Enhancing the Performance in Dynamic Decision Making:
The Adaptive Model Reconstruction Using Feedforward vs. Feedback Decision Strategy

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Abstract

This study examined the cognitive processes of strategic decision making in simulatied dynamic environments. The experimental study using two different types of interactive decision making games found that high performers adopted more feedforward strategy and they pursued more model expansion than low performers did. These findings were confirmed in a supplementary study which manipulated to force the subjects to use feedforward strategy in their dynamic decision making. Results suggest that, in dynamic decision environment, the performance relies on the decision making strategy that managers adopt, i.e., feedforward strategy rather than feedback strategy. This study concludes by discussing its implications for theoretical development and strategic decision makers in complex dynamic environments.

Introduction

Today's continuously changing hypercompetitive managerial environments bring about uncertainty, comlplexity, and conflict(Ginsberg,1992; Sterman,1994).

This dynamic complexity requires that top managers' mental models must keep pace with a changing environment(Barr, Stimpert & Huff,1992) and that managers should make fast decisions in high-velocity environment(Eisenhardt,1989).

This study addressed the lack of normative research on the strategic decision making in dynamic environments by examining the cognitive processes of the strategic decision makers in dynamically simulated environments.

We empirically explored the conditions under which strategic decision makers perform better and ultimately overcome the cognitive biases/limitations and dynamic deficiencies using two simulated dynamic decision making games, i.e., Beer Distribution Game and People Express Management Flight Simulator.

Introduction

According to Edwards(1962), a dynamic decision making requires(1) a series of decisions rather than a single decision, (2) these decisions are interdependent, i.e., decisions at one point constratint the possible decision of next period, and (3) environment changes, i.e., both autonomously and as a consequences of previous decision.

Brehmer(1990) asserted that first, decision maker can not exercise full control over the rate at which he has to make a decision or choose the moment in time when he will make his decision. Second, the dynamic decision making process is not a one shot case but interdependent and this make it more important for the process of the behavior. Third, each tasks must be defined by its time schedule.

Diehl and Sterman(1994) concluded that the mental constructs and heuristics subjects bring to bear in complex tasks are dynamically deficient, and subjects are unable to account well for delays and feedback effects because, first, people's mental representations of complex tasks are highly simplified, tending to exclude side effects, feedback processes, delays and other elements of dynamic complexity, and second, even when these elements are known, people's ability to infer correctly the behavior of even simple feedback systems is poor.

Introduction

Feedforward vs. feedback strategy

Feedback strategy includes a decision making to respond to the discrepancy between decision making in t=n-1 period and results of t=n period. This is explained for a series of adaptive process to the results from the past action(Brehmer,1990).
In contrast, feedforward strategy includes a decision making through model building available to t=n period using the cumulative information until t=n-1 period from prior knowledge or memory.
What it means to generate a model by past information is, using past information to generate a strategic model that is applicable future and past.
Which is different from feedback strategy(Brehmer,1990).

However, decision making studies implemented the dynamic environment have not yet dealt with general managerial environment(Brehmer & Svenmarck, 1995)

Experimental Design

	1st Experiment	2nd Experiment
# of Subjects	Singles: 6 persons Pairs: 2*6 persons	Singles: 14 persons Pairs: 2*14 persons
Experiment Task Material	Beer Distribution Game(Sterman,1993)	People Express Management Flight Simulator(Sterman,1993)
The role of Subjects	As a wholesaler, s/he must decide the quantity to order quantities, the production capacity of the factory, and the amount of inventory the distributor has in store.	The player decides the number of aircraft to purchase, marketing expenses, the number of personnel to hire or dismiss, airline fares, and the range of services offered on board.
The objectives of experiments	To minimize total inventory costs	To attain the optimal growth rate, market share, net profit and stock price.
Experimental procedure	The BDG was played for a period of 30months(two and a half years). Subjects were given 150 seconds to assess the situation on hand each month, after which they were required to enter the order amount and justify their decisions, and then the next period instantly began.	The 2nd experimental procedure was identical to that of the first experiment except for the fact that the experimenters spent more time explaining the basic structure of the PEG due to its relative complexity.

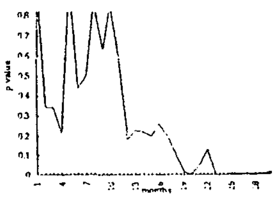
Materials

The BDG also has only two phases a normal phase in which both the order quantities from the retailers and the shipments from the distributors are stable; and an abnormal phase during which the wholesaler must face a severe supply shortage(sharp increase in retailer order; zero shipment from the distributor) immediately followed by a sharp decrease in demand(no order from retailers' excessive shipments from the distributor).
The latter abnormal phase is clearly differentiated from the normal phase in BDG.

The PEG simulation is more complex than the BDG in that it has five decision variables and four goal variables. Moreover, there is no sharp contrast to indicate the beginning of an abnormal phase, but rather a gradual worsening as would occur in real life without any dramatic decrease in the goal variables to give an early warning of impending problems.

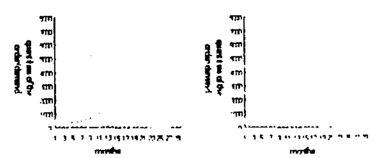
1st Experiment Results

The difference between the Single and Pair groups became greater as the game proceeded into the abnormal phase.



The Degree of the Difference in overall inventory cost between the two groups

Decisions made by the Typical Pair and Single subject



1st Experiment Results

The difference in the number and diversity of inferences between the pair and single groups is insignificant during the normal phase, when the supply and demand patterns are stable. However, during the abnormal phase, when the dynamic changes in demand and supply increase the complexity of the environment, the pair group made a greater number of inferences compared to the single group($t(10)=3.035$, $p<0.0125$). Moreover, the inferences made by the pair group were also of a greater variety($t(10)=2.768$, $p<0.0198$).

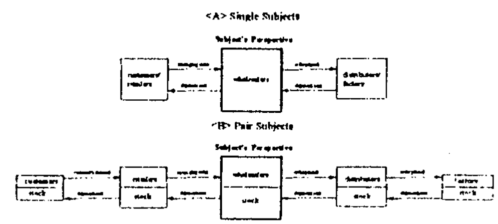
		Normal Phase		Abnormal Phase	
		Single subjects	Pair subjects	Single subjects	Pair subjects
Number of Inferences	mean	5.5	7.0	11.3	17.6
	t- test	t(10) = 1.860, P(|t| ≤ T) = 0.0924		t(10) = 3.0346, P(|t| ≥ T) = 0.0125	
Diversity of Inferences	mean	56.0	73.5	90.0	130.3
	t- test	t(10) = 1.965, P(|t| > T) = 0.0776		t(10) = 2.7680, P(|t| > T) = 0.0198	

Number and diversity of inferences   Single vs Pair

1st Experiment Results

This figure compares the final models constructed by the Single group and the Pair group. The model constructed by the Single group consists only of the incoming order from retailers and the shipments from the distributor, overlooking the accumulation of inventory.

First, the Pair model accounts not only for direct impact of the incoming order from the retailers, but also for the indirect effects the customer demand will have. Second, the pair model takes into consideration the distributors that have no direct relation to the subject's wholesaler, but who are nevertheless stocked by the same factory as that of the subject's distributor.



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1st Experiment Conclusions

The results of this experiment clearly demonstrate that Pair subjects, through divergent inferences, construct more comprehensive models, enhancing their effectiveness in dynamic decision making.

The Beer Distribution Game is an oversimplification of the real world, consisting of only one decision variable, one goal, a clearly differentiated abnormal phase and a single correct model. In the actual business world, however, there is bound to be more than one variable that decision makers need to manipulate, multiple goals, a variety of possible models of the problem, and no clearly distinguishable abnormal phase. Therefore, the results of this experiment need to be reproduced with a simulation game that is a closer replica of the complex business world to justify such an argument, which was the purpose of the second experiment.

2nd Experiment Results

The results indicate that the Pair group did not necessarily make more inferences than the Single group as could reasonably be expected based on the results of the previous experiment. This could be interpreted in terms of the first experiment as a plausible explanation for the lack of difference in performance between the two groups. Likewise, the fact that the HPQ group made more diverse inferences relative to the LPQ group can account for the superior performance of the HPQ group.

The four performance measures: Singles vs.Pairs, High vs. Low performers

Differences between		Growth Rates		Market Share		Net Profit		Stock Price	
Single vs. Pair		Singles	Pairs	Singles	Pairs	Singles	Pairs	Singles	Pairs
	means	9.85	16.62	0.252	0.322	12.4	14.51	14.90	18.14
	t-test	P(|t|≥ T)=0.13		P(|t|≥ T)=0.06		P(|t|≥ T)=0.27		P(|t|≥ T)=0.13	
HPQ vs. LPQ		HPQ	LPQ	HPQ	LPQ	HPQ	LPQ	HPQ	LPQ
	means	23.90	1.69	0.373	0.193	17.34	9.32	22.26	11.13
	t-test	P(|t|≥ T)=0.0004		P(|t|≥ T)=0.0001		P(|t|≥ T)=0.001		P(|t|≥ T)=0.000	

Differences in terms of inferences: Singles vs. Pairs, High vs. Low performers

Differences between		Number of Inferences		Diversity of Inferences	
Single vs. Pair		Singles	Pairs	Singles	Pairs
	means	24.62	32.18	19.23	23.55
	t-test	P(|t|≥ T)=0.1271		P(|t|≥ T)=0.1404	
HPQ vs. LPQ		LPQ	HPQ	LPQ	HPQ
	means	19.71	30.33	15.01	25.17
	t-test	P(|t|≥ T)=0.0869		P(|t|≥ T)=0.0045	

2nd Experiment Conclusion

The results from the second experiment indicate that pairing subjects together does not guarantee high performance in dynamic decision making. One possible cause of the inconsistency between 1st and 2nd experiment result can be found in the explicit distinction between the normal and the abnormal phases in the BDG simulation. in the PEG simulation, there was no marked abnormal phase, which could account for the lack of difference in performance between the Single and Pair subject. However, the positive correlation between the number, and especially the diversity of inferences, and the high performance in dynamic decision making remained consistent throughout both experiments.

3rd Experiment

The third experiment was conducted to investigate possible methods of encouraging the decision maker to make diverse inferences in dynamic decision making.

3rd Experimental Design

Direct Enforcement	Model Space Map
The experimenter asked subjects to think of at least three different ways in which their decision would affect the other entities in the simulated environment.	The experimenter provides subjects with a Model Space Map (MAP) which shows the possible inferences that can be made together with the inferences that have already been made by the subject.

The results from the third experiment reveal that providing the Model Space Map did not impact on the final performance of the subjects. This seems to suggest that indirect encouragement of divergent thinking via an external aid is insufficient to improve the quality of decision making in complex business simulations. On the other hand, the direct enforcement of diverse inferences proved to be a very effective way of improving performance in dynamic decision making.The 'with ENF' groups were superior to the 'without ENF' groups in terms of all four goal variables, and the differences between the two groups were highly significant [Growth Rate: $F(3,18)=13.22$, $Pr > 0.002$; Market Share: $F(3,18)=8.99$, $Pr > 0.009$; Net Income: $F(3,18)=16.12$, $Pr > 0.001$; Stock Price: $F(3,18)=24.28$, $Pr > 0.002$].

Conclusion

We argue that the key success factor in dynamic decision making is the number and especially the diversity of inferences.

Pairs constructed a model that includes all the important entities and relations, whereas the Single group's model was oversimplified.

the number and especially the diversity of inferences made was still discovered to have a significant impact on performance even in more complex tasks.

The final experiment thus searched for a method of encouraging the decision maker to make such diverse and numerous inferences in order to improve the quality of the decisions, but only the more brute-force method proved effective.

This study has important implications for improvement of the quality of decisions made in the dynamic environment by presenting a new framework supported by empirical results. It fails, however, to consider more powerful factors, such as motivation and emotion. Future research should continue the strand of this study to develop less conspicuous and more feasible methods of aiding the decision maker.

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