDM individual's attention upon what had just changed for the better, and the high HA person upon what had just changed for the worse, thereby modifying the relationship of each to the gambler's fallacy.

P is also hypothesized to have acted as a time frame modifier in the present study. It also appeared to modify the relationships of RDM and HA to the gambler's fallacy. Both very high and very low levels of P exaggerated the effects of the latter two dimensions. The tentative conclusion drawn from the data was that in very high P subjects, the effects resulted from internal strategies based upon a long-term view of the consequences of betting, while in very low P subjects, the effects resulted from short-term environmental consequences and the structure they provided. The results for very low P were similar to those for high NS.

In many situations, short-term and long-term considerations come into conflict. This certainly appears to have been the case for the young children in Mischel's studies who were trying to choose between a small reward now and larger one later (e.g., Mischel, et al., 1989). However, it is hypothesized that the present gambling task was so simple, structured, and repetitive, that there was little difference between patterns of betting based upon repeated responses to immediate environmental changes and betting patterns based upon a long-term strategy. Consistent use of either time frame appears to have been effective.

While the present investigation is only a first step, the approach taken appears to hold potential for improving our understanding of both personality and decision making. The original hypotheses were generally supported by the results. In addition, the combination of TPQ dimensions was able to account for almost 50 percent of the observed variance in the gambler's fallacy (as measured by loss/win). This is a considerable amount of variance for a general personality questionnaire to predict of a specific behavioral measure, particularly since the subject sample was basically an unselected group of college students (i.e., not a sample chosen so as to exhibit any particular gambling patterns).

Part of the reason for the strength of the resulting multiple regression may have been due to the operationalization of the gambler's fallacy. The measures chosen were not dichotomous, but continuous. In other words, rather than simply classifying subjects as either displaying or not displaying the gambler's fallacy, each of the chosen measures (e.g., loss/win) allowed for a continuous range of values, thus increasing the sensitivity of the measure. In addition, the averaging together of many trials (e.g., all wins) most likely improved the reliability of the measures. The sensitivity of the behavioral measures probably contributed to the opportunity to find a sizable multiple regression in the present study.

The results help to elucidate the nature of the TPQ dimensions. The individual relationships between the TPQ dimensions and gambling behavior were generally supportive of the roles assigned to them by Cloninger, while the higher order effects help to elucidate possible modes of interactions between the dimensions in guiding behavior. The distinct separate roles found for P and RDM in relation to gambling support the suspicions of personality researchers who have questioned the homogeneity of the RD scale (e.g., Waller, et al., 1991).

The results also have implications for the gambler's fallacy. Previous research has tended to focus upon this pattern of betting as an overall phenomenon found in group data. Explanations have tended to focus upon cognitive errors such as the belief in the "law of small numbers" (Tversky & Kahneman, 1971), a belief that if the last few outcomes have strayed from the overall expected ratio, a corrective bias in the other direction should shortly follow (e.g., a series of wins means that losses will soon follow). There has been little regard for why some individuals display the gambler's fallacy while others do not. The current study is a step in that direction. Whether a bridge can be built between traditional cognitive explanations and the present formulation remains to be seen. For example, it may be found that persons high in HA may be more likely to develop a belief in the law of small numbers.

D8. Limitations of the Present Investigation

It should also be noted that there are various patterns of behavior which can be termed the gambler's fallacy (three of which were used in the present study), but that does not mean that all are equivalent, particularly in their relationships with dimensions of personality. The different ratios used in the present study (3loss/1loss, 1win/3win, loss/win) did not result in identical findings. The strongest results tended to be found for loss/win which is the only one of the three to compare bets following the two different types of outcomes (losses and wins) and should therefore have been most sensitive to individual differences in sensitivity to reward and harm.

More generally, the present task was quite restrictive. Subjects had only one choice, whether to increase or decrease the amount of their bets. They could not choose higher or lower odds. They could not choose not to bet. They could not even choose "heads" or "tails" as in the flip of a coin. The availability of such options in even simple games of chance may limit the generalizability of the present results.

In addition, the present task was not as consequential for subjects as gambling in the real world. There was little money at stake ($5.00 in initial stakes) and that had been provided by the experimenter. However, these limitations should have reduced the likelihood that any significant results would be found on the present task, particularly since the focus was upon personality dimensions hypothesized to be sensitive to losses and gains. In addition, doing well, or not doing badly can be motivating in and of themselves, particularly in the group situation in which subjects were tested. Still, it is possible that more consequential stakes might significantly alter the present results.

D9. Future Directions

It should be clear by now that the present investigation has raised more questions than it has answered. Planned future studies will attempt to address some of them. One plan is to examine subjects' self-reported strategies on this sort of task. It is not necessary that subjects be aware of their behavioral patterns, but if P is regarded as the tendency to engage in strategies, which are often verbally encoded, then high P subjects should be most accurate in describing their own patterns. High NS subjects might be most likely to report becoming bored by the end of a repetitive task. High RDM subjects should be most likely to emphasize wins, and high HA persons, losses. In addition, since HA is positively associated with the gambler's fallacy, it may be found that high HA subjects are more likely to hold beliefs such as the law of small numbers (e.g., "If I've just been winning, then I'm due to lose."), or some other similar assumption (e.g., The more I've won, the more I can lose.")

Another issue which remains to be addressed is the relationship between HA and passive avoidance. There were some indications that HA might be related to active avoidance, but the present task did not allow subjects the option to passively avoid betting on a particular trial. A future modification of the task will allow subjects to do so. If HA is specifically related to passive avoidance then it should be positively correlated with non-bet trials. If not, and the results are otherwise similar to the present task, then perhaps HA should be considered a measure of sensitivity to harm rather than a specific response to harm, as others have suggested (e.g., Waller, et al., 1991).

The passive avoidance modification mentioned above would also provide data regarding P. Will high P subjects simply be those who are most likely to persist in playing the task? In other words, will they be least likely to passively avoid betting? If so, it would argue for Cloninger's original interpretation of P. Or will there be a more complex sort of interaction between P and other dimensions, such that high P, high RDM subjects are most likely to continue, but high P, high HA subjects are most likely to stop and stay stopped for long periods? These sorts of complex results would support the present interpretation of P as a measure of long-term strategies.

Finally, another future study might compare the utility of Tellegen's MPQ personality questionnaire to Cloninger's TPQ. The MPQ has dimensions that are of a similar nature to those of the TPQ, at least on the surface. The MPQ includes Positive Emotionality, Negative Emotionality, and Constraint (which is negatively correlated with NS), as well as more specific subscales. Tellegen's work is more specifically based upon the separation of positive and negative emotions than is Cloninger's. It would be interesting to compare the effectiveness of each questionnaire in predicting gambling behavior and to ascertain whether unique information is provided by either one.

With such a wealth of questions remaining to be addressed, it only remains to decide how best to proceed.

APPENDIX A

CITY COLLEGE
of the
CITY UNIVERSITY OF NEW YORK
Department of Psychology

CONSENT FORM

I have voluntarily decided to participate in this study. It has been explained to me that the study will involve filling out questionnaires which ask questions about my attitudes, opinions, interests, and feelings. The other type of task is a gambling game. I will be given a starting bank account equal to $5.00 at the beginning of the game, and will then make a series of bets. I will be allowed to keep whatever money I have in the bank at the end of the session. I understand that I can withdraw from the study at any time, but that I will not be allowed to keep the money in the account unless I complete the gambling game. The procedure lasts approximately 45 minutes to an hour. The information obtained from myself and other subjects will be kept strictly confidential. No one will be given access to any data identifying subjects by name. Before beginning, I have been given an opportunity to ask any questions I chose about the procedure, and am satisfied with the answers I received to the questions I raised. I also understand that at the end of the study I will again be given the opportunity to raise any questions that have occurred to me, and discuss the results, should I choose to. My behavior during the study will not have any relation to my standing in college.

PRINT NAME:______________________________

SIGNATURE:_______________________________ DATE:________

APPENDIX B

Table 1X: Orthogonal Three Factor Tridimensional Personality Questionnaire (TPQ) Solution.

A. Rotated Four Factor Matrix Solution for TPQ, based upon 428 CUNY undergraduate psychology students.

	Factor 1	Factor 2	Factor 3
NS1	-.418	.584	.
NS2	.	.782	.
NS3	.	.612	.
NS4	.	.747	.
HA1	.797	.	.
HA2	.712	.	.
HA3	.775	.	.
HA4	.699	.	.
RD1	.	.	.679
RD2 (P)	.	-.379	.383
RD3	.	.	.721
RD4	.	.	.706

Note: only loadings with absolute values > .30 are shown. Orthogonal rotation accomplished through VARIMAX (SPSS Users Guide, 1988).

Table 2X: Orthogonal Four Factor Tridimensional Personality Questionnaire (TPQ) Solution.

A. Rotated Four Factor Matrix Solution for TPQ, based upon 428 CUNY undergraduate psychology students.

	Factor 1	Factor 2	Factor 3	Factor 4
NS1	-.399	.617	.	.
NS2	.	.801	.	.
NS3	.	.524	.	-.350
NS4	.	.799	.	.
HA1	.827	.	.	.
HA2	.689	.	.	.
HA3	.799	.	.	.
HA4	.661	.	.	-.339
RD1	.	.	.686	.
RD2 (P)	.	.	.	.895
RD3	.	.	.768	.
RD4	.	.	.711	.

Note: only loadings with absolute values > .30 are shown. Orthogonal rotation accomplished through VARIMAX (SPSS Users Guide, 1988).

Table 3X: Correlations of individual TPQ dimensions with mean bet size during different 50 trial periods in the gambling task, for pure sample subjects who completed more than 200 trials.

Trials	(NS) Novelty (n=32)	(HA) Harm (n=30)	(RDM) Reward (n=27)	(P) Persist (n=27)
1 - 50	.323*	.177	-.001	.280
51 - 100	.257	.167	.333*	.379**
101 - 150	.075	.141	.285	.276
151 - 200	.109	.086	.252	.271
201 - 250	.091	.113	.296	.308

KEY
* p <= .10
** p <= .05
*** p <= .01

Table 4X: Correlations of individual TPQ dimensions with mean bet size during different 50 trial periods in the gambling task, for pure sample subjects.

Trials	(NS) Novelty	(HA) Harm	(RDM) Reward	(P) Persist
1 to 50	.323** (n=38)	.175 (n=34)	.115 (n=37)	.169 (n=32)
51 to 100	.269* (n=38)	.141 (n=34)	.298* (n=37)	.304* (n=32)
101 to 150	.103 (n=37)	.093 (n=34)	.318* (n=37)	.242 (n=32)
151 to 200	.111 (n=34)	.081 (n=32)	.157 (n=30)	.261 (n=29)
201 to 250	.091 (n=32)	.113 (n=30)	.296 (n=27)	.308 (n=27)

KEY

* p <= .10
** p <= .05
*** p <= .01

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