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Hyteresis and Uncertainty: The Effect of Uncertainty on Delays to Exit Decisions

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The effects of feedback variability and the availability of information on exit decisions in a nonprofitable venture were investigated in a computer simulated marketing scenario. Half of subjects received feedback relatively low in variability and half of subjects received feedback substantially higher in variability. Half of subjects in each variability condition had the opportunity to purchase additional information regarding their investment. Subjects receiving feedback higher in variability delayed exit decisions longer, invested more often, and invested more resources than subjects receiving feedback lower in variability. Subjects with no opportunity to purchase information delayed exit decisions longer, invested more often, and invested more resources than subjects with the opportunity to purchase information. The results are consistent with Dixit's (1992) theory of

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uncertainty and hysteresis and indicate that an uncertain environment can affect whether a decision maker continues to invest when costs are higher than profits.

Hysteresis is defined in the physical sciences as the "failure of an effect to reverse itself after its underlying cause has reversed itself" (Dixit, 1992, p. 122). In economics, this term refers to situations where removal of a temporary factor or influence on a financial system does not restore the variables in the system to their original condition (Cross, 1993; Davidson, 1993; Katzner, 1993). In particular, hysteresis is said to occur when profits fall below costs and investment does not cease and when profits rise above costs and no investment occurs (Dixit, 1992). Hysteresis has important implications for economics, organizational psychology, and management studies. It occurs often in organizations (Ferderer, 1993, Hooper & Mann, 1989, Staw & Ross, 1989), and appears to contradict theory of expected utility. According to early investment theories (Marshall, 1949), firms should maximize value and exit investments at the point that profits fall below costs. However, individuals and firms often do not follow Marshallian theory of investment; thus it has become increasingly important to determine why investors seem to violate rational choice theory. Recent research in economics and in organizational psychology has suggested that uncertain conditions may cause individuals and firms to delay exit decisions under uncertainty (Bowen, 1987, Dixit, 1989a, 1992; Kelly, 1991). Uncertainty may precipitate a "zone of inaction" where the most valuable course of action is to delay decision making until more information is gathered.

This research synthesizes theory and methodology from economics and psychology, hopefully offering a better understanding of continued investment in nonprofitable investments. Although uncertainty and financial decision making under failure are topics of interest in both psychology and economics, the fields have generally viewed the issues from dissimilar perspectives and studied it differently. This is not to say that the approaches are incompatible, but rather that they are complementary. Hence, we attempted to conduct an investigation that uses the strength of both fields to answer these questions in a manner pertinent to the study of financial decision making in both disciplines. The purpose of this investigation was to examine whether investors decrease or delay exit decisions under uncertain conditions in order to reduce uncertainty and gain information.

Decision Making under Failure

According to traditional investment theory, firms enter markets when the price of a resource exceeds the long run average cost of staying in the economic market, and firms exit markets when the price of the resource falls below average variable cost (Dixit, 1989a, 1992; Dixit & Pindyck, 1994; Marshall, 1949). If a firm does not enter the market when the net present value (NPV) becomes positive or exit the market at the point where the NPV becomes negative, then, according to traditional economic theory, the firm is behaving

irrationally and hysteresis is occurring (Ingersoll & Ross, 1992). Expected utility theory posits that because individuals and firms have shown that they value conditions of profit more than non-profit, they should display this preference consistently by exiting the situation as soon as feedback indicates that the situation is non-profitable (Camerer, 1995).

Theory of expected utility and investment theory following from it have come under fire from both economists (Camerer, 1995) and psychologists (Herrnstein, 1990). Though it withstood early tests and criticisms, more current understanding holds that it is not a universal predictor of decision making (Camerer, 1995). Herrnstein (1990) suggested rational choice theory predicts what behavior should occur under ideal circumstances but does not describe how decisions are made, while Camerer (1995) contends that utility theory is useful under a more narrow set of circumstances. Another group of economists have sought to widen the range of what is considered "rational" decision making, explaining that what seems to be irrational behavior may actually be rational under certain circumstances (Dixit, 1989a, 1989b, 1992; Dixit & Pindyck, 1994; Cukierman, 1980; Kelly, 1991). It is these researchers who have suggested that delays to exit decisions under nonprofitable circumstances may be caused by increased uncertainty.

Hysteresis and Adaptation

It is thought that hysteresis may be adaptive under conditions of uncertainty. Uncertainty, in economics, refers to variable, conflicting, or sparse feedback and information about the conditions surrounding a situation (Dixit, 1992; Episcopos, 1995; Ferderer, 1993; Pindyck, 1988, 1993). Under uncertain financial conditions, investors may delay entrance or exit in investment situations because conditions may quickly change (Busby & Pitts, 1995; Hubbard, 1994). An investment decision may be suspended until the point that uncertainty is reduced, or investing is so overwhelmingly profitable or unprofitable that it overrides the level of uncertainty. Thus, it may be rational to delay decisions to begin investing in a situation because of the "option value" of delaying investment (Bartolini, 1992; Bertola, 1989; Episcopos, 1994; Henry, 1974b). If one makes the decision to invest in an uncertain situation as soon as it becomes profitable, then one gives up some possibilities of investing in other situations, especially if there are barriers to exiting the initial situation. If it is known that the investment is unprofitable and that conditions will not change, then an investor can only lose by delaying an exit decision. However, the world is fraught with incomplete knowledge, and under these conditions uncertainty can raise the value of waiting, because the value of the investment may change in the future (Bartolini, 1992; Cukierman, 1980; Ingersoll & Ross, 1992).

Therefore, the rational point to exit a financial market under uncertainty is not always when NPV becomes negative, but rather (1) when uncertainty is decreased and the decision maker can predict if the future market will bring profit or failure, or (2) when waiting for more information is more costly than losing the option to invest in the future (Chi & Nystrom, 1995; Ingersoll &

Ross, 1992; Kelly, 1991; McDonald & Seigal, 1985). Sunk costs and irreversible investments are thought to further increase the value of delay.

Sunk costs and uncertainty. Initial sunk costs are often required to begin investment in a situation. If investment is abandoned at the exact point that price falls below costs in a situation clouded by uncertainty, and then if in the future price begins to exceed costs again, sunk costs must be reincurred to reenter (Cukierman, 1980; Dixit, 1992; Goodson, 1995; Henry, 1974a). There is a "zone of inaction" above and below the point where profits are equal to costs in which decision makers do not exit the investment situation until sunk costs have been accounted for (Dixit, 1992). Accordingly, research in organizational psychology has found that individuals are less likely to abandon a failing financial situation if there are sunk costs (Arkes & Blumer, 1985; Garland, 1990). Uncertainty compounds the effects of entrance (sunk) costs and exit costs and widens the "zone of inaction" causing investors to delay exit decisions until profits fall even further or uncertainty is reduced.

Irreversible decisions under uncertainty. A tacit assumption of early economic theory was that if an investor entered an investment scenario it could be easily exited, and if an investor exited an investment situation it could be easily reentered. This is not always the case, even when sunk costs are disregarded. Many financial decisions are irreversible to some degree. An investor is less likely to abandon an investment under uncertain conditions because the situation cannot be reversed in the future (Henry, 1974a; Ramani & Richard, 1993). Research has indicated that when decisions are irreversible, it is often more valuable in the long run to extend the "zone of action" even further and delay decision making until information is gained and uncertainty is reduced or costs are even higher above profits (Henry, 1974a; Northcraft & Wolf, 1984).

Information gathering. According to Cukierman (1980), sometimes it is more valuable to invest additional financial resources to gain more information in an uncertain situation than it is to immediately decide to exit the investment or to let additional time pass to gain more information. For a given cost of information, an increase in uncertainty about the situation can make it more profitable to invest resources to acquire more information before making an investment decision. The passage of time may reveal information that makes it possible to discriminate between profitable and unprofitable opportunities (Price, 1995). Gathering more information over time improves the expected utility of a particular investment.

Empirical Support

There is some support of Dixit's (1989a, 1989b, 1992) assessment of the effects of uncertainty on hysteresis (George & Morisset, 1993; Pindyck, 1993). However, the research has focused on hysteresis in entrance decisions. Pindyck (1993) found investment in nuclear plant production decreased as a function of uncertainty regarding the cost of production of the plants. George and Morisset

(1993) found uncertainty in the cost of capital for investment, and the profitability of investment decreased entrance in investments in Chile. Price (1995) found uncertainty in an aggregate measure of demand in manufacturing industries delayed investment in manufacturing. Although these data are correlational, and studies could not control for possible confounding factors, the data strongly suggest that uncertainty can delay investment decisions in financial markets.

Escalation and uncertainty. The escalation of commitment research in organizational psychology focuses more on increased investment under failure rather than continued investment under unprofitable conditions. Much research on escalation of commitment in social and organizational psychology has been conducted in attempt to determine why individuals violate rationality and make "erroneous" decisions to increase investment under failure (Garland, Sandefur, & Rogers, 1990; Staw, 1976; Staw & Ross, 1989). Psychologists have investigated why individuals increase their investment during failure while economists have been studying continued investment in any nonprofitable situation. Psychologists have also studied the phenomenon in a different manner; attempting to determine the reasons behind erroneous decisions rather than attempting to determine the frequency of violations as economists have done (Camerer, 1995). Further, psychologists have been more interested in individuals rather than the aggregate and in single decision studies rather than time series analyses. However, both fields have made their own contributions to the study of financial decision making under failure, and recent research in psychology has proposed an explanation in line with Dixit's (1992) theory of the phenomenon.

Decision dilemma theory proposes continued investment under failure could be due to the equivocality of the environment (Bowen, 1987). According to Decision Dilemma Theory (1987), while in the midst of situations that call for financial decision making it is often impossible to determine objectively whether success or failure will occur with further investment. Many situations labeled as escalation of commitment are labeled so only after the failure of the venture. These *post hoc* analyses are due to the primacy of hindsight over foresight, but recommitting resources that end in failure may not be errors, but decisions made under equivocal conditions (Bowen, 1987). The issue of delay is central to decision dilemma theory because investors are thought to continue investing in a "failing" situation in order to delay an exit decision because feedback is equivocal or lacks a discernable pattern. Organizational psychologists consider the theory a possible explanation of continued investment under failure (Staw & Ross, 1989), and a recent study by Hantula and DeNicolis-Bragger (in press) has found empirical support for Bowen's theory.

Studies of decision making and escalation of commitment from a behavior analytic view have used more longitudinal methodologies and have found that the variability of a history of returns (feedback) can effect financial decision making and escalation of commitment. A continuous schedule of returns, or a fixed schedule of returns is analogous to receiving relatively certain feedback, while a variable schedule of returns is more uncertain. In this research, subjects

who received schedules of continuous or fixed ratio positive reinforcement (financial feedback) for decisions ceased investment behavior as soon as positive reinforcement (feedback) was eliminated, but subjects who received a variable ratio schedule of reinforcement continued to invest after all returns stopped, until they were certain that no positive feedback would follow (Goltz, 1992; Hantula & Crowell, 1994). This research suggests that the history of uncertainty in financial feedback can influence decision making and supports Dixit's (1992) theory that present uncertainty can influence the timeliness of exit decisions.

Psychological research on information acquisition. Additional research on information acquisition in decision making shows that obtaining information about a situation can effect the decisions made, even if the information is not predictive. Investigating information requests in escalation of commitment, Conlon & Parks (1987) found that a prompted request for prospective and retrospective information decreased the tendency to escalate commitment, even when subjects did not receive the requested information, perhaps because the prompt for an information search sensitized subjects to the lack of information available, which may have decreased the tendency to escalate resources. Similarly, study of rumor in stock market trading suggests that information about a situation can effect decision making regardless of the source. DiFonzo and Bordia (1997) found information portrayed as "unreliable" significantly influenced subjects' stock trading tendencies. These studies indicate that the ability to purchase information and the content of the information may influence when individuals exit an investment situation, regardless of the source and type of information.

An Integrated Approach

Though there has been correlational support in economics, and some indirect empirical support in organizational psychology, the premise of Dixit's (1992) theory and Cukierman's (1980) hypotheses regarding uncertainty and hysteresis remain largely untested from an economic perspective. Several economists have lamented the lack of systematic empirical support for Dixit's theory (Campa, 1993; Episcopos, 1995; Pindyck, 1993). The purpose of the following experiment was to test Dixit's and Cukierman's hypotheses in a controlled environment and in a manner that would help to integrate the two fields in the study of financial decision making.

HYPOTHESES

There were three main hypotheses tested in this investigation:

HYPOTHESIS 1. *Subjects who receive relatively uncertain feedback will delay exit decisions* and *reinvest more resources than subjects who receive relatively certain feedback. The level of uncertainty is determined by the variance of the feedback (Dixit, 1992).*

HYPOTHESIS 2. *Subjects given the opportunity to purchase information regarding the outcome of their financial investment will exit sooner and invest fewer resources than those subjects with no opportunity to purchase such information.*

HYPOTHESIS 3. *Of the subjects given the opportunity to purchase information, subjects who purchase a greater percent of information regarding their investments will invest fewer resources than subjects who purchase less information regarding their venture.*

METHOD

Subjects and Setting

Students ($N = 155$) enrolled in undergraduate psychology courses participated as an extra credit option.

Apparatus

A computer program written in Delphi programming language simulated the investment scenario on IBM computers.

Scenario

Subjects were told to assume the role of a Vice President of Marketing for an American pharmaceutical company that had the opportunity to invest in the marketing of a new product for Euromed, a fictitious European pharmaceutical company. Subjects could continue to invest in the marketing of EuroMed's product until they decided to quit, or until they expended their entire budget. The decision to exit the investment scenario was irreversible. Once subjects decided not to invest, the experiment ended. If the Vice President of Marketing successfully invested, the company would retain 10% ownership of the new product. If marketing was not successful due to the Vice President's investment, then the company would lose all of the funds that were allocated. The Vice President of Marketing could exit the investment situation at any point and was held responsible for all decisions he/she made. Instructions are shown in Appendix A.

In the *information acquisition* conditions instructions indicated that the Vice President would have the opportunity to purchase information summarizing past investment performance and future conditions before the opportunity to invest.

Procedure

Subjects met in the psychology computer laboratory and were given introductory information by a trained experimenter while seated in front of a computer terminal. Following instructions and a sample investment opportunity, subjects received the opportunity to invest in the marketing of the product.

If subjects chose to invest at each opportunity, they were asked how much

they wanted to invest. Subjects could invest up to $10,000 each opportunity in multiples of $1000 by entering the amount into the computer. The feedback to subjects was the amount that profits were above costs or costs were above profits in dollars, and a time-series graph indicating net costs or profits. In all conditions, the outcome of the investment was failure, resulting in the cessation of production and marketing of the product. After their fifth and after their last investment opportunities, subjects were asked to fill out questionnaires that checked the manipulation of the independent variables and their perceived level of responsibility.

Independent Variables

Uncertainty. Subjects were randomly assigned to one of four conditions. The uncertainty variable manipulated the variance of the feedback subjects received to be either high or low. For the first two investment opportunities, feedback was identical for all subjects and indicated that profits were above costs. Following this, 12 feedback points in which mean costs were above profits were programmed into the computer in a particular order for the high and low uncertainty conditions. The variability of the 12 feedback points was determined to be substantially greater for the uncertain condition (σ^2 = $4916) than for the relatively certain condition (σ^2 = $1844), but mean costs were $5000 above profits for both conditions. If subjects continued to invest for more than 14 opportunities (the first two identical feedback statements and the 12 manipulated feedback statements) the set of 12 points was repeatedly generated in a random order until subjects ran out of funds or decided to exit the scenario.

Research has indicated that the temporal patterning, or the pattern of feedback can also affect investment behavior (Siegal & Rachlin, 1995). Because the temporal patterning of the feedback was not of explicit interest to the hypotheses tested, attempts were made to hold the "degree of patterning" in the feedback somewhat equivalent. In order to assess the degree of patterning in the high and low uncertainty conditions, the feedback data were analyzed using a 0,0,1 ARIMA (AutoRegressive Integrate Moving Average) model.[1] The first 12 feedback amounts and the means and standard deviation for the feedback, and the autocorrelations, and their *p* values are presented in Table 1.

Information acquisition. The other independent variable was the availability of information and the amount of information purchased. In the *information available* condition, subjects were asked at each investment opportunity if they wished to purchase information summarizing past and present financial conditions and future information available. The cost of the information was

[1] ARIMA determines the autocorrelations or the serial dependency of the data. An autocorrelation is expressed as the "lag" between data points, a particular lag being the number of data points between a given data point and the predicated one. The question addressed by the ARIMA 0-0-1 model was, "If point *X* is known, can point *X* and *Y* be predicted, where point *Y* is the lag?" The autocorrelations lags for the high and low uncertainty conditions were small or near zero, indicating that the two conditions were similar in their lack of temporal patterning (SPSS, 1993).

TABLE 1

Feedback Data and Descriptive Statistics and Autocorrelation through Lag 4 by Condition

	Uncertainty level	
Investment period	Low	High
1	$ 6,000	$ 6,000
2	$ 2,000	$ 2,000
3	$−5,200	$ −500
4	$−6,500	$ −9,000
5	$−4,900	$ 1,700
6	$ 400	$ −2,000
7	$−6,200	$ −9,600
8	$−5,400	$ −8,000
9	$−5,000	$ −1,000
10	$−6,100	$−11,700
11	$−4,600	$ 600
12	$−5,100	$−10,000
13	$−4,800	$ −1,500
14	$−6,700	$ −9,000
Mean	$−5,000	$ −5,000
Standard deviation	$ 1,844	$ 4,915
Autocorrelations (*p*)		
lag 1	−.072 (.70)	.003 (.99)
lag 2	−.059 (.93)	.23 (.61)
lag 3	−.10 (.95)	−.02 (.80)
lag 4	−.071 (.98)	.27 (.63)

always $3000, which was deducted from the maximum amount of resources they could invest each month and from the total resources they were able to invest. These subjects could acquire summary information about past investment and performance and qualitative information about the future financial market that could affect them. The statements about the future of the investment scenario were general in nature so as to mimic the type of information decision makers are able to gather. Details of the quantitative and qualitative information provided to those subjects who purchased information are displayed in Appendix B.

Dependent Measures

The dependent variables were delay in seconds from the first decision until exit, number of times invested, and amount invested.

Design and Statistical Analyses

The four conditions were high uncertainty/no information available, high uncertainty/information available, low uncertainty/no information available, and low uncertainty/information available. The dependent variables of total amount invested and delay in seconds until an exit decision were both intended

to measure subjects' tendency to persist. Because both variables were assumed to measure the same construct (hysteresis) and the two measures are theoretically related and statistically correlated, a 2 × 2 MANOVA was conducted to determine the effects of the two independent variables on hysteresis. Two separate 2 × 2 ANOVAs were conducted to determine the effect of the independent variables on the separate dependent variables. The effect size *r* was conducted on the main and interaction effects for the 2 × 2 ANOVAs (Rosenthal & Rosnow, 1991). A regression analysis was conducted to test the third hypothesis and determine if the percent of time subjects in the information acquisition condition purchased available information affected the amount invested. A Bonferroni procedure was used to protect against inflated alpha for the 2 × 2 ANOVAs resulting in a critical probability level of $p < .025$.

Survival analyses. Survival analysis was used to determine if the uncertainty and information manipulations affected the survival of subjects in the experiment. A survival analysis tests whether a particular manipulation enables subjects in one group to survive longer than subjects in another group. In this case, the survival analysis further evaluated whether the uncertainty and information availability manipulation affected the survival of subjects in the experimental marketing scenario. In survival analysis, a hazard rate indicates the number of subjects who start to invest in a particular investment period, but withdraw before the next opportunity (McCain, 1986). A cumulative survival rate indicates how many subjects remained in the situation in progressive trials. Analysis of survival scores produces a chi square statistic testing the null hypothesis that the subgroups are part of the same survival distribution (SPSS Inc., 1993). The phi coefficient is reported as a measure of effect (Rosenthal & Rosnow, 1991).

Perception Measures

Questionnaires were presented off-line to all subjects after the fifth and last investments to determine if subjects felt responsible for the decisions they made and to check the uncertainty and information manipulations. Answers on the responsibility measure were on a 1 (strongly disagree) to 7 (strongly agree) scale. Three distinct factors were revealed for the responsibility measure by principle components analysis and oblique rotation. The uncertainty scale checked how uncertain subjects felt when making their decisions. One factor was found for the uncertainty measure. Questions, factors and alpha levels are displayed in Table 2.

RESULTS

Manipulation Checks

Fewer subjects responded to the manipulation checks occurring after the fifth trial because a number of subjects exited the experimental scenario before the fifth investment opportunity, and were instructed to complete only the "end

TABLE 2

Responsibility and Certainty Perception Measures

Factor	Questions	α Mid	α End
Responsibility (rated 1–7) (higher more responsibility, some reverse scored)			
Perceived responsibility		.80	.72
	I was solely responsible for the allocation decisions entered into the computer.		
	The decisions regarding how much to invest were my own.		
	I did not feel personally responsible for the allocation decisions entered into the computer.		
Information considered		.78	.60
	I did not consider each allocation decision carefully.		
	I considered much information before making each allocation decision.		
	I felt I should put a lot of thought into each allocation decision.		
Bad feelings		.69	.74
	I felt badly when the product I was marketing did not make a profit.		
	Allocation decisions that were, in retrospect, poor made me feel dissatisfied with myself.		
	I didn't feel like it was my fault when either a good or bad outcome occurred.		
Uncertainty (Rated 1–7) (Higher more certain, 3, 7, 8, 9 reverse scored)			
Uncertainty		.89	.86
	The feedback I received helped me to understand how well the product was doing.		
	The feedback I received helped me to determine how my investments in the marketing of "optiflow" would turn out.		
	The feedback I received made me uncertain about whether the marketing of the product I invested in was doing.		
	The feedback I received from my investment decisions helped me to make future decisions about whether or not to invest, and about how much money to invest.		
	The feedback I received helped me to determine when to continue investing and when to exit the situation		
	The feedback I received helped me to predict the outcome of the marketing of the product "optiflow".		
	The feedback I received about the product in completely confusing, and did not help me at all.		
	The feedback I received seemed very unstable.		
	I was uncertain about the outcome of the situation because the feedback changed so much.		

of experiment" manipulation checks. Analyses revealed no overall differences between the end of experiment checks for those subjects who did fill out mid experiment manipulation checks and those subjects who did not fill out the midexperiment manipulation checks. Several subjects did not respond to the final manipulation check, probably because they did not attend to the instructions in the exit screen that indicated that subjects should fill out the final

manipulation check. Analyses revealed no overall differences in the dependent variables between subjects who completed the final manipulation check and those few subjects who failed to complete the final manipulation check.

Responsibility manipulation checks. Perceived responsibility was above the midpoint for all conditions and factors for the mid- and end-experiment assessments. The *t* tests comparing perceived responsibility for relatively certain and relatively uncertain subjects revealed no differences for both the mid- and end-experiment assessments for all factors. Similarly, comparing perceived responsibility for information available and information not available manipulations revealed no differences.

Uncertainty manipulation checks. Subjects in the information available condition perceived less uncertainty than subjects in the non-information available condition in the middle of the experiment, t (91) = 1.74, p = .043, r = .18 and at the end of the experiment, t (135) = 2.76, p = .004, r = 23. Subjects in the relatively certain condition also experienced less uncertainty than subjects receiving more variable feedback after their fifth investment, t (91) = 2.98, p = .002, r = .30 and after their last investment, t (135) = 2.32, p = .011, r = .20.

Dependent Variables

The three dependent variables measured to test the hypotheses were the total number of trials subjects invested, the delay in seconds from entrance into the experiment to an exit decision (including looking time for those in the information available condition), and the total amount of funds invested by each subject, including the amount invested in the purchase of information. The number of trials invested was measured using survival analyses. Mean values for all conditions and for each of the independent variables for all dependent variables are reported in Table 3.

Uncertainty effects. The MANOVA revealed a significant main effect for

TABLE 3

Means and Standard Deviations for Dependent Variables

Variables measured	Total delay in seconds	Overall $ invested including info	Trials invested
Relatively certain/Information	322 (256)	37,567 (36,010)	7.3 (8.1)
Relatively uncertain/Information	390 (245)	48,142 (37,787)	9.2 (7.5)
Relatively certain/No information	383 (211)	51,562 (38,649)	11.3 (8.37)
Relatively uncertain/No Information	486 (213)	69,500 (36,093)	16.2 (9.77)
Relatively certain	351 (237)	44,057 (37,642)	9.1 (8.4)
Relatively uncertain	439 (233)	59,069 (38,250)	12.8 (9.4)
Information available	358 (251)	43,189 (37,111)	8.3 (7.8)
Information not available	442 (217)	61,947 (37,998)	14.1 (9.8)
Overall	399 (237)	52,387 (38,590)	11.2 (9.1)

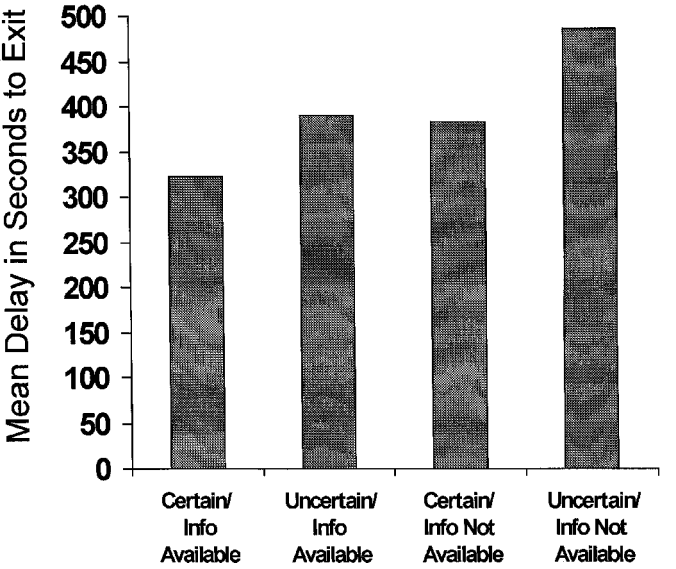

FIG. 1. Mean delay in seconds to an exit decision for all conditions.

uncertainty, F (2, 150) = 3.00, p = .05. As Fig. 1 shows, subjects receiving relatively uncertain feedback delayed their exit decisions to a greater degree than subjects receiving relatively certain feedback. The univariate main effect of uncertainty on seconds to an exit decision was found to be significant, F (1, 151) = 5.12, p = .025, r = .18. Figure 2 displays mean total investment for all four conditions. Subjects who received relatively uncertain feedback invested more total resources (dollars invested plus information costs) than subjects who received relatively certain feedback. The univariate main effect of uncertainty on total investment was found to be statistically significant, F (1, 151) = 5.64, p = .019, r = .19.

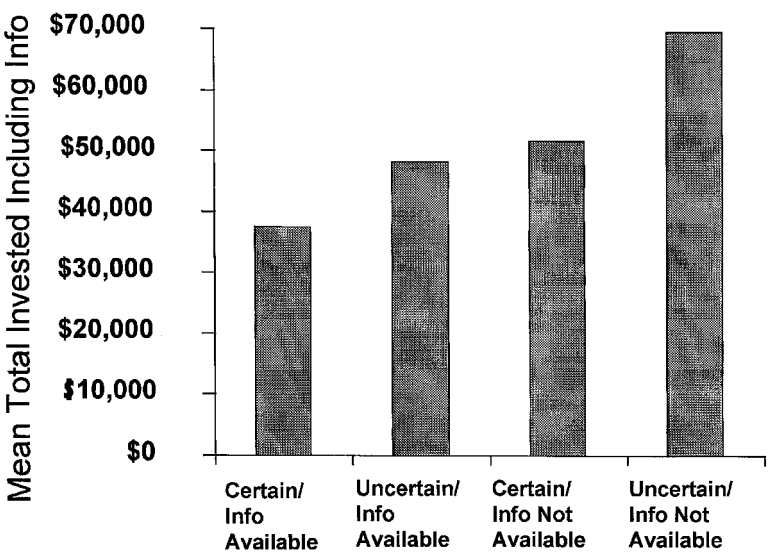

FIG. 2. Mean total investment including the cost of information for all conditions.

Figure 3 shows the difference in cumulative survival trials for all four conditions. A survival analysis found the median number of survival trials for the high uncertain condition was 12.2 trials, significantly higher than the median number of survival trials for the low uncertainty condition of 7.1 trials (χ^2 (1) = 7.4, p = .007, Φ = .22). All of these results support the first hypothesis that predicted increased uncertainty would cause greater delay to investment, greater investment of resources, and more times invested.

Information effects. The MANOVA revealed a significant main effect for information availability, F (2, 150) = 4.38, p = .01. Subjects with no opportunity to purchase information remained in the experiment longer than subjects who had the opportunity to purchase information. The main effect of information availability on seconds to an exit decision was found to be significant, (F (1, 151) = 4.3, p = .040, r = .17). Subjects with no opportunity to purchase information also invested more money (including the cost of information) than did subjects with the opportunity to purchase information. The main effect of information availability on total investment was found to be significant, (F (1, 151) = 8.68, p = .004, r = .24).

Survival analysis found that the median number of survival trials for the information available manipulation was 4.8 trials, significantly lower than the median number of survival trials for the information not available condition of 13.42 trials (χ^2 (1) = 16.2, $p < .001$, Φ = .32). These results were supportive of the second hypothesis that predicted subjects not able to purchase information would delay exit decisions longer, invest more resources, and invest more times than subjects able to purchase information.

Interaction and cell effects. No significant interactions between uncertainty

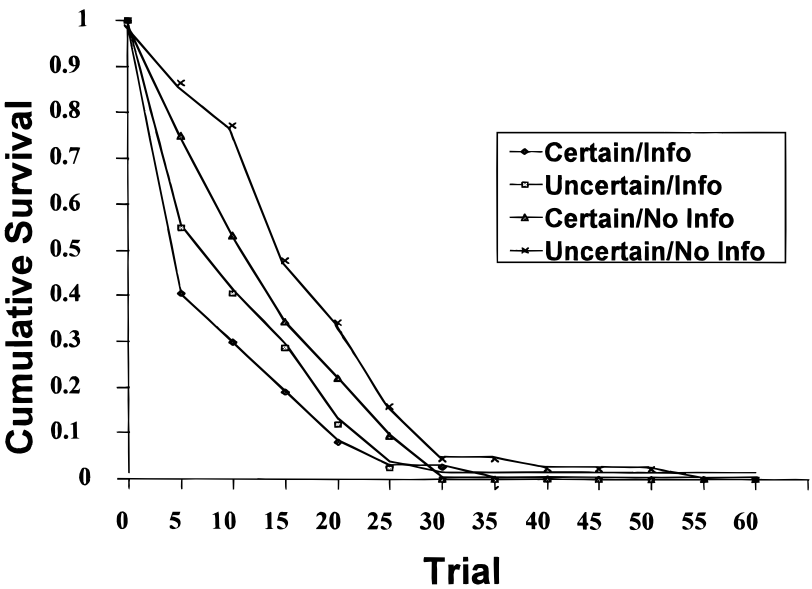

FIG. 3. Cumulative survival of subjects presented as a proportion of the total number of subjects existing in each condition for all conditions.

and information availability were revealed in the MANOVA. Nor were there significant interactions between uncertainty and information availability for the univariate ANOVAs.

Regression analysis. Examination of normality plots and histograms determined that the percent of opportunities information was purchased was positively skewed. The log root transformation was performed on the percent of information purchased and resulted in a more normal distribution. The square root transformation normalized total investment of resources.

A significant negative correlation was found between percent of opportunities information was purchased and total amount of funds invested, $r\ (74) = -.39$, $p < .000$. The regression equation for predicting total resources invested from percent of opportunities purchased information was found to be a significant predictor of total investment, ($F\ (74) = 13.54$, $p < 000$) and is presented below in Eq. (1).

$$y = 164.16 - 54.92x \tag{1}$$

These results supported the third hypothesis that predicted an inverse linear relationship between the percent of opportunities that subjects purchased information (for those able to purchase information) and total resources invested.

DISCUSSION

These results provide empirical support for Dixit's (1989a, 1992) premises about the effects of uncertainty and information on hysteresis, and are also consistent with research in organizational psychology that has found escalation of commitment is more likely to occur when decision makers have received a history of more variable feedback (Goltz, 1992, 1993; Hantula & Crowell, 1994) or more equivocal feedback (Bowen, 1987; Hantula & DeNicolis-Bragger, in press).

Manipulation checks indicated that subjects receiving relatively uncertain feedback (as determined by the variance of the feedback) perceived greater uncertainty than did subjects receiving relatively certain feedback. The manipulation checks also demonstrated that subjects with the opportunity to purchase information summarizing and interpreting investments and financial feedback perceived less uncertainty than subjects who had no opportunity to purchase this information. These checks suggest that decision makers are consciously aware of levels of uncertainty, and analyses of the dependent variables indicate that more variable feedback and a lack of information availability caused subjects to invest in more trials, invest more resources and delay exit decisions more than subjects with less variable feedback and the ability to purchase information

Subjects with the opportunity to purchase information invested fewer resources in the marketing situation than those without the opportunity, even when including the resources subjects in the *information available* condition

expended for information. These results support Cukierman's (1980) suggestion that investing resources in acquiring information may occur more often under uncertainty. The regression analysis revealed that subjects with the opportunity to purchase information who purchased a greater percentage of information invested fewer resources than subjects who purchased information a lower percentage of the time. These results provide support for the premise that decision makers adapt to uncertainty by postponing exit decisions to gain information.

Theoretical Implications

Economics. The results of this experiment support Dixit's (1989a, 1992) contention that uncertainty may engender continued investment when profits fall below costs and that hysteresis may be a reaction to a fluctuating environment. These results also support Cukierman's (1980) and Dixit's proposition that increased uncertainty may increase the value of information; when uncertainty is reduced and it becomes more evident to decision makers that the situation will have an unprofitable outcome, investors will exit the situation. It is possible, as some economists (Camerer, 1995) and some psychologists (Herrnstein, 1990), have put forth, that expected utility theory only holds true in particular situations. However, it may be possible, that if we consider time, expectations, and context, we may widen our conception of what rational behavior is.

Keynes stated that "many of the greatest economic evils of our time are the fruits of risk, uncertainty and ignorance" (Price, 1995, p. 147). However, though uncertainty has been considered a problem in financial situations, until recently few suggested failing to exit the situation as soon as profit occurs may be adaptive under uncertainty. From an economic viewpoint, failing to exit a situation as soon as profits fall blow costs has long been considered irrational, regardless of the uncertainty surrounding the situation. Some correlational field research in economics has implied that uncertainty can cause investors to hesitate to enter financial situations when a situation becomes profitable (Campa, 1993; Episcopos, 1995; Ingersoll & Ross, 1992; George & Morriset, 1993; Pindyck, 1993; Price, 1995). Dixit suggests that this hesitation may be economically advantageous. The present study is the first controlled experimental research testing the bases of Dixit's (1989) theory in exit decisions.

Subjects in this investigation made decisions that brought about general (or short term) hysteresis, which is often labeled persistence of commitment (Cross 1993). Subjects seemed to be searching for information regarding the outcome of the situation, and this may be adaptive in many cases. Under uncertainty, the "zone of inaction" is expanded, such that delay may be the most valuable option. However, the question becomes, when does general hysteresis become permanent hysteresis? And when does continued delay become irrational? Perhaps long term hysteresis is brought about by factors other than uncertainty, or is brought about in situations when uncertainty is never substantially reduced. The effects of uncertainty on long term hysteresis might be more difficult to test in controlled experimental situations.

Organizational psychology. Equivocality can be defined as the lack of pattern or predictability of feedback (Hantula & DeNicolis-Bragger, in press). Bowen (1987) suggested that feedback that is high in equivocality would cause subjects to escalate commitment because they would be under conditions of uncertainty. This experiment held the patterning of the data constant for all conditions, as assessed by autocorrelations, but the findings are supportive of Bowen's premise that increased uncertainty would cause investors to escalate commitment. Bowen (1987) also suggests that increased access to information may reduce escalation of commitment by decreasing equivocality. This research supports Bowen's premise that continued investment under failure may not always be irrational, and that information availability may reduce escalation of commitment.

These results are also consistent with the stream of research demonstrating that more variable feedback histories could engender escalation (Drummond, 1994, 1995; Goltz, 1992, 1993; Hantula & Crowell, 1994). Subjects in the relatively uncertain condition received more variable feedback than subjects in the relatively certain condition, and they invested more resources. A variable ratio history of profits and losses places decision makers under uncertainty; the prior history clouds the future. Subjects who are receiving variable feedback take longer to assess the situation and determine if it is failing or conditions are still changing. The current research expands the methodological and theoretical bases of the escalation of commitment research into an interdisciplinary view and investigates the role of information availability in financial decision making in reducing uncertainty.

Information always has some value in organizations. The value of information may be partially determined by the level of uncertainty in the environment. According to the data from this experiment, uncertainty functions as an establishing operation for information (Michael, 1993). Information becomes more valuable as the amount of uncertainty is increased. Subjects expend more resources to get information in a more uncertain environment. Feedback from decisions made may increase or decrease the level of uncertainty (Hogarth, 1981; Kleinmuntz, 1985). Sometimes the information may affect the perceived level of uncertainty, but not the actual level of uncertainty regarding the outcome of the situation. Perhaps this provides an explanation for people purchasing investment information or "tip sheets" even when the information seems to be random or unreliable. Thus, the variability that characterizes the market is an establishing operation, which also serves to motivate purchase of information that is largely useless and often costly. Decision makers seem to believe that any explanation at all is better than no explanation and it has been found that decision makers stray farther from "rational" choice when they are able to obtain useless information than when no information is available at all (DiFonzo & Bordia, 1997).

The information available to subjects in the information condition provided a summary of investment activity and of the outcome of the investments, as well as a general statement about conditions that could affect the investment scenario. This information had some forecasting properties, but an organization

in an investment situation could most likely provide this information to decision makers if they had the human or technical resources to collect and interpret the information. In some cases the costs of obtaining such information would not be the costs of gathering concealed or privileged information, but the investment of time and human resources needed to transform this information into interpretable form. In some cases information may be obtained in a form that is not useful to decision makers. In this case, the issue may be whether or not to invest the resources to interpret information and create criterion for success of an investment (Berry & Linoff, 1997). The current research indicated that this investment may be a valuable one.

Bridging the Gap in Economics and Psychology

The method used in the present study combined some design characteristics typical of organizational psychology experiments and some more typical of those used in experimental economics. Experimental economics is a relatively new approach that has come into moderate popularity mostly in the last two decade. The premise behind the origin of this line of research has been that economists have typically conducted field research in an attempt to fit data to predictive models. This method has been limited by the fact that there are many interfering factors that cannot be controlled when conducting field research (Roth, 1995). Experimental economics has attempted to borrow some of the techniques used in the behavioral sciences in order to control for a multitude of extraneous variables and isolate causality. However, although economists have begun to complement their abundance of field research with controlled experimental research, they have barely scratched the surface. Hysteresis is one of the areas where there has been little experimental research. This research studies economic issues, but employed some techniques unique to the behavioral sciences. The research on financial decision making has run along parallel, but separate lines in the field of economics and psychology and there has been little attempt to integrate the research into more comprehensive theory (Armstrong, Coviello, & Sanfrenek, 1993; Brockner, 1992; Dixit, 1989a, 1992; Garland et al., 1990; Pindyck, 1988, 1993). This research was an attempt to bridge the gap between the two bodies of research on decision making under failing conditions in social and organizational psychology and economics.

The integrated approach in this study allows analyses of differences in behavior between groups and of differences in behavior within the individual. This study analyzed behavior within groups using survival analysis and used between group analyses to study the effects of the manipulations in different groups. Though economists have often been interested in repeated decision making over time, they have mostly studied outcomes of aggregate financial decision making rather than of individual decision making. There is a often a thin veil separating the individual from the aggregate in financial decision making (Camerer, 1995). This study asked subjects to make decisions as an individual representing an institution rather than as the entire institution. In many cases one individual is behind the decision of an institution, and the

individuals in this study comprised an aggregate whose behavior could be analyzed individually and as a whole. This study also spanned the gap between psychology and economics by measuring dependent variables of interest in both fields. The use of both time and money as dependent variables allows a comparison of results from escalation of commitment research and also captures the issue of temporal dynamics so important in economics.

Generalizability

Studies in experimental economics often allocate financial incentives to subjects for the decisions they make, while psychologists argue that this incentive may distract subjects from the real purpose of the study (Camerer, 1995). This study did not use financial incentives. Situational constraints made it difficult to allocate money to subjects. Research has indicated that results from studies that did not use incentives do not differ significantly from those that did use such incentives (Camerer, 1995). The findings of this study do mimic the findings of uncontrolled economic research that found that uncertainty can cause a continuance of the status quo (Campa, 1993; Episcopos, 1995; Fernandez & Rodrik, 1991; Pindyck, 1993; Price, 1995).

Another concern with organizational research and experimental economics is that it often employs undergraduates as subjects, as was done in this study. Using undergraduates as subjects may simulate the level of uncertainty that decision makers in organizations feel. Results from escalation of commitment research has shown little difference in results depending on whether subjects are undergraduate students or MBA students (Armstrong et al., 1993; Garland & Newport, 1991).

Subjects in this study made financial decisions over time. They were able to exit the scenario at any time, but had the option to make numerous decisions. Much prior laboratory research on financial decision making has analyzed data collected from subjects who were only asked or allowed to make a single decision (e.g., Arkes & Blumer, 1985; Bazerman, Guiliano, & Appelman, 1984; Singer & Singer, 1985). Decision making in actual organizations often occurs over time. Research on decision making indicates that static, one time, decision making is very different in nature and outcome than decision making occurring over time (Bateman, 1986; Baum, 1973; Hogarth, 1981). It has also been noted that decision making under uncertainty is especially sensitive to time horizons and constraints because the true state of affairs is revealed over time (Bernanke, 1983; Langholtz, Gettys, & Foote, 1993; Garland et al., 1990; Hantula & DeNicolis-Bragger, in press).

Future Directions

Future studies should investigate the effects of varying financial incentives for “profitable” decisions and should consider longitudinal experiments in which subjects return to the laboratory over an extended time period. The credibility, the accuracy, and the nature of the information and information sources

(cf. DiFonzo & Bordia, 1997) in hysteresis situations is another area that should be investigated. Conlon and Parks (1987) found that subjects in investment simulations requested different types of information about the situation depending on whether or not they were responsible for decisions to invest. Interactions between information type, source, and decision context remain an open question. Other issues that should be investigated simultaneously with the manipulation of uncertainty are sunk costs and irreversible investment. Dixit (1989a, 1992) suggests that decision makers are more sensitive to investment when there are (sunk or exit) costs to enter or exit the investment scenario and these resources cannot be regained. Irreversible investment can aggravate the effects of uncertainty (Henry 1974a, 1994b; Ramani & Richard, 1993). If decision makers are aware that any decision they make cannot be reversed (an irreversible decision) or cannot be reversed without cost (sunk and exit costs) then the tendency toward the status quo under uncertainty might extend until profits are even further below costs or uncertainty is very low. In the present experiment, the decision to exit the scenario was irreversible; subjects could not invest again once they exited the situation. Irreversible investment is a fruitful area for future research.

The number of opportunities to invest or exit a financial situation may also determine how long one continues to invest in failing conditions. Some research has found that when there are sunk costs in an investment situation the number of opportunities that investors have to make investment or exit decisions may effect the degree of escalation or persistence (Garland et. al., 1990). Future research should investigate whether the level of uncertainty interacts with the number of investment opportunities in determining when investors will exit the situation.

Conclusions

This investigation supports Dixit's (1989a, 1992) and Cukierman's (1980) hypotheses that hysteresis in exit decisions may not be due to irrational decision making but to reactions to uncertainty whereby decision makers continue to invest in an attempt to reduce uncertainty and gain knowledge about the outcome of the situation. This research also provides some preliminary evidence that information regarding the outcome becomes more valuable as uncertainty increases. This research investigates the effects of uncertainty on financial decision making in a manner that spans the terminology and the methodology of economics and psychology, and its implications are important for economics and social and organizational psychology. Perhaps with continued replication and extension of the issues in this study economists will become less focused on modeling decisions that individuals and organizations should make and become more interested in the factors affecting the decisions that individuals do make (Herrnstein, 1990).

APPENDIX A

Directions Given to All Subjects

You are the vice president of marketing at *AmeriPharm*, a large American based pharmaceutical company. You are responsible for the decisions to invest in the marketing of different pharmaceutical products. You have just been asked by a foreign pharmaceutical company, *EuroMed*, to invest in the marketing of a new pharmaceutical product that was just approved for marketing in Europe. The newly approved product, "optiflow", has been shown to decrease the likelihood of varicose veins in adults, especially those over 55. Varicose veins can be very painful, even crippling.

The new product would initially be marketed for a trial period, during which time, you, as vice president of marketing at AmeriPharm, must decide whether to invest and how much money to invest. You may invest in the marketing of the product as many times as you deem necessary. You may invest as many or as few times as you wish until you have allocated all of your funds.

You have been allocated a total of $100,000 to invest in the promotion of the product overall. You may invest a maximum of $10,000 maximum for each single investment, which must be invested in thousand dollar intervals. You may invest from $1000 to $10,000 each time you choose to invest, or you may choose not to invest in promotion. However, if you choose *not to invest*, then you are choosing to EXIT the marketing situation. You will not be able to invest in the future. You may exit the situation by choosing not to invest, or by clicking on the "quit" button which will be displayed on your screen at all times.

You may continue to invest in the marketing of the product until funds are all allocated, or you may decide to stop investing at any marketing period. The amount of funds you have allocated and your remaining budget will be posted each time you invest. You will also receive feedback on the profits made from the product for that marketing period.

You may pull out of the marketing situation at *any time* by clicking on the "quit" button. You may also exit by deciding not to invest. The trial period will continue as long as you invest, or until your budget is completely allocated. If, at the end of the trial marketing period, profits made from the product are above the total cost of production and marketing, production will be continued on the product, AmeriPharm will retain profits made, and AmeriPharm will retain 10% ownership of the product line, but if total costs are above profits at the end of the trial period production of the product will cease. If you stop investing in the marketing of optiflow before you have allocated the maximum funds, the remainder of the money will be utilized for marketing other AmeriPharm products.

As vice president of the marketing department, you are responsible for all marketing decisions, and the funds allocated for you to invest. You *will* be held accountable for all money that is lost. Your performance evaluation will reflect your performance. After each investment you will receive information regarding profits made from the marketing of "optiflow" for that period. AmeriPharm

will retain these profits if the marketing of "optiflow" is successful. Click on the button that says "continue" if you understand the information and would like to continue with the experiment. You will first be asked to invest in a trial investment period which *will not count*.

Directions Given to Subjects in Information Available Condition

After you invest marketing funds each period you will also have the OPTION to purchase information from a consultant regarding your investment situation. You may decide before you invest each opportunity if you wish to purchase the information or not. If you purchase information you will be presented with information summarizing your past investments into marketing of the optiflow product, past and present success of your investment, and any information that is available about the future of the project. The information will cost you $3000 for each purchase. The cost of the information will be subtracted from the maximum amount of funds you have available to invest each opportunity and from your total allocation budget

APPENDIX B

Information Given to the Information Acquisition Group When They Purchased Information

Quantitative Summary Information

1. Number of times subject invested to that point
2. Total amount subject invested to that point
3. Amount invested last investment
4. Number of times subject bought information
5. Total cost of information subject bought
6. Percentage of times profits were above costs
7. Percentage of times costs were above profits
8. Remaining budget
9. Net amount of funds lost/gained

Sample of qualitative information. This information consists of general statements about conditions which could possibly effect the marketing/financial scenario of AmeriPharm and Euromed and therefore of optiflow. Subjects received one such statement each time they purchased information.

The president of **Euromed**, the European company which asked you to invest in the marketing of their product optiflow, is in the hospital due to a mild heart attack. The vice president of production **Euromed** will fill his duties for the month which he is expected out.

A war in the mideast could possibly effect the marketing of products in that area.

Modifications have been made recently in the trade regulations of several European countries in which optiflow is being marketed.

A new leader has been appointed to the Food Drug Administration (FDA) in America.

Germany has announced an aggressive economic plan that they believe will lower inflation and unemployment in East Germany.

AmeriPharm has announced a new Human Resource policy in which all expatriates are provided with 2 extra weeks vacation to visit home if they desire.

The British government recently made modifications to the amount of time that a drug must be tested before it can be approved for marketing. The modifications will go into effect May of 1998. Any pharmaceutical products manufactured after this date must adhere to these standards.

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