An Experiment to Study the Relationship between Decision Scope and Uncontrollable Positive Feedback Loops

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Abstract

How human beings perceive, think, act, and/or interact with systems of dynamic complexity have more, deeper and important research issues to be carefully studied. Our past efforts were mostly focused on conducting researches in this area through designing, playing, and/or learning with some microworlds/management flight simulators/ learning laboratories/ dynamic decision games. Recently, we put some effort to study more carefully about the dynamics nature of the microworlds being played with focus on the uncontrollable positive feedback loops and their influences on players' decision-makings. In this paper, we employs "STRATAGEM-2" microworld to design an experiment to test a hypothesis: "Will the decision scope be reduced when players trigger some uncontrollable positive feedback loops hidden in the microworld?" The results of our experiment strongly support this hypothesis. In addition, we start to believe that better and deeper understanding about the characteristics of uncontrollable positive feedback loops will provide the system dynamics discipline an alternative way to interpret some of the very critical dynamics nature of a microworld or a real world system under studying.

Introduction

How human beings perceive, think, act, and/or interact with systems of dynamic complexity have more, deeper and important research issues to be carefully studied. Our past efforts were mostly focused on conducting researches in this area through designing, playing, and/or learning with some microworlds/management flight simulators/ learning laboratories/ dynamic decision games (e.g., Young et al., 1991; 1992; Wang and Young, 1992; Young et al., 1993; Young et al, 1994; Young and Wang, 1995; Young and Chen, 1995; Young and Lo, 1996; Young and Wang, 1996). Recently, we put some effort to study more carefully about the dynamics nature of the microworlds being played with focus on the uncontrollable positive feedback loops and their influences on players' decision-makings (Young and Chen, 1996). This research employs "STRATAGEM-2" microworld (Sterman & Meadows, 1985) to design an experiment to test a hypothesis: "Will the decision scope be reduced when players trigger some uncontrollable positive feedback loops hidden in the microworld?" In other words, the hypothesis assume the players have many possible decision rules and can choose any one they like before some hidden uncontrollable positive feedback loops are triggered without consciousness. They can also swing from this rule to another without any obstacle. But after some uncontrollable positive feedback loops are triggered and dominate the system, the decision rules which the players can choose will become much fewer, that is the decision scope is reduced. When the decision scope is reduced to some very restricted

level, the system will be very difficult to recover and make the players feel extremely helpless.

The characteristics of the uncontrollable positive feedback loops

The uncontrollable positive feedback loops has the following characteristics which are quite similar to those of a land mine and therefore are very uncontrollable: (Young and Chen, 1996)

1. Hidden: The uncontrollable positive feedback loops is hidden in a system. It needs something to trigger it. Under some circumstances, the uncontrollable positive feedback loops will be triggered; in others, they may keep unexploded mode.
2. Powerful: After an uncontrollable positive feedback loops is triggered, it will lead the concerned variables to start exponential growth or decline. The longer the time, the bigger the destruction.
3. Expansive: Triggering an uncontrollable positive feedback loop will raise a series of system behaviors, it may trigger another uncontrollable positive feedback loop and make more destruction. In other word, the effect of uncontrollable positive feedback loop is expansive.
4. Difficult to rescue: Once an uncontrollable positive feedback loop is triggered, since there may not exist any controllable variables which can influence that uncontrollable positive feedback loop, it is impossible to rescue the system.

In essence, there are two types of uncontrollable positive feedback loops. One is self-activated uncontrollable positive feedback loops; the other is decision-activated uncontrollable positive feedback loops. In Figure 1, we can see the self-activated uncontrollable positive feedback loops are embedded in the infrastructure. It consists of flows and wires in the infrastructure. It is possible for these flows and wires to form positive feedback loops. It is generated by natural rules (for example, if we borrow money from others, it must accompany with interest). There is no controllable variable in the loop.

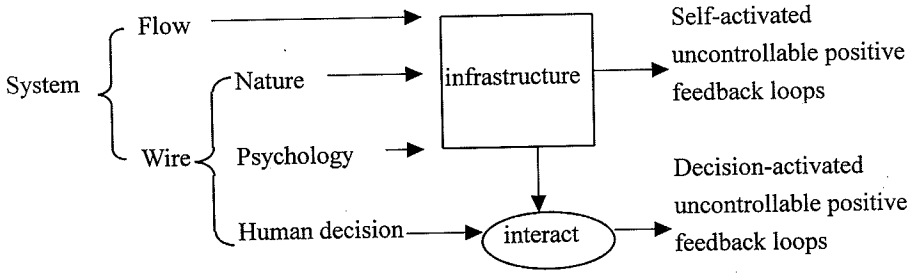

Figure1: The types of uncontrollable positive feedback loops and their formation

The decision-activated uncontrollable positive feedback loops are the ones which are not exist in the infrastructure, but formed by the interaction of decision-maker and the infrastructure. So when the decision-activated uncontrollable positive feedback loops are triggered, we can disarm it by changing our interaction with the infrastructure. In addition, there is "momentum" in the system. Because of the momentum, even when the

interaction changed, the problems produced by uncontrollable positive feedback loops will not be fixed immediately. In the same way, it will not trigger uncontrollable positive feedback loops until the accumulation of the concerned level variable reach the critical point. So it may not be obvious in the early stage of the system, but after some time, it will dominate all the system.

The relationship between decision scope and uncontrollable positive feedback loops

While a decision-maker interact with an infrastructure, there would be many conditions to restrain him from doing something he wanted to do. In other words, very few rules can be executed among the rules he wanted to be executed. It is a typical case of the restriction of degrees of freedom of decision making. For managing a business, the restrictions may be from outside the system, such as government regulations, industrial environments, competitive situations, capital, technology, and so on.

However, from system dynamics point of view, the decision-making may be not only influenced by the constraints outside the system, but also from the dynamic complexities within the system. The uncontrollable positive feedback loops studied in this article is one form of them.

After the uncontrollable positive feedback loops are activated, we would find the growing behavior pattern of the concerned variables. This kind of growth is dangerous, because it is not controlled by the decision-maker. If the uncontrollable positive feedback loops is triggered, it will dominate all the system. Under this situation, the player is restricted to make useless decisions which he doesn't really want to, so the decision scope is much reduced.

The Background of the experiment

The data of this research adopts parts of Wang's (1994) experiment (also, Young and Wang, 1995; 1996). Wang's experiment used the task of STRATAGEM-2 to study "The Design of the Management Learning Laboratory and the Learning Transfer". Subjects of 11 students in Wang's experiment were used. They were asked to played 4 trials(25 intervals per trial). Their rewards were in accordance with the total scores of 4 games. All the subjects had read the instructions of the game before playing. Besides this, there was no other assistance during the experiment.

The original data included the decision-records and the decision-rules of the 11 subjects in all the 4 trials. This research used different methods to reanalyze and test hypotheses we proposed in this research.

In the task, subjects were asked to used the decision variable of "Capital Orders"(In this research, they were also the decision rules) to balance the aggregate supply and demand. In other words, they had to minimize the discrepancy between "Capital Stock" and "Backlog-total" during the 25 intervals.

The only one exogenous variable in the task is "Consumer Goods Orders". In the first trial, it started at 450 in the first interval, but adjusted to 500 in the second interval and then fixed at 500. In other trials, it started at 500 and then fixed.

Research method

The most important issue that this paper concerned is "Is decision scope influenced by the uncontrollable positive feedback loops?" This paper used the decision rules obtained from Wang's study to translate decision values into analytical mathematical functions. We use "uncontrollable positive feedback loops" perspective to observe the performances and the decision scope of the subjects under the condition

which no other learning assistance existed.

The hypotheses proposed are as follows:

Hypothesis 1: The decision performances were different between systems fallen into the uncontrollable positive feedback loops and systems NOT fallen.

Observing variables: "The intervals in the uncontrollable positive feedback loops" and "decision score".

Observing method: The decision scores when fallen into the uncontrollable positive feedback loops was significantly different from the scores not fallen.

Hypotheses 2: The frequencies of changing decision rules were different between systems fallen into the uncontrollable positive feedback loops and systems NOT fallen.

Observing variables: "The intervals in the uncontrollable positive feedback loops" and "the frequencies of changing decision rules".

Observing method: The frequencies of changing decision rules in the periods of uncontrollable positive feedback loops being activated were significantly different from the frequencies that were NOT in the periods of uncontrollable positive feedback loops being activated.

In addition, the measuring methods of different variables were as following:

(1)The intervals in the uncontrollable positive feedback loops:

This paper rendered a series of coding principles from the operating definition of the uncontrollable positive feedback loops for the two variables—"backlog-total" and "capital stock".

(2)Decision score:

The sum of the absolute differences between the two variables—"backlog-total" and "capital stock".

(3)The frequencies of changing decision rules:

According to Wang's study, there were three types of decision rules, they were type A, B, and C. Every time when the rule changed, the frequencies would add one time.

The results

To hypothesis 1, according to the statistics, there were 1012 effective intervals (subtract the first and the 25th interval, 11 subjects, 4 trials per subject). As shown in table1, there were 493 intervals in the uncontrollable positive feedback loops, and 519 intervals out of the uncontrollable positive feedback loops. Due to the exponential nature of the Strategem2 task, the data were transferred to the Naperian logarithm form. Table 1 showed the results. The average scores in the uncontrollable positive feedback loops (mean=6.7040, S.D.=1.669) and the average scores out of the uncontrollable positive feedback loops (mean=6.1121, S.D.=1.990) were different significantly (T-value=5.14, p<0.000).

Table 1: The average scores analysis:

	In uncontrollable positive feedback loops	NOT in uncontrollable positive feedback loops
mean	6.70	6.11
S.D.	1.67	7.99
N	493	519

T-value=5.14, 2-tail sig.=0.000

To hypothesis 2, the output was shown in Table 2. All the data in the experiment were re-coding by the new coding rules. There were 11 subjects triggered 63 times uncontrollable positive feedback loops in 44 trials. Among them, only 8 triggers accompanied with changing decision rules, while other 55 not changed. On the other hand, in 46 periods which were not fallen in the uncontrollable positive feedback loops, we had 37 terms which changing decision rules, while only 9 terms doesn't changed. As shown in table2, χ^2 test suggested that those difference were not occasional (χ^2=50.324, p=0.000). Subjects who were fallen in the uncontrollable positive feedback loops tend not to change their decision rules. On the other hand, subjects who were not fallen in the uncontrollable positive feedback loops, seemed had more choice to change their decision rules.

Table 2: The relationship between fallen in uncontrollable positive feedback loops and decision rules' change

	In uncontrollable positive feedback loops	NOT in uncontrollable positive feedback loops	Total
The Frequency of Changing Decision Rule	8	37	45
The Frequency of NOT Changing Decision Rule	55	9	64
Total	63	46	109

χ^2=50.324,p=0.000

Conclusion and Discussion

This experiment explained the significance of hypothesis 1. Under the presumption of rationality, subjects' goals should be "try their best to minimize the score to get high gains". But the experiment output exhibit that subjects always made the decision that led to very high score in the uncontrollable positive feedback loops dominating period. If we hold the presumption of rationality, then there is a possible cause that the subjects lose the freedom to change their decision rules, so they could just follow the wrong decision when the uncontrollable positive feedback loops dominate the system.

Observing the dynamic complex system, we find that there might be many factors can influence subjects' decision scopes, the uncontrollable positive feedback loop is just one of the factors. But the uncontrollable positive feedback loops perspective has a special meaning. The system is not always in critical situation. Sometimes it is really very dangerous, and sometimes not. If the decision-makers know how to escape from the dangerous uncontrollable positive feedback loops, they can make the system in a relative safe situation. In other words, the uncontrollable positive feedback loops perspective can save subject's cognitive loading, so that he can focus his attention on the really dangerous uncontrollable positive feedback loops under critical situation.

The significance of hypothesis 2 demonstrated that uncontrollable positive feedback loops did restrain the decision scopes. So while the system is dominated by the uncontrollable positive feedback loops, the degrees of freedom of decision-making decline. The decision-maker can still have a chance to change his rules only after he can successfully go through the destruction of those uncontrollable positive feedback loops.

Generally speaking, this paper explained the subjects' poor performance in the STRATAGEM-2 model. This is because the decision-makers triggered the uncontrollable positive feedback loops and could not change their decision rules. In addition, we start to believe that better and deeper understanding about the characteristics of uncontrollable

positive feedback loops will provide the system dynamics discipline an alternative way to interpret some of the very critical dynamics nature of a microworld or a real world system under studying.

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