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When Time Is Money: Decision Behavior under Opportunity-Cost Time Pressure

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Decison-making dilemmas can arise because errors may result either from deciding too soon or from delaying decisions too long. Delay can result in lost opportunities or reductions in payoffs from the most accurate decision. This paper investigates decision processes in environments where there is time stress due to the opportunity cost of delaying decisions. First, using computer simulation, the relative accuracy of alternative decision strategies is examined in environments that differ in terms of the levels of opportunity cost of delay. The lexicographic choice rule is shown to be a very attractive decision process in situations where there is opportunity-cost time pressure. Two experiments test the adaptivity of actual decision behavior to the presence or absence of opportunity-cost time pressure along with variations in goals (accuracy emphasized vs. effort savings emphasized), dispersion in probabilities or weights across the outcomes of the choice options, and the degree of correlation among the outcomes. Subjects were generally adaptive to opportunity-cost time pressure. However, failures in adaptivity were identified when choice environment properties with conflicting implications for adaptation were present simultaneously. In particular, under opportunity-cost time pressure, subjects received a lower expected payoff when the goal was to emphasize choice accuracy than when the goal was to emphasize savings in effort. The question of when adaptivity in decision making might fail is discussed.

INTRODUCTION

"High-velocity" environments are characterized by rapid changes in technology, demand, competitors, or regulatory rules (Eisenhardt, 1989) and often involve stress due to the need to make choices under time pressure. However, such time stress is often due not so much to strict deadlines as it is to the potential opportunity cost of delaying decisions. As Eisenhardt (1993, p. 121) notes, "the decision-making dilemma in such environments comes from the fact that it is easy to make mistakes by deciding too soon and equally ineffective to delay choices or to imitate others." In particular, delay in deciding can result "in failure as. . .windows of opportunity close" (Eisenhardt, 1993, p. 121). In some cases, the longer the delay in making the decision, the lower the expected return (value) from even the most accurate of decisions. For example, if a company delays a new product introduction to get test market results, competitors may observe the test, develop their own versions of the product, and introduce these versions before the first company finishes test marketing (Ono, 1995). More generally, the company's prospects may continuously degrade with delay; the longer the delay, the more effective competitors' responses may be.

We investigate decision making under situations where there is opportunity-cost time pressure. We are interested in how people adapt their decision-making strategies (Payne, Bettman, & Johnson, 1993) when faced with opportunity-cost environments and in the possible limits or even failures in adaptivity that may arise in such environments. In particular, we focus on how people decide when there are conflicts between the processing implications of opportunity costs and the implications of other variables such as goals and the degree of conflict (intercorrelation) between outcomes.

Next, we review prior research on decision making under time pressure. Then we summarize an accuracy–effort framework for adaptive decision behavior and report a simulation study of decision strategies based on that framework. Using the simulation results and

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prior research, we develop a set of hypotheses regarding adaptivity (and possible failures in adaptivity) to opportunity-cost time pressure and report two experiments that test these hypotheses. Finally, we discuss the implications of the results for adaptive decision making.

TIME PRESSURE AND DECISIONS

Research suggests three major ways in which people respond to decision problems under time pressure. First, people accelerate their processing (i.e., spend less time processing each item of information; see Ben Zur & Breznitz, 1981). Second, processing tends to be more selective under time stress, focusing on the more important and/or negative information about alternatives (Ben Zur & Breznitz, 1981; Wallsten, 1993). Third, decision strategies may shift as a function of increased time pressure (Payne, Bettman, & Johnson, 1988; Svenson, Edland, & Slovic, 1990).

There may be a hierarchy of responses to time pressure. Under moderate time pressure, Payne *et al.* (1988) report that their subjects accelerated processing and processed somewhat selectively. Under more severe time pressure, people accelerated their processing, were even more selective, and changed strategies from a more depth-first (alternative-based) to a more breadth-first (attribute-based) pattern of processing as time pressure increased. As discussed in the next section, this shift in processing pattern is consistent with an accuracy/effort framework for strategy selection (Payne *et al.*, 1993).

The studies cited above all used deadlines to impose time stress (e.g., a time limit of 15 s per choice in Payne *et al.*, 1988). With very few exceptions (e.g., Kerstholt, 1994), the terms "time pressure" and "time constraint" are used interchangably (Svenson & Maule, 1993). Deadlines can make the use of some normative strategies impossible due to limits on how much information can be processed in a given time, thus limiting the range of feasible approaches for adapting to time pressure (Keinan, 1987). Because of our interest in studying adaptivity, we focus on situations with opportunity-cost time pressure, where there is time stress but a broad range of strategies is still possible.

THE ADAPTIVE DECISION MAKER: AN EFFORT/ACCURACY FRAMEWORK

People often have a variety of information processing strategies for dealing with judgment and choice tasks, ranging from careful and reasoned examination of alternatives to simple and fast rules of thumb (heuristics) (for an overview of the properties of various decision strategies, see Payne *et al.*, 1993, or Svenson, 1979). The strategy a decision maker uses is highly contingent upon a host of task and context factors, such as the number of alternatives available, information format, response mode, and the correlations among attributes (Einhorn & Hogarth, 1981; Hammond, 1990; Payne *et al.*, 1993).[1]

Given a set of available strategies and facing various task demands, how do people decide how to decide? One framework for explaining contingent decision behavior focuses on the accuracy and cognitive effort characterizing the available strategies (Payne *et al.*, 1993; for related ideas, see Beach & Mitchell, 1978, and Bockenholt, Albert, Aschenbrenner, & Schmalhofer, 1991). Cognitive effort has been measured by the number of elementary information processing operations (e.g., acquiring an item of information, comparing two pieces of information, or multiplying one value by another) needed to make a decision using a specified decision rule (Bettman, Johnson, & Payne, 1990). Accuracy has been measured in a variety of ways, including a comparison of the expected payoff when using a choice heuristic with the expected payoff from using a more normative rule like weighted additive value or expected value maximization.

The basic hypothesis of the effort/accuracy framework is that the strategy used to decide represents an adaptive balancing of the goals of being as accurate as possible while conserving limited cognitive resources. Although people are often adaptive decision makers, failures in adaptivity exist. For example, Kleinmuntz and Schkade (1993) note that the choice of a strategy for decision making will be based on subjective *ex ante* estimates of relative effort and accuracy and these estimates will not always be veridical. Adaptivity may also fail in situations characterized by multiple task or context variables with differing implications for adaptive processing.

A number of studies have validated the effort and accuracy model of strategy selection. Creyer, Bettman, and Payne (1990), for example, found that subjects acquired more information, took more time, were less selective in the processing of information, were more alternative-based, and were more accurate when the goal was to maximize accuracy rather than to minimize

[1] Task effects describe factors associated with the general structure of the decision problem, including time pressure. Context effects refer to factors associated with the particular values of the options in the specific decision set under consideration, such as the similarity among options. In general, task factors are more likely to be noticed a priori or early in the decision. Context factors, on the other hand, are often noticeable only after some information has already been processed.

effort (see also Stone & Schkade, 1994). Thus, there was a shift in strategies in the direction that one would predict using the effort/accuracy framework.

Stronger tests of the effort/accuracy framework have been conducted by using computer simulations of the effort and accuracy characterizing typical decision strategies to generate hypotheses about processing patterns and then carrying out experimental studies of actual decision behavior to test these hypotheses. Of particular relevance to the present studies, the simulation model of Payne *et al.* (1988) showed that certain heuristics like the lexicographic rule and elimination-by-aspects are actually more accurate than more normative procedures like additive utility under severe time deadlines (because there is not enough time to fully complete the more complex adding rule). The preferred strategies under time constraints generally involved processing at least some information about all the alternatives as soon as possible (breadth-first or attribute-based strategies). The simulation model also showed that heuristics involving attribute-based processing were relatively more accurate when the dispersion in probabilities was high rather than low.[2] In experiments with human subjects, people adapted their decision processes in ways consistent with the simulation results (Payne *et al.*, 1988), shifting decision strategies in the direction of more selective and more attribute-based processing under severe time pressure.

Interestingly, Eisenhardt (1989) found that management teams that simultaneously processed two or more alternatives in a breadth-first fashion made quicker and better decisions in "high-velocity" environments than those teams that processed alternatives using more sequential, depth-first (alternative-based) consideration of one alternative at a time (see also Judge & Miller, 1991). These results suggest that adaptivity in environments characterized by opportunity-cost time pressure may be also involve a shift toward more selective and more attribute-based processing as time pressure is increased.

In addition to adaptivity to salient task factors like time constraints and goals, people also have been shown to be adaptive to more subtle context factors like the dispersion in weights characterizing a decision problem (Payne *et al.*, 1988) and whether the correlation between outcomes is positive or negative (Bettman, Johnson, Luce, & Payne, 1993). For example, Bettman *et al.* (1993) showed that people respond to interrattribute correlation by shifting their processing strategies: when the correlations between outcomes were negative, implying greater conflict, people increased their processing and that processing was more alternative-based. Importantly, those subjects who adapted more to different correlation levels performed better in the sense of selecting options with higher values.

	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Probabilities	.20	.27	.21	.32
Gamble A	$0.69	$6.41	$2.96	$0.27
Gamble B	$0.37	$5.14	$4.38	$8.94
Gamble C	$7.53	$3.13	$7.62	$4.28
Gamble D	$7.84	$6.07	$8.70	$1.28

FIG. 1. Sample decision problem.

We wish to examine how a decision maker might change his or her strategy for processing information when faced with an opportunity-cost decision environment. Although the above research provides some guidance about expected strategy changes, we use computer simulation to investigate the effects of opportunity-cost time pressure in more detail. In particular, we examine the relative accuracy of various decision strategies and how opportunity-cost time pressure may interact with different context variables that have been previously shown to impact the accuracy of decision strategies (i.e., dispersion in weights and interattribute correlation). The simulation represents an evaluation of different strategies in various task environments by an idealized adaptive decision maker. We then use the results of the simulation and previous research to generate hypotheses for our experiments.

A SIMULATION INVESTIGATION OF OPPORTUNITY-COST TIME PRESSURE

The Decision Task

The decision task in the simulation was a risky choice. Each decision problem had four alternative gambles with four outcomes (see Fig. 1 for an example). Outcome values ranged from $.01 to $9.99. The probability that a given outcome occurs (e.g., Outcome 1) is the same for all alternative gambles. However, each gamble may have a different payoff for that outcome. Such choice problems allow us to easily relate consequences to choice among gambles in our experimental work (i.e., people can play selected gambles for real money).[3]

[2] To illustrate dispersion of probabilities, a four-outcome alternative (gamble) with a low degree of dispersion might have probabilities of .26, .29, .18, and .27. Alternatively, a gamble with a high degree of dispersion might have probabilities of .56, .06, .14, and .24.

[3] Our risky-choice context with multiple outcomes is structurally similar to riskless multiattribute choice problems (Keeney & Raiffa, 1976). Given that a good deal of research on choice processing has used riskless stimuli, much of the terminology describing processing uses the term attribute instead of outcome. We use this standard

The Decision Strategies

In solving choice problems of the kind just described, the decision maker must search among the probabilities for each outcome and the values (payoffs) associated with the outcomes for each alternative. Different decision strategies can be thought of as different rules for conducting that search. In the simulation, we examined six choice rules (equal weight additive value (EQW), lexicographic (LEX), elimination-by-aspects (EBA), satisficing (SAT), weighted additive value (WADD), and random choice (RAND); see Payne *et al.*, 1993, for definitions). The first four choice rules represent heuristics in that potential information is ignored (effort is saved) at the cost of a potential loss in choice quality (accuracy is lower). These four heuristics vary substantially in how much information is used and in how the information is used. For instance, the LEX and EBA rules are associated with the use of relatively limited amounts of information and processing of information within attributes (attribute-based), whereas the EQW and SAT rules are associated with processing across attributes (alternative-based). Also, rules like LEX, EBA, and SAT tend to be associated with more selective processing (i.e., different amounts of information are processed across alternatives or attributes). In general, greater variability or selectivity in search is associated with the use of noncompensatory decision strategies where a good value on one attribute cannot compensate for a bad value on another attribute (see Payne, 1976). The weighted additive rule and the simple random choice rule represent the complete use of information and the complete lack of information search, respectively. The WADD rule also is associated with consistent processing (the same amount of information is examined for each alternative and attribute), consideration of tradeoffs, and alternative-based processing of information. Such rules are often viewed as normative models of how decisions should be made (Keeney & Raiffa, 1976; Frisch & Clemen, 1994).

The Task Variable of Opportunity-Cost Time Pressure

One could manipulate opportunity-cost time pressure for a decision problem by reducing the payoff received as a direct function of the amount of time or effort spent in making the decision. However, that makes comparison across problems with different numbers of alternatives and attributes difficult. Consequently, we manipulated opportunity-cost time pressure by using the number of elementary information processing operations (EIPs) needed to complete the weighted additive rule in the particular decision environment being studied as a standard of comparison.

To illustrate our approach, refer to the decision problem given in Fig. 1. To implement the weighted adding strategy, a decision maker would first read the probability for Outcome 1, then the value for Gamble A on Outcome 1, and then multiply these two values. Then he or she would read the probability for Outcome 2, the value for Gamble A on Outcome 2, multiply these two values, and add that product to the product for Outcome 1. This process would continue for all four outcomes, followed by the same process for Gamble B. Then the weighted values for Gamble A and Gamble B would be compared. After similar processing for Gambles C and D, the decision maker would choose the gamble with the highest weighted value. Therefore, using the method for calculating EIPs described in Payne *et al.* (1993), there would be 32 read EIPs (acquisitions of information), 16 product EIPs (weighting operations), 12 addition EIPs (compensatory combinations of information), and 3 comparison EIPs (determining which of two values is larger) needed to solve the problem in Fig. 1 using the WADD rule, for a total of 63 EIPs. If a person used WADD or expected value maximization to choose among the alternatives, option D would be selected, with an expected value (weighted sum) of $5.44.

Now consider implementing a lexicographic rule on the same problem. The decision maker would first read the probability for Outcome 1, then the probability for Outcome 2, and then compare the two, retaining the larger. Similarly, the remaining probabilities would be read and compared to ascertain the most probable outcome. Then the values on that outcome for each gamble would be read and compared to find the largest value on the most probable outcome. The gamble with that largest value would be selected. To solve the problem in Fig. 1 using the LEX rule would require a total of only 17 EIPs (8 reads, 6 comparisons, and 3 elimination operations). The lexicographic choice rule would select option B, with a lower expected value of $5.24.

Dividing the number of EIPs needed to solve the problem using the LEX rule by the number of EIPs needed to solve the same problem using the WADD rule indicates that the LEX rule should be about 27% (17/63) as effortful as the WADD rule. Now assume that the decision environment involves an opportunity-cost, i.e., there will be value loss due to delay. Further, assume that the value loss to delay means that any

terminology below. For example, the standard term attribute-based processing describes processing where information on one attribute is examined for several alternatives before another attribute is considered. In our risky-choice context, that term will refer to examining values for one outcome across several alternatives before considering another outcome.

outcome received after the time (effort) needed to use a complete WADD strategy would lose 25% of its original value (i.e., be worth 75% of its original value). For instance, if the WADD rule were used in such an environment to select option D and Outcome 1 occurred, then the payoff would only be .75 times $7.84, or $5.88. The expected payoff in that case, given the selection of option D, would be .75 times the expected value of option D, or $4.08 (.75 times $5.44). More severe opportunity-cost environments would be associated with higher losses due to delay and hence receiving lower percentages of the original values after the decision was made.

To continue our example, if taking 63 EIPs to solve a decision in such an opportunity-cost environment means an expected value loss of 25% (you keep 75%), what would happen if you were to use a LEX rule to make the decision more quickly? First, use of the LEX rule would lead to a different choice, i.e., option B, and that option has a lower expected value, $5.24. However, one would expect that the value loss would not be as great as with the WADD rule since the decision was made more rapidly. We assume that the amount lost due to delay is proportional to the number of EIPs used by the LEX rule relative to WADD. That is, instead of a loss of 25%, the loss would be 27% of 25% (i.e., (17/63) times 25%), or roughly 6.7%. Then the expected payoff for the LEX rule would be the EV of Gamble B times the proportion of the value retained, or $5.24 times (1 − .067), or $4.89. More generally, the formula is Expected PAYOFF = $(1 - ((\text{EIPs}_{\text{Rule}}/\text{EIPs}_{\text{WADD}})^{*}$ Value Loss$))^{*}$Expected $\text{Value}_{\text{Rule Choice}}$.

Thus, there is some value loss due to using the LEX rule to decide in the opportunity-cost time pressure environment, but it is less than the value loss from using the WADD rule. This is true even though the LEX rule does not select the "best" choice in terms of expected value. Nevertheless, in this case a quicker decision using a generally less accurate heuristic (LEX) yields a higher expected payoff ($4.89) than a slower decision using the rule which is most accurate when there is no time pressure (WADD, $4.08).

In the simulation, opportunity-cost time pressure or value loss (discount) due to delay was varied across four levels: no discount, 25% discount, 50% discount, and 75% discount. These levels represent the loss in value if the decision maker uses as many EIPs as the WADD rule. The various levels of discount or value loss represent the degree to which an environment punishes delays in decision making, with higher values leading to larger losses.

Context Variables

In addition to the task variable of opportunity-cost time pressure, two context variables were manipulated in the simulation. The first context factor varied was the dispersion in probabilities (low vs. high). Probabilities of .26, .29, .18, and .27 exemplify low dispersion for a four-outcome problem, with probabilities of .56, .06, .14, and .24 an example of high dispersion. Dispersion in probabilities is a context factor that is relatively easy to notice.

The second context variable was the correlation among the outcome values. This variable was set at negative (high conflict among outcomes, or an average correlation between outcomes of −.33),[4] zero, and positive (low conflict, or an average correlation between outcomes of .6). The correlation among outcomes is more difficult to notice than the dispersion in probabilities because it requires comparing values for several alternatives on several attributes. A major question examined in our experimental work is how the presence of salient goals and opportunity-cost time pressure may interact with more subtle context factors to determine how, and how well, people adapt their decision behavior.

Procedure

The six decision rules were individually applied to 1000 decision problems in each of the 24 conditions defined by a 4 (levels of time pressure—0, 25, 50, or 75% discount) by 2 (degree of dispersion—low or high) by 3 (correlation structure—negative, zero, or positive) factorial. Payoffs for each problem were randomly generated from a distribution bounded by 0 (e.g., $0.00) and 1000 (e.g., $10.00) using correlation structures specified by using the appropriate correlation values between cells (i.e., −.33, 0, or .6) in the columns of the Microsoft Excel 5 for Windows spreadsheet representing each decision problem. The dispersion levels for probabilities were generated by using one of two methods designed to produce low levels of dispersion or high levels of dispersion, as appropriate for the condition in the simulation (see Johnson & Payne, 1985, p. 402 for details). The decision rules and simulation were programmed using Excel and Decisioneering's Crystal Ball, software for running Monte Carlo simulations using spreadsheets.[5]

[4] It can be shown that for problems with *n* outcomes, the maximum average negative intercorrelation among all pairs of outcomes is $[-1/(n-1)]$ (Green & Krieger, 1986).

[5] Note that the simulation includes some simplifying assumptions. For example, WADD weights values by probabilities, whereas other models (e.g., subjective expected utility, prospect theory) use subjective values and/or decision weights. In addition, we weight each EIP equally in our effort measure. Although different EIPs do require different amounts of time (Bettman *et al.*, 1990), earlier simulation work has shown that the simpler equal weight assumption leads to nearly identical conclusions (Payne *et al.*, 1988).

TABLE 1

Simulation Results for Accuracy of Heuristics as a Function of Opportunity-Cost Time Pressure, Correlation between Outcomes, and Dispersion in Probabilities

	Negative correlation				Zero correlation				Positive correlation			
	Discount rate				Discount rate				Discount rate			
Strategy	0%	25%	50%	75%	0%	25%	50%	75%	0%	25%	50%	75%
					Low dispersion							
WADD	607[a]	455	299	150	671[a]	504	336	168	749[a]	562	376	187
EQW	556	483	404	336	650	565	480	396	742	645	552	456
EBA	553	468	383	297	614	514	416	318	683	564	450	334
LEX	557	542[a]	501[a]	467	628	590[a]	550[a]	514[a]	723	680[a]	635[a]	593[a]
SAT	509	476	434	410	592	560	525	485	670	640	615	590
RAND	506	504	497	492[a]	502	501	493	491	494	499	500	508
					High dispersion							
WADD	678[a]	509	338	170	707[a]	531	358	178	759[a]	569	383	192
EQW	559	486	410	339	648	564	483	394	737	641	549	458
EBA	577	490	397	309	623	523	431	330	679	561	450	329
LEX	666	626[a]	580[a]	543[a]	684	643[a]	609[a]	562[a]	745	700[a]	660[a]	620[a]
SAT	512	479	440	411	574	543	521	491	668	638	611	590
RAND	497	496	500	508	497	496	500	499	494	492	495	503

Note. The 0% discount rate corresponds to no time pressure; a 75% discount rate is the most severe time pressure. WADD, weighted additive strategy; EQW, equal weight strategy; EBA, elimination-by-aspects strategy; LEX, lexicographic strategy; SAT, satisficing strategy; RAND, random strategy. Results are the expected payoff for each strategy based upon 1000 trials.

[a] The most accurate strategy for each environment.

Results

Table 1 shows the average payoff values for each of the six rules in the 24 simulation conditions. Figure 2 shows the results graphically for the 0 correlation, low and high dispersion conditions.

First, note that given how the choice options were generated, all the environments are equally friendly in terms of the average payoff due to random choice. Also, by our definition of payoff, the WADD rule provides the greatest payoff *under no time pressure* in all the environments. The no time pressure results from this simulation mimic those reported in Payne *et al.* (1988) and Bettman *et al.* (1993). Heuristics often provide payoffs close to those provided by the WADD rule; however, which heuristic works best varies according to context variables such as the dispersion in probabilities. For example, the EQW simplification generally does relatively better in low dispersion environments and the LEX heuristic does relatively better in the high dispersion environments. Also, all the heuristics do relatively better in environments characterized by positive rather than negative correlation structures.

Of greatest interest, however, are the results for differing levels of opportunity-cost time pressure. As is clear from Table 1 and Fig. 2, as the cost of delaying a decision goes up (i.e., the discount is larger), the expected payoff from the WADD rule decreases faster than the payoffs for any of the other choice rules. In fact, in all the environments WADD provides a payoff lower than random choice under the highest levels of time pressure.

Each of the choice heuristics has lower payoffs as time stress is increased; however, the lexicographic rule seems to provide above random payoffs across a range of time pressure conditions and across a variety of different contexts. Thus, shifting to a more attribute-based decision rule is adaptive for increasing opportunity-cost decision environments, as it was for more time-constrained environments (Payne *et al.*, 1988).

WHEN MAY ADAPTIVITY FAIL?

These simulation results characterize how the accuracy of various decision strategies changes under different levels of opportunity-cost time pressure, dispersion in probabilities, and correlation between outcomes. Our premise of adaptivity in decision making suggests that the behavior of actual decision makers would correspond, at least directionally, with the behavior of the idealized decision makers studied in the simulations.

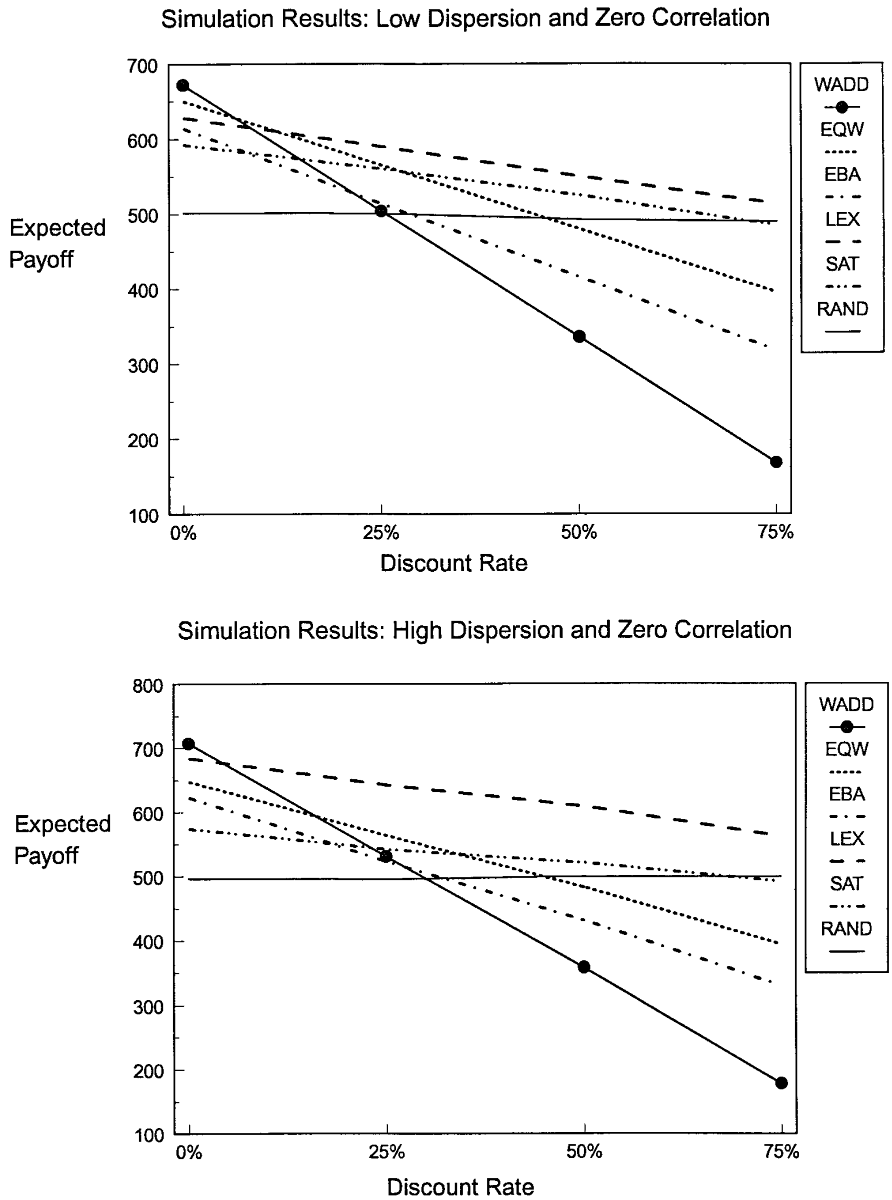

FIG. 2. Simulation results for accuracy of heuristics under zero correlation. *Note.* The 0% discount rate corresponds to no time pressure; a 75% discount rate is the most severe time pressure. WADD, weighted additive strategy; EQW, equal weight strategy; EBA, elimination-by-aspects strategy; LEX, lexicographic strategy; SAT, satisficing strategy; RAND, random strategy. Results are the expected payoff for each strategy based upon 1000 trials.

Although there is a substantial amount of research support for such adaptivity in decision behavior, adaptivity is not always perfect (Payne *et al.*, 1993).

Under what conditions might adaptivity to task and context demands be limited? Several possibilities are discussed in Payne *et al.* (1993), including issues of knowledge about properties of choice tasks, knowledge about strategies and their efficacy in various environments, and factors influencing the ability to execute strategies. For instance, Kleinmuntz and Schkade (1993) point out that some task characteristics will be easier to detect than others and therefore may have a "disproportionate" influence on strategy selection. A more general issue is when an information format makes the underlying structure of a decision problem nontransparent (Hammond, 1990; Tversky & Kahneman, 1988).

Adaptation to one task or context factor also may interfere with adaptation to another task or context factor. Even before information search begins, a decision maker may undertake an a priori strategy change on the basis of an obvious task or context variable. Once such a strategy change is set in motion, subjects may be reluctant to shift strategies a second time in response to another less obvious variable. Of course, if the implications for processing and performance are the same for multiple task and context variables, there is no dilemma for the decision maker. However, when the implications of adapting to one variable, e.g., goal, dispersion, or correlation structure, are inconsistent with what is required to adapt to another task variable, such as opportunity-cost time pressure, problems can arise.

The goal of our experiments is to examine how individuals change their processing when there are multiple task and context factors with conflicting implications for how one should decide. For instance, the goal of being as accurate as possible implies more processing and the use of more normative strategies like WADD. The simulation results for opportunity-cost time pressure, however, suggest that strategies like WADD may not function well in such time-stressed environments. Hence, we might expect that individuals would have difficulties in adapting to an opportunity-cost time pressure environment with accuracy goals.

EMPIRICAL HYPOTHESES

The simulation results provide us with more details about the effects of opportunity-cost time pressure. Now we use these results, prior research, and the ideas above to generate hypothesized main effects and interactions for opportunity-cost time pressure, goals, and dispersion.

First we consider opportunity-cost time pressure. Based upon the simulation results and the earlier time pressure studies, we hypothesize

> *H1a.* Decision makers faced with opportunity-cost time pressure will shift decision strategies in the direction of rules like lexicographic choice. This shift will be reflected in decreasing amounts of information processing, increased selectivity in processing, and increased use of attribute-based processing.

If decision makers adapt to increased opportunity-cost time pressure as outlined in H1a, processing characteristic of the lexicographic rule will lead to higher payoffs under time pressure. However, under no time pressure, such processing will not lead to higher payoffs, because the WADD rule yields higher performance (and is characterized by more processing, less selective processing, and more alternative-based processing). Hence, we state

> *H1b.* Choices consistent with lexicographic types of processing will result in higher levels of payoff under opportunity cost time pressure, on average, and lower levels of payoff under no time pressure. Choices consistent with weighted added types of processing will show the opposite pattern.

Next, we hypothesize that goals impact processing as predicted by the effort/accuracy model of the adaptive decision maker and as shown in previous research (e.g., Creyer *et al.*, 1990):

> *H2a.* A goal emphasizing accuracy will lead to more processing, less selectivity, and more alternative-based processing than a goal emphasizing effort.

However, we expect that the results for performance will be more complicated. In particular, we expect an interaction of goals and opportunity-cost time pressure on performance. As in previous research, we expect a goal emphasizing accuracy to lead to higher performance when there is no time pressure. However, we expect that accuracy goals may lead to *lower* performance under opportunity-cost time pressure. People trying to optimize on accuracy rather than effort may use strategies that actually lead to lower performance levels when the time discount is taken into account. The accuracy goal may interfere with adaptation to time stress by causing people to shift to a more extensive depth-first strategy rather than a breadth-first strategy. This hypothesis is a major focus of our study; as noted above, we believe that when environments vary in multiple ways with conflicting implications for processing, people may at times successfully adapt and may at other times exhibit failures in adaptivity. This hypothesis also reflects our belief that decision goals are more salient or have clearer implications for the individual than opportunity-cost time pressure; many people may not understand the full implications of deciding in an opportunity-cost environment. In sum, we do not expect interactions of time pressure and goal on processing; we believe that people will respond to the goal manipulation in similar ways, regardless of time pressure. However, we *do* expect an interaction of goal and opportunity-cost time pressure on performance:

> *H2b.* There will be an interaction of goals and opportunity-cost time pressure on performance: a goal emphasizing accuracy will lead to higher performance levels than a goal emphasizing effort under no time pressure, but an accuracy goal will lead to lower performance under opportunity-cost time pressure.

We will test H1a and H2a and H2b in both Experiments One and Two below. H1b will only be tested in Experiment One.

Finally, we investigate the impacts of goal and time pressure on decision behavior across variations in context variables previously shown to impact processing (i.e., dispersion in probabilities and correlations between outcomes). We do this for several reasons. First, responses to the context variables indicate the overall adaptivity of subjects in these experiments; we hope to replicate previous findings for the main effects of these factors. Second, and more importantly, we include the context variables in our designs to begin to look at how people deal with problems where there are multiple task and context variables to which one could adapt. There may be times when successfully adapting to one variable may interfere with adaptation to another variable.

In our first experiment, we investigate the main effects of dispersion in probabilities and the interactions between dispersion and goals and between dispersion and time pressure. In the second experiment, we consider main effects of correlation structure and interactions between correlation and goals and between correlation and time pressure. Dispersion in probabilities is likely to be easier to detect than differences in correlation structures; however, both dispersion and correlation structure are likely to be more difficult to detect than variations in goals. As noted above, although opportunity-cost time pressure may be easy to detect, its implications for processing, particularly in combination with other factors, may not be as easy for individuals to determine. Thus, in each case we predict that those changes in the context variables that lead to greater processing, less selectivity in processing, and more alternative-based processing will interfere with adaptivity to opportunity-cost time pressure. The specific hypotheses for the two context variables are given below: Hypothesis 3 will be tested in Experiment One and Hypothesis 4 will be tested in Experiment Two.

For dispersion in probabilities, consistent with the results or Payne *et al.* (1988), we hypothesize that

H3a. Low levels of dispersion in probabilities will lead to greater processing, less selective processing, and more alternative-based processing than high levels of dispersion.

Because we expect factors leading to more extensive, consistent, and alternative-based processing to interfere with adaptivity to opportunity cost-time pressure, we also hypothesize

H3b. Dispersion and time pressure will interact for expected payoff. Performance will be relatively poorer under low dispersion when low dispersion is combined with opportunity-cost time pressure.

As noted above for H2b, we do not expect an interaction of time pressure and dispersion on the processing variables.

Next, we predict that the main effects of correlation on processing will replicate those reported in Bettman *et al.* (1993):

H4a. More negative correlation structures will lead to greater processing, less selectivity in processing, and more alternative-based processing than more positive correlation structures.

Again, because of these expected processing effects of negative correlation between outcomes, performance should be particularly poor when this condition is combined with opportunity-cost time pressure. More specifically, we hypothesize

H4b. Correlation structure and opportunity-cost time pressure will interact for performance: performance should be relatively poorer under negative correlation when opportunity-cost time pressure is present.

Finally, the specific design of Experiment Two will allow us to test a more detailed hypothesis regarding adaptivity:

H4c. Those subjects who adapt their processing more to correlation will perform better in the no time pressure condition, but greater adaptivity of processing to correlation levels will lead to poorer performance under opportunity-cost time pressure.

OVERVIEW OF EXPERIMENTS ONE AND TWO

The focus of our experiments is how opportunity-cost time pressure, along with variations in goals and context factors, influences the details of decision processing. Thus, we utilize a computerized system for collecting process-tracing data as well as choice data.

Computer Software for Data Collection

Subjects' information acquisitions, response times, and choices were monitored using the *Mouselab* software system (Payne *et al.*, 1993). For both experiments, choice stimuli were presented by *Mouselab* as a matrix of available information, with four columns containing the four outcomes. The first row of boxes in the matrix contained the probabilities for each of the four outcomes; the four remaining rows of boxes contained payoff information for each of four alternative gambles. The probability values and dollar values were all hidden behind closed boxes that subjects were permitted to open one at a time by moving a mouse-controlled cursor into a box. In conditions involving time pressure, a clock appeared in the upper lefthand corner of the computer screen and counted down as the subject decided. As detailed below, the time on the clock was set so that subjects would generally not run out of time, and the payoff was based on the proportion of time remaining on the clock. Subjects terminated decision processing by clicking a mouse button while in a"choice" box corresponding to one of the four available gambles. The *Mouselab* program recorded the order in which boxes were opened, the time spent in each box, and the chosen option, allowing for the construction of several dependent variables.

Dependent Variables

Accuracy and choice measures. The primary measure of choice accuracy, PAYOFF, was simply the expected payoff for each subject's chosen option. For no time pressure trials, this was simply the expected value of the chosen alternative. For time pressure trials, this expected value was multiplied by the proportion of time left on the clock after decision processing was completed: PAYOFF = Chosen Gamble EV*(1 − (Time Taken/Total Time on the Clock)). Finally, to control for differences in the stimulus sets, PAYOFF was divided by the maximum expected value for any option of the decision set to yield a measure called RELPAY. Thus, RELPAY = (PAYOFF/Maximum Possible EV in the Decision Set). Both PAYOFF and RELPAY thus reflect discounts due to time pressure. The results for the PAYOFF and RELPAY measures were essentially the same, and we focus on the results for PAYOFF. However, we include the results for RELPAY in the tables to aid interpretation.

Two additional measures characterizing subjects' chosen alternatives were calculated and used to examine H1b. These binary measures reflect whether the alternative chosen is the alternative that would be indicated by the expected value maximization rule (EVMAX) or the lexicographic rule (LEXMAX). Note that for a particular decision, the alternative with the highest expected value may also be the alternative with the best value on the most important attribute, so both the expected value maximization and the lexicographic rules may indicate that the same gamble is best.

Processing variables. The information acquisition data recorded by *Mouselab* were used to create seven variables reflecting aspects of subjects' decision processing. First, the variable TIME reflects total processing and is simply the total time spent for a choice trial. The variable ACQ (acquisitions) also reflects the total amount of processing, and is calculated by summing the total number of times information (e.g., probability or dollar payoff) boxes were opened for a particular trial. Finally, a third measure of the amount of processing is the average time spent per acquisition of an item of information, denoted TPERACQ.

The next three variables reflect selectivity in decision processing. Two measures are the variances in the proportions of time spent on each attribute (VARATT) and on each alternative (VARALT). Lower values for these two variables indicate that decision processing was more evenly spread over all four attributes or alternatives, respectively. The third selectivity measure, PTMI, is the proportion of the total time spent on boxes involving the values of the most probable outcome for a particular decision problem. Higher values of PTMI should characterize more lexicographic-like processing.

The seventh processing measure reflects the sequence in which dollar value information is acquired. Given the acquisition of a particular piece of value information, the two cases of most interest for the next acquisition are acquiring information on the same alternative but a different outcome (an alternative-based transition) and obtaining information on the same outcome but a different alternative (an attribute-based transition).[6] A simple measure of the relative degree of alternative-based versus attribute-based processing is calculated by subtracting the total number of attribute-based transitions for a trial from the total number of alternative-based transitions for a trial and dividing this difference by the sum of the attribute-based plus the alternative-based transitions (Payne, 1976). This measure of the relative degree of alternative-based versus attribute-based decision processing of value information is denoted PATTERN and ranges from a value of −1.0 (indicating totally attribute-based processing) to a value of 1.0 (indicating totally alternative-based processing).

These processing measures can be related to the decision strategies. The WADD rule, which examines all information, should have high values for TIME, ACQ, and TPERACQ; low values for VARATT and VARALT; low values for PTMI; and high values for PATTERN. The EQW strategy should have relatively high values for TIME, ACQ, and TPERACQ; low values for VARATT and VARALT; low values for PTMI; and high values for PATTERN. The EBA and LEX rules, since they do not process all available information, involve simpler processing operations, and focus on the most probable outcome, should have lower values for TIME, ACQ, and TPERACQ; higher values for VARATT and PTMI; and lower values for PATTERN (more attribute-based). For VARALT, the LEX rule should have lower values and EBA should have higher values. Finally, the SAT rule should have lower values for TIME, ACQ, and TPERACQ; higher values for VARALT; relatively lower values for VARATT and PTMI; and high values for PATTERN.

EXPERIMENT ONE

Method

Subjects. Seventy-two undergraduate students participated in this experiment to fulfill a course requirement. Subjects were also entered into one of two $50.00

[6] Recall that we retain the term attribute-based processing here to remain consistent with the literature on decision processing.

lotteries, although they were unaware of this additional compensation when they volunteered for the study. Subjects were run individually, and experimental sessions took roughly 45 min to complete. Each subject was randomly assigned to a condition involving either no or severe time pressure; 36 subjects were assigned to each of the no and severe time pressure conditions.[7] Thus, opportunity-cost time pressure was manipulated between subjects.

Stimuli and manipulation of dispersion. Stimuli were 32 sets of four risky options, each involving differing dollar payoffs for four possible outcomes. Every option in a set was defined in terms of the same four outcome probabilities, and probability values were constrained to sum to 1.0. Possible payoffs ranged from $0.01 to $9.99.

Subjects considered 8 decision sets with low dispersion in outcome probabilities, and 8 decision sets with high dispersion in outcome probabilities. These stimuli are a subset of those in Payne *et al.* (1988). The correlations between dollar values for each of the four attributes were zero on average, and no dominated alternatives were included in the sets. Subjects considered each of the 16 decision sets twice, once under an accuracy goal and once under an effort goal, described further below. Thus, both dispersion and goal were manipulated within subjects.

Procedure. All instructions and stimuli were presented via the *Mouselab* program. Subjects read that the purpose of the experiment was to understand how people make decisions and that there were no right or wrong answers. After becoming familiar with *Mouselab*, subjects received experimental task instructions and completed four practice decisions, one for each of the possible goal by dispersion conditions. For the first two practice decisions, all of the boxes on the computer screen remained open during decision processing to allow subjects to learn about the structure of the decisions. Subjects received feedback on their payoffs for each of their four practice decisions.

The 32 experimental stimuli were separated into two blocks, with the two members of each effort/accuracy goal pair always presented in differing blocks. The rows and columns of the sets were permuted between the two goal conditions so that this repetition would be less noticeable to subjects. Within each block, stimuli were individually randomized for each subject, and which of the two blocks was presented first was counterbalanced across subjects.

Time pressure manipulation. Subjects were assigned to either a no time pressure or a severe opportunity-cost time pressure group. In the severe opportunity-cost time pressure condition, a clock appeared in the upper lefthand corner of the computer screen and counted down as subjects made their decisions. Subjects in the time pressure group were informed that their payoff or winnings for each trial would be equal to the amount of money their chosen alternative paid for the outcome occurring *multiplied by the proportion of time left on the clock when a final decision was indicated*. Thus, subjects completing a decision in 25% of the available time would receive 75% of the chosen gamble's payoff, while subjects completing a decision using 75% of the available time would receive only 25% of the chosen gamble's payoff. The clock was programmed to count down over 30 s; subjects were not told how much time was on the clock.[8] Based on on the prior results of Payne *et al.* (1988) and Bettman *et al.* (1993), 30 s exceeded the time needed to perform the task.

Since we intended to have an opportunity-cost manipulation of time pressure and not a deadline manipulation, there would be a problem if many subjects ran out of time. However, only 7 of the 1152 decisions made by the subjects in the time-pressured condition took more than 30 s. Thus, subjects almost always made a decision before the value of the expected payoff was $0.[9]

Four practice problems involving feedback were given to facilitate understanding of the time pressure environments. Immediately after each practice problem, a screen with feedback appeared. In the time pressure group, the feedback screens reported the subject's chosen gamble, the outcome occurring (outcomes were randomly generated according to their stated probabilities), the monetary payoff associated with the relevant gamble/outcome pair, the proportion of clock time used, and the adjusted payoff (equal to the appropriate payoff multiplied by the proportion of time left on the clock). For the no time pressure group, feedback screens re-

[7] An additional 20 subjects were initially assigned to a moderate level of opportunity-cost time pressure. Preliminary results indicated that means for the moderate time pressure condition tended to simply fall between those for the no time pressure and severe time pressure conditions, so the moderate time pressure group was dropped from the experimental design midway through data collection.

[8] Subjects in the two studies reported below used an average of roughly 12 s of the 30 s available. Thus, on average their winnings were discounted by 40%.

[9] As a comparison, the subjects under the most severe time constraint in Payne *et al.* (1988), 15 s, ran out of time about 74% of the time. Of course, in their time constraint task, choice of a particular option led to the same payoff regardless of how much time was taken to choose that option.

ported the subject's chosen alternative, the outcome occurring, and the associated monetary payoff.

Goal manipulation. Before each decision trial, subjects viewed a computer screen instructing them as to whether their task for the particular trial involved a relative focus on maximizing accuracy or on minimizing effort. Subjects were instructed that minimizing effort involved making a choice in as little time as possible. In order to explain the goal of maximizing accuracy, examples were used. One example illustrated the importance of probability values (i.e., that a .75 chance at $10.00 was better than a .50 chance at $10.00), and a second illustrated the importance of dollar values (i.e., that a .75 chance at $20.00 was better than a .75 chance at $10.00). Subjects were instructed that they should attend to both payoffs and probabilities "in combination" in order to effectively maximize decision accuracy, although subjects were not explicitly instructed regarding normatively accurate decision rules or operations like the WADD rule. Subjects were explicitly told that "maximizing accuracy involves winning the most money possible," and the feedback screens presented during the practice trials reported the subject's monetary payoff for the preceding decision, adjusted for time pressure if the subject was in the time pressure condition.

Finally, subjects were told that both minimizing effort and maximizing accuracy were important for every trial, but that trials would differ in the degree to which a relative focus on accuracy or on effort was required. Specifically, subjects were told that a score reflecting effort minimization and a score reflecting accuracy maximization would be computed for each trial. On effort minimization trials, subjects were informed that effort would count three times as heavily as accuracy in computing a total score for that trial. Similarly, on accuracy maximization trials, accuracy was to be weighted three times as heavily as effort. In order to reinforce the goal manipulation and to ensure that subjects did not forget their goal task, a reminder line appeared at the bottom of each choice screen. For each accuracy trial, this line read "TOTAL SCORE = (3) (ACCURACY) + (1) (EFFORT)." Analogous wording was used for each effort trial. Subjects were told that they would be entered in a $50.00 lottery if their total scores exceeded an unspecified cutoff value. However, all subjects were entered into the lottery. Similar goal manipulations had been successfully used in Creyer *et al.* (1990).

Manipulation check. At the end of the experiment, subjects were asked how hurried they had felt during the experiment (HURRIED), rated on a seven-point scale where higher numbers indicated a greater feeling of being hurried or time-pressured. The effect of opportunity-cost time pressure on HURRIED was significant (Means: none = 3.99, severe = 5.51, $F(1,70) = 26.3$, $p < .0001$), indicating that the manipulation of opportunity-cost time pressure was successful in generating feelings of being hurried.

Results

Multivariate analysis. Because we expected the dependent variables to be intercorrelated, we initially performed a multivariate analysis of variance with dependent variables PAYOFF, ACQ, TIME, TPERACQ, VARATT, VARALT, PTMI, and PATTERN.[10] EVMAX and LEXMAX were not included because they are binary variables. The main effects for time pressure ($F(8,63) = 98.1$, $p < .0001$), goal ($F(8,63) = 9.9$, $p < .0001$), and dispersion ($F(8,63) = 10.5$, $p < .0001$) were all highly significant. Likewise, there was a significant interaction of time pressure by goal ($F(8,63) = 4.1$, $p < .0001$). The interaction of time pressure by dispersion was marginally significant ($F(8,63) = 1.9$, $p < .08$), and the dispersion by goal interaction was not significant ($F(8,2004) = 1.15$, ns). The three way interaction between time pressure, goal, and dispersion was also not significant ($F(8,2004) = 0.45$, ns). The means for the dependent variables for each time pressure, goal, and dispersion condition are reported in Table 2. Next, the univariate tests for the various process and outcome measures are presented.

Main effects of time pressure. As stated in H1a, we expected higher opportunity-cost time pressure to be associated with decreased amounts of processing (lower values for ACQ, TIME, and TPERACQ), more selective processing (higher values for VARATT, VARALT, and PTMI), and more attribute-based processing (a lower value for PATTERN).

Opportunity-cost time pressure had the expected main effects on ACQ (Means: none = 24.6, severe = 15.4, $F(1,70) = 20.4$, $p < .0001$), TIME (Means: none

[10] We expected several of the process and outcome measures to be correlated. Generally speaking, as our reasoning regarding the hypotheses implies, measures of amount of processing will be negatively correlated with measures of selectivity and positively correlated with the degree of alternative-based processing. Selectivity will generally be negatively correlated with the degree of alternative-based processing. These expectations were borne out by correlations (all significant at $p < .0001$) between ACQ and VARATT ($r = -.61$), TIME and VARATT ($r = -.50$), ACQ and VARALT ($r = -.24$), TIME and VARALT ($r = -.18$), ACQ and PATTERN ($r = .49$), TIME and PATTERN ($r = .37$), and VARATT and PATTERN ($r = -.80$). The correlation between VARALT and PATTERN was not significant ($r = -.02$).

TABLE 2

Process and Performance Measures as a Function of Opportunity-Cost Time Pressure, Goal, and Dispersion: Experiment 1

	No time pressure				Severe time pressure			
	Accuracy		Effort		Accuracy		Effort	
Dependent measure	Low dispersion	High dispersion	Low dispersion	High dispersion	Low dispersion	High dispersion	Low dispersion	High dispersion
ACQ	28.8	25.3	23.7	20.4	17.7	16.3	15.1	12.4
TIME	26.0	23.4	20.9	18.5	14.1	13.4	12.0	10.6
TPERACQ	.55	.53	.51	.49	.43	.44	.41	.41
VARATT	.040	.063	.062	.084	.058	.083	.073	.110
VARALT	.015	.017	.020	.020	.020	.022	.023	.028
PTMI	.30	.33	.34	.36	.33	.36	.36	.40
PATTERN	.02	−.14	−.13	−.34	−.10	−.26	−.16	−.41
RELPAY	.92	.91	.90	.91	.48	.50	.54	.59
PAYOFF	5.61	5.82	5.46	5.86	2.92	3.22	3.28	3.78
EVMAX	.33	.39	.27	.38	.34	.27	.27	.28
LEXMAX	.39	.36	.42	.41	.43	.48	.46	.57

Note. ACQ, number of acquisitions; TIME, time taken; TPERACQ, time per acquisition; VARATT, variance in the proportion of time spent on each attribute; VARALT, variance in the proportion of time spent on each alternative; PTMI, proportion of time spent on the most important attribute; PATTERN, index reflecting relative amount of attribute-based (−) and alternative-based (+) processing; RELPAY, expected amount won divided by the maximum amount which could be won; PAYOFF, expected amount won; EVMAX, proportion of highest expected value choices; LEXMAX, proportion of choices highest on the most probable outcome.

= 22.2, severe = 12.5, $F(1,70) = 25.0$, $p < 0001$), and TPERACQ (Means: none = 0.52, severe = 0.42, $F(1,70) = 15.9$, $p < .0003$). People not only processed less information under opportunity-cost time pressure but also processed it faster.

Time pressure had the expected directional effects on variables reflecting selectivity, but the results were not significant for VARATT (Means: none = 0.062, severe = 0.081, $F(1,70) = 2.60$, $p < .12$) or PTMI (Means: none = 0.34, severe = 0.36, $F(1,70) = 2.29$, $p < .14$). For VARALT, time pressure had a marginally significant main effect (Means: none = 0.018, severe = 0.023, $F(1,70) = 3.03$, $p < .09$). Thus, there is only weak support for increased selectivity under increasing time pressure.

Finally, time pressure had the expected directional effect on PATTERN, but this effect was not significant (Means: none = −0.14, severe = −0.230, $F(1,70) = 0.67$). To summarize, opportunity-cost time pressure had the same directional effects on processing as the more traditional constraint form of time pressure: increased time pressure lead to less processing, faster or accelerated processing, somewhat more selectivity, and a directional change to more attribute-based processing. The results were weaker than those in the earlier Payne *et al.* study, perhaps due to the fact that the current study used a between subjects manipulation of time pressure, whereas Payne *et al.* used a within subjects manipulation. We will consider this issue again below.

Now we consider the effects of opportunity-cost time pressure on performance, as stated in H1b and H2b. We consider H2b below in the section on time pressure by goal interactions. H1b states that choices consistent with lexicographic processing will result in higher payoffs under opportunity-cost time pressure and lower payoffs under no time pressure. Choices consistent with maximizing expected value should exhibit the opposite pattern.

We use LEXMAX and EVMAX to examine this hypothesis. LEXMAX is the proportion of choices selecting the option that would be chosen by the lexicographic rule (i.e., best on the most probable outcome), while EVMAX is the proportion of choices selecting the option that would be chosen by the WADD rule (i.e., the option with the highest expected value). Given the stimuli in Experiment One, LEXMAX and EVMAX are negatively correlated ($r = -.60$, $p < .0001$).[11] The patterns of correlations between the processing measures and LEXMAX and EVMAX are as expected: LEXMAX is negatively correlated with ACQ ($r = -.28$), TIME (r

[11] In the second experiment, EVMAX and LEXMAX were positively correlated due to the different interattribute correlation structures used in that experiment. This positive correlation compromises our ability to test H1b in Experiment Two.

= −.22), and PATTERN ($r = -.39$) and positively with VARATT ($r = .44$); EVMAX is positively correlated with ACQ ($r = .18$), TIME ($r = .12$), and PATTERN ($r = .29$) and negatively with VARATT ($r = -.32$)(all significant at $p < .0001$).

The data most directly relevant to testing H1b are the correlations between LEXMAX and PAYOFF and between EVMAX and PAYOFF for the two time pressure conditions. If H1b is true, we expect that LEXMAX will be positively correlated with PAYOFF under time pressure and will be negatively correlated under no time pressure, with the opposite pattern expected for EVMAX. The correlation between LEXMAX and PAYOFF is .23 ($p < .0001$) under time pressure, as expected, and is nonsignificant ($r = .04$, ns) under no time pressure. The correlation between EVMAX and PAYOFF is negative but nonsignificant under time pressure ($r = -.02$, ns) and is positive when there is no time pressure ($r = .36$, $p < .0001$). These results support H1b.

Further evidence that performance is related to shifts in strategy under time pressure is provided by correlations between processing measures and PAYOFF. In the time pressure condition, VARATT ($r = .51$), VARALT ($r = .23$), PTMI ($r = .13$), and PATTERN ($r = -.36$) are all correlated with PAYOFF at $p < .0001$. Thus, more attribute-based and selective processing (such as in LEX) leads to higher PAYOFF under time pressure. In contrast, the correlations between processing variables and PAYOFF were all slightly positive and nonsignificant under no time pressure.

Main effects of goal. According to H2a, a goal emphasizing accuracy should lead to more processing, less selectivity, and more alternative-based processing (Creyer *et al.*, 1990). The results generally were consistent with the above expectations.

Subjects processed more extensively under an accuracy goal, making more acquisitions (ACQ: Means: accuracy = 22.6, effort = 17.7, $F(1,70) = 48.6$, $p < .0001$), taking more time (TIME: Means: accuracy = 19.2, effort = 15.5, $F(1,70) = 38.6$, $p < .0001$), and spending more time per acquisition (TPERACQ: Means: accuracy = 0.49, effort = 0.45, $F(1,70) = 15.3$, $p < .0003$).

Subjects also were less selective under an accuracy goal, over both attributes (VARATT: Means: accuracy = 0.061, effort = 0.082, $F(1,70) = 30.6$, $p < .0001$) and alternatives (VARALT: Means: accuracy = 0.018, effort = 0.023, $F(1,70) = 4.35$, $p < .05$). When given an accuracy goal, subjects also concentrated less extensively on the most probable attribute (PTMI: Means: accuracy = 0.33, effort = 0.37, $F(1,70) = 19.2$, $p < .0001$).

Finally, subjects processed information in a more alternative-based manner under an accuracy goal (PATTERN: Means: accuracy = −0.12, effort = −0.26, $F(1,70) = 22.9$, $p < .0001$). A shift in goal leads not only to different amounts of processing, therefore, but also to shifts in strategy. In sum, the main effects for goal strongly support H2a.

Time pressure by goal interactions. We did not examine main effects for opportunity-cost time pressure or goal on PAYOFF, because our primary hypothesis regarding performance, H2b, was that opportunity-cost time pressure and goal would interact to determine PAYOFF. Accuracy goals were expected to have differing implications for adaptive performance than opportunity-cost time pressure does. In particular, we argued that a goal emphasizing accuracy would lead to higher payoffs than a goal emphasizing effort in the absence of time pressure, but that a goal emphasizing accuracy would actually lead to *lower* payoffs than a goal emphasizing effort under opportunity-cost time pressure.

The expected interaction of time pressure by goal on PAYOFF was significant ($F(1,70) = 29.43$, $p < .0001$) and of the anticipated form. Under no time pressure, accuracy goals led to higher payoffs ($5.72) than effort goals ($5.66), at a cost of 5 more s of processing time (see Table 2). However, under opportunity-cost time pressure, the expected payoff received for the accuracy goal ($3.07) was $.46 less than the expected payoff received for the effort goal ($3.53); subjects processed about two and a half seconds longer in the accuracy condition (see Table 2). These results provide strong support for H2b.

This detrimental effect of the accuracy goal in the time pressure conditions was not due to subjects choosing alternatives with relatively lower undiscounted expected values. The interaction between time pressure and goal was not significant for the EVMAX measure (χ^2 (1, $n = 2296$) = .04, ns)(since EVMAX is a 0–1 variable, a logit analysis was used). The interaction between time pressure and goal was also not significant for the LEXMAX measure (χ^2 (1, $n = 2296$) = .14, ns).

We did not expect opportunity-cost time pressure and goal to interact for our processing measures, and this was generally the case. The interaction was not significant for ACQ ($F(1,70) = 2.23$), TPERACQ ($F(1,70) = 1.38$), VARATT ($F(1,70) = .00$), VARALT ($F(1,70) = .16$), PTMI ($F(1,70) = .01$), or PATTERN ($F(1,70) = 1.23$); there was a significant interaction for TIME ($F(1,70) = 4.38$, $p < .05$). Thus, subjects generally process in similar ways in response to different goals regardless of the level of time pressure, supporting our notion that responding to goals may interfere with appropriate reactions to time pressure.

Effects involving dispersion. In H3a we argued that lower dispersion in probabilities would lead to greater amounts of processing, less selective processing, and more alternative-based processing. Lower dispersion is associated with higher values of ACQ (Means: low = 21.4, high = 18.6, $F(1,70) = 27.8$, $p < .001$) and TIME (Means: low = 18.2, high = 16.5, $F(1,70) = 15.7$, $p < .001$), but there is no main effect on TPERACQ (Means: low = .47, high = .47, $F(1,70) = 1.33$). Lower dispersion is also associated with lower values of VARATT (Means: low = .058, high = .085, $F(1,70) = 40.3$, $p < .0001$) and PTMI (Means: low = .33, high = .37, $F(1,70) = 9.4$, $p < .01$), but there is no significant effect on VARALT (Means: low = .019, high = .022, $F(1,70) = 2.4$). Finally, low dispersion led to higher values for PATTERN (Means: low = −.09, high = −.29, $F(1,70) = 29.9$, $p < .0001$). Thus, H3a is generally supported.

H3b proposed that there would be an interaction between dispersion and time pressure on PAYOFF, because the processing which is characteristic of low dispersion conflicts with the processing which is adaptive for time pressure. Unfortunately, the time pressure by dispersion interaction for PAYOFF was not significant ($F(1,70) = 1.05$), and H3b is not supported.

Discussion

The effects of opportunity-cost time pressure on decision processing were in the directions hypothesized in H1a (less processing, more selectivity, more attribute-based), but the results did not all reach significance. H1b was supported, however; choices consistent with lexicographic processing resulted in higher payoffs under time pressure but did not under no time pressure, with the reverse being true for choices consistent with maximizing expected value. These results are important, because they show that subjects who adapt in ways suggested by previous work and the simulation attain higher payoffs under time pressure.

Goals emphasizing accuracy have the effects predicted in H2a, leading to more processing, less selectivity, and more alternative-based processing. Perhaps our most important result, however, is finding support for an interaction of goals and opportunity-cost time pressure on payoffs, as hypothesized in H2b. A goal emphasizing accuracy leads to higher performance than a goal emphasizing effort under no time pressure, but under opportunity-cost time pressure accuracy goals lead to lower performance than effort goals. This result shows that adaptivity can be compromised in situations with multiple factors with conflicting implications for adaptive processing.

An alternative explanation of these results is that subjects were asked to optimize some combination of accuracy and effort (the "total score" described above in the procedure), not accuracy alone. Hence, subjects' lower payoffs under accuracy goals and time pressure may reflect their attempts to balance accuracy and effort, and these attempts cannot be measured by payoff scores alone. However, subjects under an accuracy goal both received lower payoffs *and* took more time under opportunity-cost time pressure than subjects under effort goals. The time pressure performance of subjects under an accuracy goal was thus dominated by subjects under an effort goal on both components of "total score," payoffs and time. Thus, we believe that our results provide clear evidence of failures in adaptivity.

Finally, lower dispersion in probabilities generally led to greater processing, less selective processing, and more alternative-based processing, supporting H3a. Contrary to H3b, however, there was no interaction of dispersion and time pressure on payoff.

In sum, Experiment One yields several very interesting results regarding adaptivity to time pressure, particularly those for H1b and H2b. The results for goal and dispersion on processing variables were generally as expected, but those for time pressure were somewhat weak. The manipulations for goal and dispersion were within subjects, whereas opportunity-cost time pressure was varied between subjects. In general, a between subjects design provides subjects with increased experience with whatever opportunity-cost time pressure decisions they are facing. However, a within subjects manipulation of time pressure provides an even stronger test of adaptivity, since subjects must switch strategies from one trial to the next to be adaptive. A within-subjects design also controls for individual differences in preferred processing patterns.

We ran a version of Experiment One with 42 subjects where opportunity-cost time pressure, goal, and dispersion were all manipulated within subjects. In this experiment, the effects of time pressure on processing were strongly significant in the expected directions for all variables except VARALT. In addition, the important time pressure by goal interaction on PAYOFF was also significant ($p < .002$) and in the direction expected in H2b ($6.04 for accuracy, no time pressure; $5.98 for effort, no time pressure; $3.25 for accuracy, time pressure; $3.56 for effort, time pressure). Obtaining this interaction both between and within subjects provides strong support for our notions about failures in adaptivity. Finally, the main effects of goal and dispersion are as expected in H2a and H3a, but the expected time pressure by dispersion interaction on PAYOFF is again not significant.

Thus, the within subjects version of Experiment One bolsters confidence in our results. We decided to also use a within subjects design for Experiment Two and to examine another context variable, correlation between outcomes. It is important to replicate both the effects of opportunity-cost time pressure on processing and the important time pressure by goal interaction on payoffs. It is also critical to generalize such results over different context variables, such as correlation, that have been shown to affect processing and performance, especially the time pressure by correlation interaction on payoffs proposed in H4b.

EXPERIMENT TWO

We manipulated opportunity-cost time pressure (none or severe), goal (effort or accuracy), and correlation between outcomes (positive or negative) in a complete within subjects design. Correlation can have a major impact on the relative accuracy of choice heuristics, and people are adaptive to changes in correlation structures (Bettman *et al.*, 1993). Hence, we hypothesize that people will adjust their processing in response to correlation, as proposed in H4a. More importantly, we expect that adapting to negative correlation by processing more, being less selective, and processing more by alternative will lead to decreased adaptivity to opportunity-cost time pressure. In particular, we expect performance to be relatively poorer under negative correlation when time pressure is present (H4b) and that increased adaptivity to correlation will lead to higher performance under no time pressure but lower performance under time pressure (H4c). The latter prediction can be tested in Experiment Two because of special features in the stimuli, explained in detail below.

Finally, Experiment Two seeks to replicate the effects of time pressure and goal on processing (H1a and H2a) and the crucial interaction of opportunity-cost time pressure and goal on decision performance (H2b). We again expect an accuracy goal to lead to poorer performance under time pressure but better performance without time pressure.

Method

Subjects. Seventy-six undergraduate students participated in this experiment in order to fulfill a course requirement. Subjects were entered into a $50.00 lottery in addition to receiving course credit, although they were unaware of the lottery when they volunteered for the study. Subjects were run individually, and sessions took roughly 45 min to complete.

Stimuli and manipulation of interattribute correlation. Stimuli were identical in structure to those used for Experiment One. However, for Experiment Two, the dispersion in attribute probabilities was low for all decisions (probability values ranged from .18 to .30). Also, decision sets contained either negative or positive correlation between outcomes for Experiment Two, rather than the zero correlation that was characteristic of the stimuli for Experiment One.

Thirty-two decision problems were constructed from 8 core stimuli, 4 with positive correlation between outcomes, and 4 with negative correlation. These 8 stimuli were a subset of the stimuli used for Experiment One in Bettman *et al.*, 1993. For negatively correlated trials, correlations between the values for pairs of outcomes ranged from −.78 to 0, with an average value of −.31. For positively correlated trials, correlations ranged from .16 to .86, with an average value of .60. Each of the 8 decision sets was considered 4 times, once under each of the time pressure (none/severe) and goal (accuracy/effort) conditions. The rows and columns of the dollar values comprising the decision sets were permuted between differing conditions, in order to mask this repetition.

Procedure. The procedure was very similar to that in Experiment One and again used the *Mouselab* system. Practice trials including feedback were provided to the subjects to facilitate learning about the structure of the decisions and the time pressure manipulation.

The 32 experimental stimuli were separated into two blocks, with each member of an effort/accuracy goal stimulus pair always presented in differing blocks. Which of the two blocks was presented first was counterbalanced across subjects, and stimuli were individually randomized for each subject within each block.

Time pressure and goal manipulations. The goal manipulation was identical to that used in Experiment One. The time pressure manipulation was implemented by adapting the opportunity-cost time pressure manipulation from Experiment One to a within-subjects environment. Thus, half of subjects' decisions involved no time pressure, and the other half involved opportunity-cost time pressure. For the time pressure trials, a clock appeared on the computer screen and counted down for 30 s (trials with no time pressure were immediately recognizable, because there was no clock on the screen). In order to ensure that subjects understood the time pressure environments, they initially completed and received feedback concerning four practice problems, two with time pressure and two without. Subjects took 30 s or longer only 11 times of 1216 time pressure trials.

Manipulation checks. Subjects were asked to make eight decisions at the end of the experimental task, one from each of the time pressure by goal by correlation cells (the order was randomized for each individual subject). After each of these decisions, subjects were asked to assess (on seven-point scales) how hurried they had felt during the previous decision (HURRIED), how stressful they had found the previous decision to be (STRESSFUL), and the degree to which they noticed positive or negative interattribute correlation in the relevant decision problem (CORREL: "Please indicate the degree to which you feel that a gamble with a high (low) value on one outcome would tend to have low (high) values on the other three outcomes." Higher responses to this question indicate an assessment of relatively more negative interattribute correlation). Subjects under opportunity cost time pressure felt more hurried (Means: none = 4.06, severe = 4.71, $F(1,600) = 28.0$, $p < .0001$) and more stressed (Means: none = 3.11, severe = 3.40, $F(1,600) = 5.4$, $p < .02$). In addition, subjects correctly associated higher values of CORREL with stimuli with negative interattribute correlation (Means: negative = 4.19, positive = 3.93, $F(1,600) = 6.1$, $p < .01$).

Results

Multivariate analysis. A multivariate analysis of variance including PAYOFF, ACQ, TIME, TPERACQ, VARATT, VARALT, PTMI, and PATTERN indicated significant main effects for time pressure ($F(8,2254) = 548.6$, $p < .0001$), goal ($F(8,2254) = 44.8$, $p < .0001$), and correlation ($F(8,2254) = 211.3$, $p < .0001$). Similarly, the two-way interactions between time pressure and goal ($F(8,2254) = 6.7$, $p < .0001$), time pressure and correlation ($F(8,2254) = 4.5$, $p < .0001$), and goal and correlation ($F(8,2254) = 7.8$, $p < .0001$) were all significant. Finally, the three way interaction between time pressure, goal, and correlation was not significant ($F(8,2254) = 1.26$, ns). The means for the dependent measures by time pressure, goal, and correlation are presented in Table 3. The univariate tests for the various process and outcome measures are given below.

Main effects of time pressure. Overall, the effects of opportunity-cost time pressure on processing were significant and in the directions hypothesized by H1a. Subjects under time pressure processed less extensively. Time pressure was associated with lower values for ACQ (Means: none = 22.2, severe = 17.4, $F(1,2341) = 143.1$, $p < .0001$), TIME (Means: none = 15.5, severe = 12.1, $F(1,2341) = 159.4$, $p < .0001$), and TPERACQ (Means: none = 0.40, severe = 0.38, $F(1,2282) = 53.3$, $p < .0001$).

Under time pressure, subjects were more selective across attributes (VARATT: Means: none = 0.046, severe = 0.054, $F(1,2276) = 26.8$, $p < .0001$), but not across alternatives (VARALT: Means: none = 0.021, severe = 0.021, $F(1,2276) = 0.1$, ns). Subjects also focused more on dollar values pertaining to the most probable outcome under time pressure (PTMI: Means: none = 0.46, severe = 0.49, $F(1,2276) = 9.0$, $p < .003$).

Finally, subjects tended to process more by attribute under time pressure, as indicated by the main effect of time pressure on PATTERN (Means: none = 0.10, severe = 0.03, $F(1,2261) = 14.9$, $p < .0001$).

Effects of goal. H2a was again supported. Subjects expended more effort under an accuracy goal, as evidenced by significantly higher means for ACQ (Means: accuracy = 22.4, effort = 17.2, $F(1,2341) = 167.2$, $p < .0001$), TIME (Means: accuracy = 15.6, effort = 12.1, $F(1,2341,) = 168.6$, $p < .0001$), and TPERACQ (Means: accuracy = 0.40, effort = 0.38, $F(1,2282) = 94.5$, $p < .0001$).

When given an accuracy goal, subjects shifted processing strategies: they were less selective over both attributes (VARATT: Means: accuracy = 0.039, effort = 0.062, $F(1,2276) = 207.4$, $p < .0001$) and alternatives (VARALT: Means: accuracy = 0.018, effort = 0.024, $F(1,2276) = 31.6$, $p < .0001$); spent a lower proportion of time processing information related to the most probable outcome (PTMI: Means: accuracy = 0.44, effort = 0.52, $F(1,2276) = 104.1$, $p < .0001$); and shifted to more alternative-based processing (PATTERN: Means: accuracy = 0.13, effort = 0.01, $F(1,2261) = 52.2$, $p < .0001$) under an accuracy goal.

Time pressure by goal interactions. Our critical hypothesis regarding decision accuracy (H2b) was that accuracy goals were expected to be associated with higher performance in the absence of time pressure, but with lower performance under time pressure.

The expected time pressure by goal interaction was found for PAYOFF ($F(1,2341) = 41.1$, $p < .0001$). Subjects actually received lower payoffs with an accuracy goal in time-pressured environments (accuracy = \$3.42, effort = \$3.86), and this result was reversed under no time pressure (accuracy = \$6.16, effort = \$6.05). Note that the expected payoff received under the accuracy goal in the time-pressured condition was \$.44 less than the expected payoff received under the effort goal, and choices in the accuracy, time-pressured condition took two and a half seconds longer than the choices in the effort, time-pressured condition. Once again, the time pressure by goal interaction for EVMAX was not signicant (χ^2 (1, $n = 2424$) = .00, ns), indicating that these results were not due to subjects choosing gambles with relatively lower undiscounted expected values more fre-

TABLE 3

Process and Performance Measures as a Function of Opportunity-Cost Time Pressure, Goal, and Correlation: Experiment 2

Dependent measure	No time pressure				Severe time pressure			
	Accuracy		Effort		Accuracy		Effort	
	Negative correlation	Positive correlation	Negative correlation	Positive correlation	Negative correlation	Positive correlation	Negative correlation	Positive correlation
ACQ	29.2	21.5	21.4	16.5	21.2	17.5	16.8	14.3
TIME	20.1	15.3	14.9	11.7	14.5	12.3	11.6	10.1
TPERACQ	.41	.42	.39	.37	.38	.40	.38	.36
VARATT	.032	.036	.058	.059	.043	.045	.067	.063
VARALT	.016	.019	.019	.031	.018	.020	.021	.027
PTMI	.40	.44	.50	.51	.44	.46	.52	.52
PATTERN	.18	.15	.03	.03	.08	.10	−.01	−.04
RELPAY	.97	.95	.96	.92	.50	.55	.59	.61
PAYOFF	5.16	7.16	5.16	6.94	2.68	4.16	3.15	4.58
EVMAX	.41	.81	.40	.73	.47	.76	.40	.72
LEXMAX	.55	.76	.62	.75	.57	.74	.56	.72

Note. ACQ, number of acquisitions; TIME, time taken; TPERACQ, time per acquisition; VARATT, variance in the proportion of time spent on each attribute; VARALT, variance in the proportion of time spent on each alternative; PTMI, proportion of time spent on the most important attribute; PATTERN, index reflecting relative amount of attribute-based (−) and alternative-based (+) processing; RELPAY, expected amount won divided by the maximum amount which could be won; PAYOFF, expected amount won; EVMAX, proportion of highest expected value choices; LEXMAX, proportion of choices highest on the most probable outcome.

quently under time pressure. Thus, our important interaction prediction documenting limits to adaptivity is replicated in all three of our studies.

As expected, there were few significant time pressure by goal interactions for processing variables, namely for ACQ ($F(1,2341) = 11.2$, $p < .001$) and TIME ($F(1,2341) = 12.4$, $p < .001$). Thus, once again, subjects respond similarly to different goals regardless of the level of time pressure.

Effects involving correlation. As stated in H4a, we expect that negative correlation between outcomes will be associated with more processing, less selectivity, and more alternative-based processing, reflecting that strategies like WADD are needed to achieve higher accuracy levels with negative correlation.

Subjects expended more effort when the correlations were negative, with significantly higher means for ACQ (Means: negative = 22.2, positive = 17.4, $F(1,2341) = 141.8$, $p < .0001$), TIME (Means: negative = 15.3, positive = 12.4, $F(1,2341) = 118.0$, $p < .0001$), and a marginally significant effect for TPERACQ (Means: negative = 0.392, positive = 0.388, $F(1,2282) = 2.8$, $p < .10$).

With negative correlations between outcomes, subjects were less selective over alternatives (VARALT: Means: negative = 0.018, positive = 0.024, $F(1,2276) = 26.0$, $p < .0001$) and spent a relatively lower proportion of time processing information related to the most probable outcome (PTMI: Means: negative = 0.47, positive = 0.48, $F(1,2276) = 6.3$, $p < .02$). However, there was no effect on VARATT (Means: negative = .050, positive = .051, $F(1,2276) = 1.3$).

Finally, in contrast to the results reported in Bettman *et al.* (1993), subjects did not shift to more alternative-based processing when faced with negative correlations between outcomes (PATTERN: Means: negative = 0.07, positive = 0.06, $F(1,2261) = .67$, ns). Thus, H4a is generally supported, with the exception of the results for VARATT and PATTERN.

Time pressure by correlation interactions. One major reason for including correlation in the experimental design was that we hypothesized a two-way interaction between opportunity-cost time pressure and correlation on PAYOFF. In particular, as stated in H4b, we expect that performance will be *relatively* more poor under negative correlation when opportunity-cost time pressure is present. As expected, this interaction was significant ($F(1,2341) = 25.5$, $p < .0001$). Under no time pressure, payoffs were \$7.05 for positive and \$5.16 for negative correlation; under opportunity-cost time pressure, the payoffs were \$4.37 for positive and \$2.92 for negative correlation. As hypothesized, performance for negative correlation is relatively poorer under time pressure: the payoff for negative correlation is 73% of that of positive correlation (\$5.16/\$7.05) under no time pressure, but only 67% of that for positive correlation ($2.92/$4.37) with opportunity-cost time pressure. Thus, H4b is supported.

Adaptivity to correlation, performance, and time pressure. Bettman *et al.* (1993) examined the degree to which an individual's adaptivity to correlation was related to performance by looking at the responses to eight pairs of gamble sets in which the two sets in a pair had the same probabilities, although correlation levels differed across the two gamble sets.[12] In particular, the differences between the positive correlation gamble set and the paired negative correlation gamble set were computed for five processing variables (ACQ, TIME, VARATT, VARALT, and PATTERN). These differences indicated the extent to which each subject adapted to the level of correlation. For each pair of gamble sets, Bettman *et al.* also calculated a measure of performance, i.e., accuracy of choices. They then tested the extent to which the degree of adaptivity in processing was related to performance by pooling the data for the eight gamble set pairs per subject over all subjects and correlating a composite index formed from the processing difference scores with the average performance scores. The index was formed by standardizing the differences for each processing variable and reversing the signs for VARATT and VARALT (because more adaptivity in response to negative correlation would normally be associated with higher values for ACQ, TIME, and PATTERN, but lower values of VARATT and VARALT). Those subjects who adapted more to different correlation levels were better performers: the correlation between the composite score of processing differences and performance in Bettman *et al.* (1993) was significant and in the expected direction ($r = -.15$, $p < .01$; the sign of the correlation is negative because more negative differences between positive and negative correlation should correspond to higher average performance levels (e.g., greater negative differences for ACQ for positive-negative correlation conditions would be expected to correspond to higher average performance)).

As stated in H4c, in Experiment Two of the present paper we expect a similar correlation pattern between processing differences and performance for the trials with no time pressure (i.e., a negative correlation, indicating that performance increases with greater adaptivity). However, based on the simulation results presented earlier, we expect that greater adaptivity to levels of correlation will *hurt* performance under opportunity-cost time pressure (and thus lead to a positive correlation between the index and performance), because of the loss in value expected if a decision maker responds to negative correlation gamble sets by increasing his or her acquisition of information and time to make the decision, lowering selectivity, and increasing processing by alternative.

As noted under Method for Experiment Two, the stimuli used in the current experiment were a subset (4 sets of 8) of the stimuli used in Bettman *et al.* (1993). Using the same method for relating processing differences (positive-negative) and performance described above, we found that the correlation between the composite measure of processing differences and average PAYOFF was in the right direction for the no time pressure trials but was not quite significant ($r = -.07$, $p < .12$; recall that the negative sign implies that greater adaptivity leads to better performance). Thus, there was an indication that those subjects who adapted *more* to different correlation levels performed better when there was no opportunity-cost time pressure. In contrast, the correlation between the composite measure of processing differences and average performance was significant and in the *opposite* direction when trials involving opportunity-cost time pressure were examined ($r = .16$, $p < .001$). That is, those subjects who adapted *less* to different correlation levels performed better on decision problems that also involved opportunity-cost time pressure. These results support H4c.

Discussion

Experiment Two replicated a major result of Experiment One, a time pressure by goal interaction for payoffs. Once again, an accuracy goal increased payoffs in the absence of time pressure but decreased payoffs under opportunity cost time pressure. In addition, and importantly, we found similar evidence for limits to adaptivity involving correlation and time pressure. Both a significant time pressure by correlation interaction and a more detailed analysis of adaptivity and performance showed that adapting to correlation in ways that are helpful without time pressure can be harmful to performance when opportunity-cost time pressure is present. These findings provide strong support for our contention that adaptivity may suffer when decisions must be made in environments with multiple aspects which conflict in their implications for adaptive processing.

GENERAL DISCUSSION

People generally adapted well to individual properties of the choice task in our experiments. When faced

[12] In the current paper, we only had such matched sets in Experiment Two. Therefore, the adaptivity analysis reported below could not be carried out for Experiment One.

with opportunity-cost time pressure, subjects generally adapted by processing less information, being more selective in their processing, and processing more by attribute, replicating previous findings (Payne *et al.*, 1988). Subjects also adapted to changes in goals by exhibiting more effort, less selectivity, and more alternative-based processing under an accuracy goal. Finally, the main effects of the context variables, dispersion in probabilities and correlation between outcomes, were also consistent with adaptivity from the perspective of a decision maker concerned with both accuracy and effort. Taken together, the present results clearly add to the evidence that people are intelligent, if not optimal, processors of information when they only have to take one property of the choice task into account.

However, the present results also suggest conditions involving interactions between variables where people may fail to adapt. In particular, in both of the present experiments we found that the goal of maximizing accuracy can interfere with the need to adapt to opportunity-cost time pressure. We showed that an accuracy goal leads to better performance when there is no time pressure, but an effort goal is associated with higher payoffs under opportunity-cost time pressure. We also found in Experiment Two that those subjects who responded more to the correlations between outcome values did better in the no time pressure condition, while those subjects who responded less to the correlations did better under opportunity-cost time pressure. Thus, our finding that people may have trouble adapting to multiple, conflicting properties of the decision situation was replicated both across different experiments and across different combinations of task and context factors.

Note that any discussion of failures or successes in adaptivity depends on acceptance of some standard for what is meant by better versus poorer performance on the task. In addition, this standard must be shared by both the subjects and the researchers. For a general discussion of alternative views of achievement on judgment tasks, see Hammond (1990).

Failures of Adaptivity

Two major classes of factors associated with potential failures in adaptivity exist. First, being adaptive requires various types of knowledge. Deficits in knowledge can include difficulties in assessing the task and context factors characterizing the decision environment, lack of knowledge of appropriate strategies, not being able to veridically assess the effort and/or the accuracy of a strategy in a particular situation, and not knowing one's desired accuracy–effort tradeoffs. Second, being adaptive requires the ability to execute strategies. The inability to execute a strategy might be due to memory and computational difficulties caused by the complexity of the task and/or by various environmental stressors (see Siegler, 1989, for a related discussion).

The present results may be interpreted in terms of several of these potential sources of failure in adaptivity. It is likely that subjects' a priori estimates of the impact of opportunity-cost time pressure on expected payoffs were vague, and although subjects carried out several practice trials and did adapt their processing to opportunity-cost time pressure, their knowledge of the impact of opportunity-cost time pressure on payoffs may have been inadequate. Subjects may have focused on responding to goals or correlation and inadequately compensated for time pressure. Generally, individuals may have problems in adaptation when the implications of adapting to individual aspects of the choice environment conflict (e.g., adapting to an accuracy goal or to negative correlation conflicts with what is required for adapting to time pressure).

A second, related explanation for the failure in adaptivity is that subjects' responsiveness to the goals of accuracy and effort was "disproportionate" (Kleinmuntz & Schkade, 1993). The instructions to emphasize accuracy or effort were given before each decision problem, which may have increased the subjective weight given to the goal manipulation.

A third possibility is that the time stress generated by the need to pay attention to the clock in the opportunity-cost conditions may have interferred with the abilities of the subjects to execute their chosen strategies (see Eysenck, 1984, for the related idea that anxiety reduces short-term storage capacity and attentional control). However, our main effect results show that our subjects shifted their processing patterns in predicted directions as a function of goals, correlational structures, and opportunity-cost time pressure, suggesting that a simple explanation based upon a general degradation of performance is not adequate.

Finally, as noted above, subjects may have tried to optimize on a criterion considering effort as well as payoffs. However, the fact that subjects under time pressure and accuracy goals received lower payoffs and also took more time does not seem consistent with this possibility. Whatever the exact reason for the failure in adaptivity exhibited by our subjects, it is clear that both accuracy goals and negative correlation interacted with opportunity-cost time pressure to lower subjects' payoffs.

Motivated Decisions

In a recent article, Pelham and Neter (1995, p. 581) ask "What are the judgmental consequences of being a highly motivated decision maker?" In a series of experiments, they find that higher levels of motivation facilitate judgmental accuracy when the judgments to be made are relatively easy but debilitate judgmental accuracy when the tasks are relatively difficult. To the extent that dealing with decisions under opportunity-cost time pressure is more difficult, our results are similar to those of Pelham and Neter. Using a choice task, as opposed to the judgment tasks studied by Pelham and Neter, we find that an accuracy goal led to increased performance in environments that did not involve opportunity-cost time pressure and lowered performance in environments that did involve opportunity-cost time pressure. Thus, decision makers who are more motivated to be accurate can sometimes make decisions in ways that are not adaptive for the tasks or environments they face.

Implications for Practice

The present results, along with prior results of ours and others, have implications for making decisions in high-velocity environments. Dumaine (1989) argues that companies often mistakenly try to compete on speed simply by doing what they already do, only faster. However, our results imply that strategy changes are needed under opportunity-cost time pressure. In particular, when deciding in high-velocity environments, the decision maker should focus on breadth of evaluation rather than on depth of evaluation. That is, the decision maker should first identify or generate multiple options to evaluate; then he or she should focus on breadth of evaluation (i.e., considering all the multiple options on important attributes). Evaluation processes which focus on single alternatives, although they can generate greater insights into the relative benefits and costs of each option, are likely to succeed only when the environment is not highly time-pressured (see Ward, Liker, Cristiano, & Sobek, 1995, for the related point that Toyota is able to "make better cars faster" by thinking about sets of design alternatives, rather than pursuing one alternative at a time in an interative fashion). More research that directly examines how alternative prescriptions for decision making fare in high- and low-velocity environments is needed.

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