Cultural Conditionality in Decision Making:

A Prospect of Probabilistic Thinking

Zhang Bingxun

Department of Information Systems
London School of Economics
and Political Science

Submitted in fulfilment of the requirements
for the award of the degree of
Doctor of Philosophy
of the University of London

April, 1992

Abstract of Thesis

This study examines the clashes and accords between Western and Chinese decision cultures and explores their serious implications for the introduction of Western decision approaches into a totally different culture, in particular, that of China. The experimental investigation was concentrated on the cultural difference in the way of dealing with uncertainty. It extended previous cross-cultural comparisons between Western and Chinese decision makers in probabilistic thinking. It is confirmed that British and Chinese college students think about uncertainty and make probability judgments differently in answering general-knowledge questionnaires. It is also found that Chinese economists disliked forecasting economic indices that demonstrate a wide probability distribution. However, Chinese amateur card players did make almost perfectly calibrated probability judgments. With these findings, it is warned that the applicability of Western decision techniques, such as decision analysis and decision support systems, certainly cannot be taken for granted in China. This study also proposes a cognitive model to describe how people make probability judgments in general, and especially emphasizes the building of problem structure and the discriminating of feeling of uncertainty. From this, future cross-cultural studies of probabilistic thinking are suggested, that will make further investigation into whether Western and Chinese decision makers create different structures for the same problem, thereby leading them to think and judge uncertainty differently. Finally, this study generalizes the discussion of the rationality behind Western decision methods and its conflicts with traditional Chinese decision culture. It is concluded that Western approaches to decision making should be introduced into China, but its assumptions and conditions must first be carefully investigated. It is predicted that more powerful decision aids will emerge from the synthesis of Western and Chinese decision cultures.

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Acknowledgements

When I came to London about four years ago, I would never have dreamt of undertaking the research topic I have just completed. I looked more like a technician then, as one of my supervisors observed. It was Professor Ian Angell who opened my mind to look in a more general way at the issue of the introduction of Western approaches to decision making. I must say that without his patient help and great encouragement, many discussions about Chinese decision culture in this dissertation would not have appeared. I also should thank him for having corrected numerous mistakes I have made in my written English, otherwise, the readers would have found it to be much harder to read.

In calibration study, I am an apprentice of Dr. Lawrence Phillips. I have greatly benefitted from his rich experience in the study of behaviourial decision making, especially in the design of the experiments and the analysis of results. Some of my viewpoints were inspired by his works and were elaborated by discussions with him. My many thanks should also go to him.

Nevertheless, I have to declare that any mistake that readers may find in this dissertation belong solely to the author; my supervisors do not share the same opinions as me in all the issues.

I finally would like to thank Mr. David Raymond Allen OBE and Mrs. Li May Phipps who set up the DHL Educational Foundation, which provided me with financial support for my study. Without their help, I would certainly have been unable to come to London and to complete this dissertation.

Chapter 1. Cultural Clash in Decision Making

1.1. Introduction

Decision making is one of the most important activities engaged in by all human beings. Such activities can be traced back to the dim and distant past. To survive calamities or battle, man searched for, and took, better courses of action. However, even though today we have much experience in making decisions, and we are armed with modern technology, it has never become an easy task, especially when we are faced with complex, dynamic and uncertain decision situations. Decision making, as a systematic science and technology has a very short history. Not until World War II, did formal, analytic techniques come to be used extensively for decision making. Arguably, it was British scientists who applied operational analysis techniques for the first time to help solve critical strategical and tactical problems (Raiffa, 1968). Since then, mainly in Western countries, a great deal of research effort has been made by scholars from a number of disciplines into making effective decisions. Various theories and techniques of decision making have arisen. Especially, within a relatively short period of time, information technology and decision analysis techniques have been rapidly developed, and have been widely applied in a variety of fields, such as business administration, social policy making, engineering evaluation, diagnosis of disease, legal judgment, etc. The influence of Western decision approaches are expanding outward to other countries, including China, the country we shall be studying in particular detail in this dissertation.

"Stones from other hills may serve to polish the jade of this one" is a well-known saying in China, which is apposite to the present Chinese desire to introduce modern Western approaches. In the past decade, the open-door policy has invited in a variety of Western techniques to improve Chinese decision making. Several years ago, Tor Melae, the chief economist of TEXACO, went to China to describe how Western managers make their investment decisions. In a one-week seminar, about ten computer software packages were demonstrated and taught, including database management systems, statistical analysis software packages, and decision support systems. Western decision theory and analysis techniques not only are being taught in universities, but also are becoming more and more familiar to Chinese decision makers. For example, occasionally some younger men within organizations have begun to use techniques such as decision trees though the older managers and officers are not taking these methods too seriously. Western decision analysts have even been invited to participate directly in decision making activities in China. For example, recently over 100 Canadian experts consulted on a crucial engineering project --- studying the feasibility of realizing a Chinese "great dream" of building a dam in the Three Gorges on the Yangtze River; and they presented a report recommending the start of this project (in fact, more Western experts have been involved, see Lieberthal & Oksenberg, 1988). Although we don't know yet, whether the analysis and conclusions of Western style can, or to what extent, affect the decision of the Chinese top decision makers on this project, there can be no doubt that Western decision approaches have been introduced into China.

However, can Western decision approaches work well, or even work at all, in China, a country of radically different history, culture, philosophy, and social ideals? In a philosophical discussion on decision analysis, Howard (1980) has pointed out, "The idea of a 'decision' is a quintessentially Western idea, an act of hubris to a believer in Eastern philosophy and a joke to the enlightened. (Can you imagine Buddha or Lao-Tzu making a decision?)." The scepticism comes, not only from theoretical analysis, but also from practice. In 1981-1982, Pollock and Chen (1986) went to China to help plan a comprehensive project for water pollution control of the Huangpu River. They found that it was difficult for their Chinese colleagues to accept Western rationalistic-normative methods of decision making --- generating alternatives, accounting for uncertainties, and eliciting the preferences of decision makers. For example, they complained that they met "a decision making environment that was almost completely devoid of a formal concern for uncertainty." And they concluded that "Perhaps it was presumptuous of us to expect the Chinese --- with a bureaucracy and decision making culture highly evolved over a period of more than 3,000 years --- to accept with more than polite acknowledgment a way of looking at problems that is so obviously Western: reductionist, empirical, quantitative, democratic in its approach." It was also found that there were few computer-based decision support systems presently in use in China, although the acceptance of decision support systems, even in the West, can no way be called an unqualified success. The Chinese reluctance to use decision support systems was accounted for by, among other things, the preference for the traditional, subjective decision making approach and for the hierarchical structure of organizations which reduces the demands for planning and decision making (Lu, Qiu, & Guimaraes, 1988). It seems to be suggested that Chinese culture does not harmonize well with the techniques of decision making which are rooted in Western, more specifically, Anglo-Saxon thought. The validity of Western decision approaches, both information technology and decision analysis techniques, cannot be taken for granted when they are transplanted into China. Broadly speaking, it should be questioned in any other culture which acts in a way radically different from Western thought --- even in countries that have experienced 200 years of British Empire! For example, Fukuda (1988) has argued that although Japan has assimilated much Western technology, and has become an industrialized country, Japanese managers still perceive the world and simplify complex realities in a way quite different from Western managers, and have their own distinctive subjective rationality. While most Western theorists see decision making as a conscious, rational process in which the manager selects a set of criteria and uses it to evaluate alternative solutions to a particular problem, Japanese managers tend to regard it as an irrational and emotional process. Indeed, Stewart (1981) has observed that in making decisions, Japanese managers prefer an intuitive process and do not readily draw ideas or conclusions from statistical analysis, although statistical control is widely used in industry and business. Japanese managers also prefer categorical predictions and are reluctant to make calculated estimates relying on probability. While American managers rely on a conceptual base that anticipates future events, the Japanese tend to perceive a continuously unfolding train of events to which they can accommodate. These observations about Japanese managers suggest that the cultural differences in decision making can also be found in many other non-Western cultures, and it should not be ignored when Western methodologies are used to develop decision support systems, or when Western decision analysis techniques are used to assist non-Western decision makers to make decisions.

However, it is overly simplistic to explain the failures in the introduction of Western decision methods into China as Chinese culture failing to foster the concept of a decision. It is so easy to cite numerous examples of the theory and practice of decision making in ancient Chinese history. For example, more than 2,000 years ago, Sun Tzu, an ancient Chinese military thinker, wrote "The Art of War" (Griffith, 1963), and proposed principles of strategy and tactics, which even today are considered to be of great value to businessmen all over the world as well as to military officers. It has even reached Hollywood: in the film "Wall Street"; the antihero used the book in his business dealings. Also a Chinese word "Yun Chou", which can roughly be translated as "devising strategy and tactics", has been used since at least the Han dynasty, or around 200 B.C. (Jiang, 1986). The term "Operational Research" is actually called "Yun Chou" in China today. The concept of decision, "Jue Ce", also has been proposed in "The Romance of the Three Kingdoms", a historical novel written several hundred years ago, a book whose value in Chinese decision culture goes far beyond its value in literature. Under the term of "Jue Ce", the author described how Zhu Geliang, a famous strategist in ancient China, helped Liu Bei to settle long-term and short-term objectives, as well as the general and concrete means achieving these objectives. In ancient Chinese architectural history, there is another interesting example. Several years ago, a senior economist visiting the RAND corporation was told that the history of cost-benefit analysis techniques could be traced back to an ancient Chinese, Ding Wei, who was in charge of rebuilding the Bian Palace in the early 11th century (Wu, 1983). At the beginning of the project, Ding Wei asked the labourers to dig many canals which linked to the Bian River outside Bian city. The soil got from digging canals was used to build the foundation of the Palace. Then a great quantity of materials needed by the project was directly transported into the construction site by water, thus saving manpower. After the Bian Palace had been rebuilt, the debris and remaining soil was used to fill up the canals, which later became avenues. So, it appears more appropriate to infer that Chinese people have a different way of decision making, rather than to accept Watson and Buede's (1987) suggestion that the fatalistic legacy of Chinese philosophies provide a stark and incompatible contrast with the Western humanist tradition. The specific features of Chinese decision tasks and intellectual environment were developed from the peculiar experience of Chinese culture, and were reinforced by isolation from generation to generation, as of course did Western thinking. Indeed, Griffith (1963) has pointed out, "Sun Tzu's realism and moderation form a contrast to Clausewitz's tendency to emphasize the logical ideal and 'the absolute', which his disciples caught on to in developing the theory and practice of 'total war' beyond all bounds of sense." Perhaps it is the cultural differences in decision making that create the resistance to Western decision approaches. What could be more serious, than that cultural differences may cause a technological decision to fail in the Western sense, is that ignorance of cultural differences and the inappropriate copying of Western decision methods could mislead, rather than effectively guide Chinese decision makers.

Clearly, the validity of Western approaches to decision making is a fundamental issue which should be painstakingly inquired into, when it is being introduced into a non-Western culture, such as that of China. I consider, in a narrow sense, that decision making itself is a culture, which involves the values that decision makers appreciate, the beliefs that they hold, and the instruments and language they are used to employing. The disagreements between the requirement of properly applying Western decision methods and the observable behaviour of Chinese decision makers, thereby, could be a reflection of various subtle and deep-seated incompatibilities between Chinese and Western cultures, and they certainly cannot be superficially explained away. However, until now, the validity of Western approaches to decision making in Chinese culture has not been seriously questioned nor deeply investigated, especially within China, although some cultural clashes between Western decision techniques and Chinese decision makers have been noted, as mentioned before. The deficiency has already led to simple negation of, or conversely blind use of, Western decision techniques in China. Based on the recognition that Chinese and Western decision cultures are probably quite different, such differences can have significant impact on the success of the introduction of Western decision approaches to China, I, therefore, decided to make a serious inquiry into this issue with my dissertation.

This raises the question of exactly how to make this inquiry. One way was to make a general investigation about the cultural clashes and agreements between Chinese and Western decision cultures, and then analyze their impact on the application of decision approaches. It was in this way that many early cross-cultural studies were undertaken, and these could have served as a guide to my study. For example, Northrop's (1946) "The Meeting of East and West" is representative of the studies in philosophy, in which Western and Eastern philosophies have been compared from many aspects, with Chinese philosophy as a major representative of those from the East. In the field of the history of scientific thought, Needham (e.g. 1956) has made a profound comparison between the developments of Chinese and of Western science and civilization. However, few studies have made a thorough comparison between Chinese and Western management and decision cultures. In fact, to my knowledge, Chinese decision culture as a whole has not been systematically explored, although relevant discussions are scattered everywhere, in historical records, philosophical books, and military works. Such a study really is a challenge and is very attractive. Obviously, it is also very difficult, as it demands the collection of rich data and a deep and general understanding of both Chinese and Western decision cultures. Following such a research path, I need to investigate and compare various aspects of these two cultures.

Nevertheless, I finally choose to concentrate my research on a particular aspect of decision making, and to dig deeply into it. Although I seem to "hold a too short rope to reach the deep well water", I believe that with this approach I will be able to demonstrate more clearly some specific cultural differences between Chinese and Western decision makers and to explain more convincingly their significant effects on the process of decision making and thus on the application of Western decision approaches. Making this choice is particularly encouraged by an important recent finding of Phillips and Wright (1977) in a cross-cultural calibration study, which showed that when being asked to answer general knowledge questions in terms of probability, Chinese and British people responded quite differently. As the adequacy of probability judgments can be directly related to one of the fundamental assumptions of modern Western decision theory, it inspired me to consider that it may also be a good way of identifying and exposing problems in the application of decision approaches through an empirical investigation of cultural differences in probabilistic thinking. Therefore, in the methodology, this study is mainly empirical, but it will not ignore the relationship between individual phenomena in decision making and the whole decision culture, and will explain particular findings as deeply as it can.

This study starts from two research lines. One is early general cultural comparisons between Chinese and Western cultures in philosophy, science, military, and particularly in the way of thinking. The other is the recent investigation of probabilistic thinking in Chinese and in Western decision makers. This study attempts to incorporate and expand these two kinds of study in the final inquiry. Following early cross-cultural studies of calibration of probability judgment, the experimental investigation will concentrate on the human cognitive process in making probability judgments. Cultural differences and similarities of probabilistic thinking between Chinese and Western decision makers will be examined, revealed and explained against the general background built up from previous cross-cultural studies. In particular, in comparison with early studies, this study will move forward in several aspects. First it will compare and explore Chinese and Western decision cultures in more detail, especially focusing on the way of dealing with uncertainty. The differences between the approach promoted by Western decision theorists, and the "natural" way that Chinese decision makers actually follow in dealing with uncertainty, will be highlighted, based on both general cultural comparison and experimental investigation. Second, it will extend the early cross-cultural study of probabilistic thinking by using less artificial tasks to observe the behaviour of Chinese decision makers. The subject will also be extended from college students or overseas Chinese to other decision makers inside the People's Republic of China. Third, the dissertation will propose a more general cognitive model in an attempt to present a better explanation of the cultural differences in probabilistic thinking, and their implications for the application of Western decision techniques in China.

In the rest of this chapter, I will first examine the principle of Western decision approaches, in order to understand its fundamental assumptions, especially the way in which it advocates dealing with uncertainty. Following that, I will show that people who were born and bred in the Chinese decision culture probably take a different way from Western people in dealing with uncertain decision problems, and this way so easily leads them to violating the fundamental premises which Western decision approaches demand. Finally, I will simply summarize the structure of this study, its main topics, content and implications.

The second chapter is a review of early calibration studies, which will help us to understand its method, measures, and analysis techniques. Several early cross-cultural studies were given particular attention. The results of three experiments will be reported and analyzed in chapter 3 and in chapter 4. A general cognitive model of making probability judgments will be proposed and described in the final chapter. At the same time, I will also attempt to make a deeper discussion about the validity of Western decision approaches on culture, through generalizing the cultural differences into a confrontation of rationality between Chinese and Western decision cultures.

1.2. Western approaches for dealing with uncertainty

One of the most important tasks in decision making is to deal properly with uncertainty. Almost all modern Western decision theorists have stressed its difficulty and devoted a great deal of effort to developing effective methods for coping with uncertainty in order to make better decisions. The importance is due to two major reasons. First, uncertainty is ubiquitous. In the real world, it is hard to discover a decision which does not involve at least slight uncertainty. All of us have experienced hesitation when facing a difficult decision. For example a manager, in deciding whether or not to launch a new product, would probably worry whether this product could open up a potential market. A complex decision environment can bring even more uncertain factors. When making a decision about international investment, an oil company may face a variety of uncertainties: geological and technological risks, stability of the government of the resource country, possibility of changes of taxation, currency exchange rates, even the oil price policy of OPEC countries; all have to be considered carefully. In policy making, heads of government have similar problems. An economic policy of tax reduction, for example, may be expected to encourage investment, but whether the population prefer investment to consumption is difficult to foresee. The development of modern science and technology has made situations of decision making even more uncertain. Today's business world has been described by Peters (1987) as chaos. Managers confront tremendous change, which is exacerbated by swift development of information technology. In this chaotic world, predictability has become history. New competitors emerge and old ones disappear overnight, with the merging and demerging of companies. The values of currencies and commodities may rise or fall by 5 per cent per week, and by 50 per cent or more per year.

Secondly, uncertainty is not only widely present in decision making, but also almost impossible to eradicate. The common post-decisional complaints, such as "If I had known X", seem to suggest that people often attribute their feelings of uncertainty to the lack of information about events or relations between events. It is supposed that if people know enough about the present states of events, they have a basis to predict the future, and if people know enough about the relations between events, they can follow a way to infer future states of events from the present states of events. Unfortunately, in many situations, it is impossible to search for all the information. For example, under time pressure, there is the barest possibility to collect enough information. In competition, one can't get relevant information, simply because rivals deliberately conceal data. With limited knowledge about nature, people sometimes find it too difficult to unfold the whole cause-effect network linking the events concerned. In some situations, historical data may reveal a law behind a series of random events, but it still tells us little about a particular case. Furthermore, cross-cultural implications can introduce new layers of uncertainty. Thus, many decisions have to be made in the face of irreducible uncertainties, and the ability of dealing with uncertainty to a great extent decides the quality of decision making.

Emphasizing that uncertainty is hard to eliminate, however, doesn't preclude its reduction. In some situations, information collection and analysis can be the first step to overcoming uncertainty. The increase of applications of information technology in decision making has mirrored the demand. In the past decades information technology has been brought into play in an attempt to collect relevant information and conducting effective data analysis. For example, management information systems claim to make the information needed by decision makers more accessible and easier to understand. With the sophisticated processing capability and modelling assistance of decision support systems, it is possible to carry out more effective information analysis, and besides to predict possible consequences and thereby give feasible alternatives. Through data communication networks, relevant information can be found more quickly and more widely, and also knowledge and experience can be shared, which may be found useful in dealing with uncertainty. For some repetitive and well-structured decision problems, expert systems can also provide expertise and procedural advice. Indeed, present decision makers who are armed with information technology may have some advantage over their predecessors or those without. For example, in the oil industry, the uncertainty of geological structure, which the managers of risk investment are faced with, may be reduced more or less, as the high-speed processing capacity of computers today is able to deal with a huge amount of seismic survey data of three dimensions in an acceptable operating time. Government policy makers may benefit from the forecasts of computerized econometric models which contain up to several hundred simultaneous equations and variables. The trouble-shooters within a nuclear power station may have more confidence in handling an emergency, after consulting other's experience through a network built between theirs and many other stations. Information technology is a powerful weapon for fighting uncertainty, however, the claims made for the automation of decision making under uncertainty have so far fallen far short of expectations, perhaps because it introduces further complexity and uncertainty.

A main difficulty in automating a decision making procedure is that many decision problems are too complicated and uncertain to be handled by a prefabricated computer program. Most of the models, such as operational research models, on which computer programs are usually based, can only be an approximate representation of implied decision problems in the real world, and so the simplification of structure and elements cannot be avoided, no matter whether it is due to technical or knowledge limitations. Obviously, unpredictable changes in the open decision environment can easily deny what usually could be considered as optimum decisions: the outputs of computer systems. For expert systems, although they may include a representation of the judgments previously made by decision makers in the decision task at hand, they too have the same problem, as the judgments may be only effective in certain predictable situations, but not in open unpredictable environments. Even though some computer systems may continue to prove useful in coping with repetitive decision problems, decision making under uncertainty really cannot be expected to be automated for a long time, if at all. Computer systems, such as decision support systems and expert systems, can be good aid tools, but poor substitutes. Moveover, it is difficult to see how culturally driven intuition, or insight, of decision makers, which is evoked in dealing with a particular uncertain decision problem, can be previously coded into computer programs. Therefore, in dealing with uncertain decision problems, we cannot expect computers to automate this process and provide certainty, and the direct participation of human decision makers is necessary for handling the irreducible uncertainty. and their subjective judgment also has important role to play in both constructing models and interpreting outputs of a model. Before they act, decision makers must think clearly about their intangible, subjective feelings, and hunches that the model does not include. These are incompatible with the logic of the decision model and there still exists a subjective judgmental gap between the output of models and real world (Raiffa, 1968). Indeed, serious researchers don't reject the input of subjective judgment in attempting to model complicated systems in the real world. For example, Klein and Young (1980) has stressed the role of subjective judgment in adjusting the Wharton model. Through regular Wharton conferences, the subjective judgments of experts in many fields are incorporated into economic forecasts. He believes that judgment and quantitative modelling methods can do better. In short, information technology can be helpful in dealing with uncertainty, but it is not enough. Because the subjective judgment of decision makers is unavoidable, other techniques must be developed, which can assist decision makers to handle their intuition or opinions about uncertainty.

In dealing with uncertainty, people generally adopt an intuitive approach, often steeped in cultural symbolism. That is, in deciding a course of action, the information about uncertainty is not explicitly separated from the information about the outcomes of alternatives, and a preferred choice is somehow reached on the basis of the information, preferences, and feelings of uncertainty. Today the potential and scale of human activity have been greatly extended, and social organizations have also become mutually-dependent and more and more complex. Acceleration of change and intricate relationships have made decision environments and tasks too uncertain and complicated to be dealt with by human intuition alone. Recently, in response to the need of decision makers to handle uncertainty more effectively and to narrow or cross the subjective judgmental gap, decision analysis, as a normative, formal and quantitative technique has arisen as the times require. In the West, it has recently been extensively applied in many fields. In an effort to arrive at a rational choice, instead of trying to automate the process of decision making, the decision analysis technique attempts to trade off uncertainties against various value aspects of the outcomes. According to decision theory (Lindley, 1985; Raiffa, 1968; Gardenfors & Sahlin, 1988), information should be first decomposed into two types: the information about the decision maker's wants and desires which can be extracted and expressed as utilities of possible outcomes of alternative; and information of decision maker's beliefs about states of the world in a given situation, which can be extracted and represented by a unique probability measure defined over the states. Using the concepts of utility and probability, preferences, intuitive judgments and feelings of decision makers about uncertainty are directly introduced into a formal and quantitative analysis of a decision problem. A preferred course of action may be revealed through a process of recomposition of the information about decision makers, following certain rules. It is believed that in balancing between uncertainty and potential gain and loss, a rational and logical way, which over the long run pursues a maximal expected utility of outcomes, is superior to the intuitive way alone.

As the term "uncertainty" has been used so widely in our everyday life and literature, I have not given any interpretation when using it in the above discussion. However, I must pause to add it now, when I want to explain why and how a certain mathematical description of uncertainty is introduced into the modern decision theory, and its assumptions and limitations. In fact, the main theoretical dichotomy between different schools stems from their differences in interpreting the uncertainty.

How has this word been defined for common use? The new edition of the Oxford English Dictionary states that uncertainty can be used to describe both the quality or the state of being uncertain, or not being definitely known, or perfectly clear, and the state or character of being uncertain in mind. For example, we can say, "the uncertainty of weather, or colour", to describe the external world, or "I suppose, he was full of uncertainties" (Oxford English Dictionary, Carlyle, 1851), to express our inner feelings. Even in the same situation, people can use both ways without difficulty. For example, with the adjectival form, they complain about the "uncertain weather", and also say "I am uncertain whether we will get as much sunshine next year as we did this year." It suggests that in common language, uncertainty sometimes is described as the property of something outside ourselves, and sometimes as the property of the inner feelings. However, this kind of mixed usage is problematical in establishing a theory to represent uncertainty, because theorists must decide what type of uncertainty they want to define and to measure, if indeed it is definable and measurable, before they actually develop their theories.

According to the dictionary definitions, uncertainty can be used in almost any situation, as long as it involves some events whose outcomes cannot be exactly predicted. However, in early studies, this term was more closely related to random phenomena, which was often differentiated as an antithesis to certainty. The game of dice is an over-used textbook example of a random event, which shows that when a die is thrown, each side of it, labelled with an integer between 1 and 6, has equal possibility of coming up. The flow of customers arriving at a service till, or the day's sales volume, are more practical examples. In such studies, uncertainty is generally observed as a property of a random event, like length or colour, which has nothing to do with human subjective perception. However, in recent decision theory, it is more often interpreted as ignorance of decision makers. For example, von Winterfeldt and Edwards (1986) point out, "uncertainty is a property of your knowledge about these events, not of the events themselves." So, if you attribute the uncertainty to an event, for example, tossing a coin, Hogarth (1987), who has the same point of view as von Winterfeldt and Edwards, would argue in this way, "What does it mean to say that the coin has 1 chance in 2 of coming down 'heads' and 1 chance in 2 of coming down 'tails'? The meaning is simply that we are uncertain whether it will be heads or tails on any particular throw. Furthermore, the chances of 1 in 2 reflect that uncertainty. Note that this statement does not mean that there are no causes for the coin to fall on one side or the other on a particular throw. Indeed, there must be causes. The statement simply implies that we are unaware of the relative forces of the various causes and so are prepared to assess chances of 1 in 2. The probabilistic statement expresses our degree of knowledge and is not a property of the coin per se (although the statement can be made in light of the coin's properties, e.g. it is not bent)."

The fundamental distinction between the two points of view is that with the concept of uncertainty, one describes the outside world, whereas the other describes human mind. The former treats uncertainty as objective existence which is independent of human subjective perception, whereas the latter only admits the uncertainty perceived in human mind. In the two different ways, uncertainty is located at the two ends of the objective/subjective spectrum of the human perception process. In deciding whether or not uncertainty exists in a given situation, inconsistency between them is unavoidable. Some events which could be considered as certain in the objective sense may be perceived as uncertain. For example, the emergence of the Halley's Comet can still be perceived as an uncertainty by an observer who doesn't know the fact that the Comet approaches the Earth once about every 75 or 76 years. Similarly, some events which could be considered as uncertain in the objective sense, may be perceived as certain. For example, in tossing a fair coin, after seeing heads coming up 20 times successively, one may perceive this event as certain, but the tails may come up in the 21st toss! It is also why we sometimes get surprised. However, more often, events which are considered as uncertain in the objective sense are also perceived as uncertain, as with most of the decision problems we often face. Even so, the degree of uncertainty is a very personal experience, and will vary substantially between different individuals. It should be noted that perceived uncertainty can only be personal or private.

There are also some scholars who do not take either of the two extreme positions. For example, Kahneman and Tversky (1982), who are engaged in the study of human intuitive judgment, have made a distinction between external uncertainty and internal uncertainty. The uncertainty which can be attributed to a causal system in the real world is classified as external uncertainty. Such causal systems may be associated with the tossing of a coin, the drawing of a hand of cards from a pack, the outcome of a football game, and the behaviour of the St. Helens volcano, which have dispositions to produce different events. In contrast, if an uncertainty is attributed only to ignorance or the state of knowledge, it is classified as internal uncertainty or more specially, ignorance. For example, the uncertainty which is reflected in such statements as, "I think Mont Blanc is the tallest mountain in Europe," or, "I hope I spelled her name correctly," can only be internal, as it is attributed to one's mind rather than to a mountain or a woman.

Uncertainty can be represented in many ways. Probability theory is the most common approach employed in modern decision theory. Other alternatives have also arisen, such as fuzzy set theory (Zadeh, 1978), the Dempster-Shafer theory of evidence (Shafer, 1976). Why should probability theory be chosen? Watson and Buede (1987) supposed that the only reason for using it is that the notion is so well imbedded in Western scientific culture that we do not stop to question if it is the only possible, let alone the correct, calculus to employ. Nevertheless, von Winterfeldt and Edwards (1986) further argued that in comparison with other theories, probabilities (here he means subjective probabilities, as we will see) are powerful in presenting how people think, and they are easier to use because of their additive property.

Probabilities simply are numbers between 0 and 1 that obey the addition and multiplication laws governing the "or" and "and" relationships between events. However, when relating them to observations about the real world, probabilities are not interpreted in the same way in different schools of thought. Weatherford (1982) has divided probability theories into four categories: classical, logical, relative frequency and subjective probability theory. The most important conflict is between relative frequency and subjective probability theories, which originates from their divergence in the conception of uncertainty. Probability of an event, in the relative frequency probability theory, is defined as a limit of relative frequency with which the event occurs in an infinite repetition of an experiment. For example, in the case of tossing a fair coin, a probability of 1/2 of heads coming up means that if the coin can be tossed an infinite number of times, the times of heads coming up is about the same as that of tails coming up. Frequentists establish initial probability through an experimental or statistical sampling process. In this theory, probability is seen as an objective property of the real world. However, the objectivity of probability has been criticized as spurious from both its definition of probability and the way it establishes initial probability by subjectivists or Bayesians as they are often called for their fancy in using the Bayes' theorem as human judgment model. De Finetti (1974) says, "PROBABILITY DOES NOT EXIST." By this he means that probability does not exist outside of a person, that is, it does not exist objectively, which is directly deduced from that uncertainty does not exist objectively. In his point of view, probability is a description of a person's uncertainty about the world. So, the Bayesian school (Ramsey, 1931; de Finetti, 1974) defines probabilities as degrees of belief which an individual has in an event or a proposition. In this theory, probability is seen as a property of the individual's subjective perception of the real world. Initial or prior probabilities, in subjective probability theory, are generally established by psychological investigations, for example, using a reference wager to determine a probability from the expression of preferences (Wright, 1986).

The decision analysis technique employs subjective probability to measure the perceived uncertainty of decision makers, and there are at least two main reasons for this choice. First, from previous discussion, we have seen that direct participation of decision makers and their subjective judgments are indispensable in decision making under uncertainty. It is simply because people have to make decisions on the basis of their intuition or hunches about uncertainty, and intuitive judgment cannot be ignored or replaced. de Finetti (1972) has stressed, "Because, whatever the explanation of the uncertainty might be..., the sole concrete fact which is beyond dispute is that someone... feels himself in a state of uncertainty, and has to decide on and adopt some point of view as a basis for previsions and related decisions." From this realization, decision theory aims to provide a framework to guide decision makers to cope rationally with uncertainty. The scientific ideology of quantitative analysis then drives decision theorists to find some means of measuring and handling decision makers' opinions about uncertainty. As we have seen, only subjective interpretation of probability can satisfy these requirements. Subjective probability must be used in decision theory. Otherwise, the intellectual justifications for the procedures of decision analysis are much weakened (Watson & Buedue, 1987).

Another reason for choosing subjective probability is argued as that it has an advantage of being able to be used to describe uncertainty of a unique event; relative frequency probability is only applicable to events that can, in principle, be repeated. This increases the utility of decision theory, since many decision problems in the real world do not have this property of repetition, they are not even imaginable a priori.

From the above discussion, we have understood why and how human intuitive judgments about uncertainty as subjective probabilities are introduced into decision theory, or more exactly, Bayesian decision theory. The disputes between different schools regarding the conception of uncertainty and probability have also been illustrated. As the topic of this study is not to appreciate the advantages or disadvantages of the various approaches, the discussion here simply serves as an explanation which highlights the reasons behind the selection of probability theory. Even so, it is apposite to clarify what these conceptions mean before engaging in further discussion. As this study is mainly concerned with human probabilistic thinking and the process in which people make probability judgments in face of perceptions of uncertainty, it will mostly concentrate on perceived uncertainty. It is the feelings that people have when they cannot make a certain judgment about the outcome of an event or when they cannot make their mind about whether a proposition is true or false. Such uncertainty could be associated with the incompleteness and inadequacy of information, random events, and even the failure of our or other's memory. From the same reason, in this study, probability is used as an instrument to measure subjective or perceived uncertainty.

It is clear that with probability theory, the decision analysis technique attempts to provide decision makers with a way of expressing their opinions about uncertainty, which can then be incorporated into a quantitative process of trade-off with the values of outcomes. However, it has been criticized for being arbitrary, because different individuals are allowed to have different probabilities for the same event, and because Bayesian decision theory is based on subjective judgments: for any state of the world, the whims of the decision maker can let him choose any probability value between 0 and 1 and thus he can reach almost any kind of decision, and still be "rational" according to the principle of maximizing expected utility.

For this, Bayesian decision theorists make two points in their defence. The first is that decision analysis accepts only consistent or coherent subjective probabilities. It means that decision makers must express their opinions in a rational way, that is, their intuitive judgments should obey several laws of probability theory. For example, if one thinks that event A is more likely than event B, and event B is more likely than event C, he or she should think A is more likely than C. The second point argued is that this criticism does not take the Bayesian theory of learning into account (Gardenfors & Sahlin, 1988). It is argued that although the "prior" probability values can be selected arbitrarily, new information, obtained from experiments or by other means, will adjust the "subjective" probability distribution. One of the fundamental results in Bayesian theory, de Finetti's (1937) representation theorem, entails that even if two decision makers start out from widely different initial distributions - for example, concerning the probabilities of the outcomes of tosses with a particular coin - they will end up arbitrarily close to each other, given sufficient time to experiment with the coin. Even though de Finetti does not believe that there are such things as "objective" probabilities, subjective probability distributions would converge toward an inter-subjective probability distribution, given more and more information about what the world actually is like.

Much more recent studies nevertheless have shown in the context of psychological experiments, that the likelihoods expressed by subjects do not satisfy the coherence properties that are necessary for the existence of subjective probabilities. For example, human heuristic strategies in making probability judgments were found to be very vulnerable, and thus insensitive to some statistical information, and so to be easily misled by worthless evidence (e.g. Tversky & Kahneman, 1974). Also subjects seemed to follow an updating process akin to that described by Bayes' theorem, but they did not utilize information obtained efficiently. People seem to have no intuitive idea of how to revise their beliefs in the light of new information (e.g. Phillips, Hays & Edwards, 1966; Phillips & Edwards, 1966). In calibration studies, various experiments have repeatedly demonstrated the overconfidence phenomenon, that is, when people are asked to assess probabilities about a series of propositions or events, the correct proportion of their assessed probabilities is less than their assessed probability (Lichtenstein, Fischhoff & Phillips, 1982). These findings remind us that when we give way to human intuitive judgment, judgmental illusions may also come in.

The deficiencies of unaided human intuition in making probability judgments shown in these studies have led some serious decision makers to doubt the applicability of decision analysis (Von Winterfeldt & Edwards, 1986), as these findings directly undermine the basic assumption that people can make disaggregated judgments about probabilities, such as when assessing prior probabilities or likelihood ratios. However, some researchers argue that it should be no surprise to find that human beings have very little inherent ability to handle uncertainty (eg. Howard, 1980). They believe that a more important problem is whether people can be helped to perform these tasks of probability judgment well. Von Winterfeldt and Edwards (1986) also assert that intellectual tools can transcend human cognitive limitations. They have argued that in order to deal with intuitively difficult arithmetic tasks, people have developed and used numerous, diverse, and effective intellectual tools and their embodiment in physical tools, so why can't they design intellectual tools to overcome human cognitive limitations in dealing with uncertainty? They believe that the problem is not whether people can perform probability judgmental tasks, but how they can be helped to do them better. Phillips (1984) stressed that the empirical findings in descriptive studies tell us only what people actually do, and give us no idea of their potential. Effort, he considered, should be devoted to finding the circumstances in which people are "intellectual athletes" and not "intellectual cripples". Howard (1980) further asserts that just like a pilot flying in bad weather needs the help of instruments, in dealing with uncertainty, the human being needs an instrument --- probability theory, and he will never be able to perform well in an uncertain environment without his instrument.

These arguments seem to be convincing in the sense that the findings of deficiencies of human intuition in dealing with probabilistic tasks only strengthens the necessity of designing and using intellectual tools like decision analysis and information technology. However, these findings did convey to us an important message that the validity of intellectual tools, whether computerized or formal analytic ones, cannot be taken for granted and they do remind us that there are many traps which can confound our efforts. Information is assumed to be essential for overcoming uncertainty, but information overload may bias human judgments about uncertain events. Decision analysis can enhance wise trade-off between uncertainty and benefit. However, human beings are not natural statisticians, and their failure in making disaggregated probability judgments can collapse a whole decision tree. The empirical method of deriving probabilities for system failure rates of individual technological components cannot make a success, if probabilistic dependencies are treated improperly (Angell & Smithson, 1991). Therefore, the validity of these intellectual tools are, at best, conditional on, among other things, the adequacy of human probability judgment. Providing intellectual tools to help people deal with uncertainty is a rather subtle task, unequivocally tied into cultural experience. An intellectual tool is just like a pole or an umbrella in the hands of an acrobat walking on a wire, which not only can help him keep balance, but also can make him more likely fall down. Perhaps it is why Phillips (1984) offered a requisite decision model and was very cautious and careful when explaining its development and application in assisting decision making. Indeed, some researchers are developing methodologies and professional practices to help people keep their "balance" and to avoiding them falling into traps. For example, Phillips (1987) has proposed several conditions under which people can make precise, reliable, accurate probability judgments. A study by Lichtenstein and Fischhoff (1980) also showed that training can improve calibration. The development of the influence diagram (Howard & Matheson, 1979) has proved helpful in making both analysts and decision makers sensitive to the issue of dependence. From the results of study, people may gain fresh confidence, but it is still far from a guarantee. These technologies are only valid conditionally, and a panacea for managing uncertainty can never be found.

1.3. An alternative way

There are numerous examples which contrast the development of Chinese science and technology with that of the West. The Chinese don't use alphabetic writing. Every Chinese character has its own form, meaning and pronunciation, that is, it is a whole thing. In ancient Chinese, the subject-predicate relationship was not defined rigidly by grammar, as it was in ancient Greece. Traditional Chinese doctors actually consider human body as a system, in which, they believe, there is a network of passages, through which vital energy circulates and along which the acupuncture points are distributed. They don't even try to allocate the particular place causing diseases as Western doctors do. It may be hard for a Western doctor to believe there are so many acupoints in human body, unless they can be shown physically. Some Chinese medicines are banned in the United States, as they were found to contain poisonous ingredients. However, these medicines have been used for several hundreds, even thousands of years, "To use poison as remedy for malignant disease" was quintessential to Chinese medicine. Western artists pay more attention to the law of perspective, geometrical arrangement of objects, while Chinese traditional paintings are characterized by vivid expression and bold outline --- freehand brushwork.

Many scholars have observed that there are remarkable differences between Chinese and Western peoples in the way they comprehend the world, and how they reach judgments and decisions. The Chinese mind has been described as non-analytic (Northrop, 1946). It is argued that the Chinese, in contrast to Westerners, have less interest in abstract reasoning. Their way of thinking is more concrete and is confined solely to the realm of the immediately apprehended, and remains on the periphery of the visible world. It is also suggested that the Chinese perceive the world as based on a network of relationships, that is they are socio-oriented, or situation-centred, in contrast to Western self-oriented, or individual-centred (Hsu, 1970). The Chinese way of thinking is described as utilitarian and pragmatic (Nakamura, 1960). Moore (1967) has suggested that the synthetic way of thinking may be an application of the Chinese spirit, or principle of harmony in the realm of the intellect. In this spirit, the Chinese tend to be highly sensitive to outside conflicts and inconsistencies, and they usually manifest a strong tendency to find some way to reconcile the incongruities in a higher integrated framework. Hang (1966) believed that one of the Chinese characteristics was a concrete and global orientation of observing things and phenomena. Chinese also tend to reason by intuitive analogy rather than by rational analysis, that is, they first find the truth by their intuition, and then strengthen it by employing various of concrete comparisons and vivid, especially historical examples. This way of thinking was described as circular, as it puts a theme in the centre and then interprets, and strengthens the theme by different comparisons. In fact the theme does not need to be verified, as from the beginning its truth is self-evident. In contrast, Western thought was described as a straight line, as it starts from a superficial point and then goes into an unknown field. So, Hang quoted Pascal's words that the Chinese way of thinking is more like the "esprit de finesse", while the "esprit de geometric" is more suitable to describe Western way of thinking.

Several previous findings in cross-cultural studies also partly confirmed the above observations and analysis. Abel and Hsu (1949), in their Rorschach study, found that the

Chinese perceive "ink-blot" pictures as a whole much more frequently than did the Caucasian American sample of de Vos' study (1966). Chiu (1972) found, in a cognitive style test, that the dominant response mode for Chinese children was relational-contextual, while the dominant modes for the Americans were inferential-categorical and descriptive-analytic. Singh, Hung and Tompson (1962) found that Chinese students scored significantly higher in aesthetic value than the American students, and the American students obtained higher scores in theoretic value than the Chinese students, although the Chinese students' score in aesthetic value is not as high as that in theoretic value.

It is obvious that the development of Western techniques for dealing with uncertainty, as well as other modern Western science and technology, follows a rational, logical and analytic tradition, which can be found in the ancient Greek formal logic and in the systematic experimental methods of the Renaissance for seeking cause-effect relationships. Decision theorists in the West are fond of developing models, building inference rules and measurement. Decision environments and tasks are being measured and modeled, human intuition and judgment are being modeled as well. Decision making is formalized as a process of decomposition and recomposition, which has been emphasized. Quantitative methods are widely used to describe objectivity, and even subjective feelings of uncertainty are measured. This approach was hardly developed in Chinese culture, and this fact must have a major effect on the application of decision approaches in China. However, much earlier, on the other side of the world, another way, the Chinese way had evolved.

According to their recent findings in cross-cultural comparison studies of probabilistic thinking, Phillips and Wright (1977, and Wright & Phillips, 1980) have suggested that the Chinese may adopt a different way from the British in dealing with uncertainty. In 1977, they carried out the first cross-cultural comparison between Chinese and British groups of students, nurses and businessmen. They found that British people have a greater tendency to view the world in terms of uncertainty than do Hong Kong Chinese. British people are more likely to ascribe different degrees of uncertainty to events, and they can express the uncertainty meaningfully as a numerical probability in response to general knowledge questions. These findings also have been confirmed by the recent experiments undertaken with the students of Japan, the United States, and the People's Republic of China by Yates and his colleagues (1989).

Phillips and Wright (1977) suggested that an individual's world-view of causality influences the tendency to adopt probabilistic thinking. They distinguished a Laplacean world-view and a fatalistic world-view, and believe that British people are more familiar with the Laplacean view, that is, "events do not just happen through the action of mysterious forces, but are caused by previous events acting according to natural laws that can be discovered by systematic investigation and enquiry", whereas most of the Hong Kong Chinese may tend to accept a fatalistic view, that is, "individuals should seek to behave in accordance with the predictable cycle of events and not attempt to influence events to their advantage". The British (Laplacean) probabilistic world-view, it was argued, tended to cultivate probabilistic thinkers, while the Hong Kong Chinese fatalistic world-view, in contrast, tended to foster non-probabilistic thinkers. Holding this world-view, Hong Kong Chinese are more likely to remain flexible in dealing with uncertainty, but not to make fine differentiation between uncertainties.

Many Western scholars may have deep impressions about Chinese "fate-orientation", and often connect them with Chinese Taoism. However, the impact of Taoism on the development of Chinese science and technology does not allow an easy interpretation. In fact, even today Chinese scholars still argue the meaning of Lao Tzu's Tao (Zhan, 1986). Even a simple sentence of Lao Tzu's "Tao Te Jing", may have three or more quite different interpretations in ancient Chinese books. The barrier of language makes it even more difficult for Western scholars to understand Tao. Needham (1956) pointed out, "It is necessary to say that, for one reason or another, Taoist thought has been almost completely misunderstood by most European translators and writers. Taoist religion has been neglected and Taoist magic has been written off wholesale as superstition, Taoist philosophy has been interpreted as pure religious mysticism and poetry. The scientific or 'proto'-scientific side of Taoist thought has been very largely overlooked, and the political position of Taoists still more so." Needham believed that the deepest scientific insights of Taoism were their profound awareness of the universality of change and transformation. Zhan (1986) praised Lao Tzu's philosophy as a hymn of nature, and believed that "Tao is nature, and nature is Tao" and what Lao Tzu advocated was "living in accordance with nature, and acting in accordance with natural laws." With the concepts of Yin and Yang representing opposites, he comprehended change as a process of a lack of balance between Yin and Yang, and a transformation from one to the other. Similar but more simple thought resulted in the I-Ching. This has led to the development of traditional science and technology of a unique form and application in ancient China.

Many years ago, Hsu (1949) presented a vivid description of the "fate-orientation" of the people living in a remote Southwest community in China, West Towners. The West Towners often said "Medicine can cure disease, but cannot cure fate". Undoubtedly it expresses a strong fatalistic tendency. However, they said this only after trying every way they could find to save a patient's life. They asked the help not only of the traditional Chinese doctors, but also of the doctors who were trained in Western medicine. So, Hsu concluded, "The average West Towner is no more fatalistic than the early American who prayed to God and kept his powder dry."

We are not trying here to deny that from today's point of view, Taoism might have had some unappreciated influences on the development of the thought and the way of decision making in Chinese history. In fact, in comparison with ancient Western philosophers, Taoists "failed to reach any precise definition of the experimental method or any systematisation of their observations of Nature. So wedded to empiricism were they, so impressed by the boundless multiplicity of Nature, so lacking in Aristotelian classificatory boldness, that they wholly dissociated themselves from the efforts of their contemporaries of the Mo and Ming schools to elaborate a logic suitable for science. Nor did they realize the need for the information of an adequate corpus of technical terms." (Needham, 1956). Also, probability theory, which Howard called the indispensable instrument in dealing with uncertainty, did not emerge within China, and the first Western book on probability theory was only published in Chinese in 1896 (Li, 1984). However, what we would like to argue here is that the process by which people make probability judgments, or translate their feelings of uncertainty caused by incomplete or ambiguous data into information about the future, is very complicated. This process may vary when dealing with different decision tasks, and many cultural and social factors can affect to some extent this process in ways other than "fate-orientation". In the formation of the Chinese way of decision making or dealing with uncertainty, perhaps not only Taoism but also Confucianism and Buddhism have played important roles. Indeed, to explain the cultural differences in probabilistic thinking, a variety of causal relationships, such as Chinese social orientation (Yang, 1981), socialization and upbringing (Hoosain, 1986) and its socio-economic situation (Yates et al., 1989), have also been suggested, which will be discussed in detail in Chapter 2.

1.4. Summary

From the above discussion, we have seen the disharmony between Chinese decision culture and Western decision methods. In the first section, I have questioned the validity of Western approaches to decision making in China and argued that a simplistic interpretation is untenable. In section 2 and 3, I have discussed the characteristics of Western decision approaches and Chinese culture and suggested that decision makers, as an important component part of decision approach, perhaps have been ignored in the rush to import techniques. Information technology can be helpful in dealing with uncertainty, but it should be remembered that what information is to a Western decision maker may be uninformative to his Chinese counterpart. Some of the tasks implicit in decision analysis, such as making probability judgments, which is confused even in the West, may be totally alien to Chinese decision makers. The effort made with decision analysis techniques can easily be doomed to fail if the probability judgments input are inappropriate for Chinese decision makers.

Since differences in decision making between the Westerners and Chinese, especially the overseas Chinese (e.g. Redding & Wong, 1986), have been supposed, it is important that empirical studies are carried out, which try to find out the cultural factors concerned, and how they affect the development and application of information technology and decision analysis techniques. Of course, a major difficulty hindering a deeper investigation is that the human information process in making decisions is itself so complicated and hard to describe clearly. This present study was aroused by a recent important finding of Phillips and Wright (e.g. 1977) in a calibration study, which showed that when facing uncertain situations, Chinese and British people make probability judgments differently. As the study is directly related to one of the basic assumptions in modern Western decision theory, it inspires the present study to concentrate on a specific aspect of decision making, and to compare particularly the characteristics of Chinese and British people in dealing with inconclusive information, making probability judgments and taking decisions when consequences are uncertain. It thus allows a deeper examination of the validity of applying Western decision approaches in China and the cultural influence on decision making. The present study aims to examine whether there are any systematic differences in dealing with uncertainty between Chinese and British people, and to investigate the cultural factors underlying the differences. For this purpose, a series of experiments will be designed and carried out, with subjects chosen from Chinese and British people, in which probability judgments will be measured. A direct implication of this study is to inform that there is a cultural dimension which should be carefully considered in the development and application of Western decision approaches. Without this we cannot expect Western approaches to produce effective decision support systems or to enhance better decisions in Chinese decision makers. Moreover, cultural interpretation about these differences can be helpful in making better use of Western decision methods in China and developing more suitable techniques for Chinese decision makers, as it may reveal both advantages and disadvantages of the Chinese way in dealing with uncertainties. It is also hoped that this study can promote mutual understanding between Chinese and Western decision makers, which is considered as very important by Hofstede (1980): "The survival of mankind will depend to a large extent on the ability of people who think differently to act together. International collaboration presupposes some understanding of where others' thinking differs from ours."

Chapter 2. Cultural Differences in Probabilistic Thinking

In the first chapter, I have explained why this study will focus only on the way of dealing with uncertainty and have suggested the cultural differences between Chinese and Western decision makers from recent cross-cultural studies of calibration. In this chapter, I will first discuss calibration study in general, including its concept, method, measure, and main findings from previous studies. Then, I will give a detailed analysis of the results reported in earlier cross-cultural studies of calibration. Various causal factors for the cultural differences in probabilistic thinking will also be discussed.

2.1. A review of calibration study

Measures

Subjective probabilities are decided in an intuitive fashion, in which there are no clear involvement of inference and analysis. The processes of deciding a probability are influenced by people's knowledge, experience, and even their emotional state when they are making probability judgments. Of course, relative frequencies stored as mental records can also become one of the inputs to the processes. However, fundamentally, what subjective probabilities describe are entirely a person's internal feelings of uncertainty about the world, and hence it seems to be fallacious to talk about objective correctness of subjective probability. The axioms of probability may be seen as imposing certain restrictions on the arbitrariness of subjective probability, and thereby can lead people to make and use subjective probabilities consistently, but a group of subjective probabilities still cannot be evaluated as correct in any objective sense, even if they conform to the axioms of probability. If probabilities were confined solely to be the expressions of personal feelings of uncertainty, it would be unnecessary to worry about their quality. However, subjective probabilities are introduced, as crucial inputs, into the processes of decision making, and thus the quality of probabilities must generate direct impact on the making of a final decision. As there are real possibilities that the judgment of subjective probability can be biased by various internal and external factors as we will see, decision theorists, analysts, and decision makers themselves are very concerned about the quality of probability judgments other than the logical consistency of probability judgments.

It is meaningless and impossible to appreciate the correctness of individual probability judgments, but in many circumstances people's probability judgment can be and is actually being verified in the light of a series of subsequent events. For example, a surgeon should not be blamed after he has predicted that an operation would have a success chance of 90 per cent, but it actually failed. However, if the surgeon has made such poor predictions over a long period of time, patients would be very worried in making their mind whether or not to accept his suggestion to take an operation. In early study, the quality of probability judgments have been evaluated in several ways. Winkler and Murphy (1968) have proposed normative goodness to measure the degree to which the probability judgments conform to the axioms of probability and substantive goodness to measure the amount of knowledge of the topic area contained in the probability judgments. More recently, Lichtenstein, Fischhoff and Phillips (1977) described a further aspect of the quality of probability judgments, calibration. Calibration measures a group of probability judgments against facts or reality. A group of probability judgments made for uncertain events can be evaluated as calibrated if, over the long run, for all the uncertain events assigned the same probability, the proportion that they actually occur is equal to the probability assigned. Calibration can be defined in the same way for a group of probability judgments which are made for propositions. Calibration is not a logical standard of probability judgments. It measures how accurate a group of probability judgments are in the long run and against reality or facts. It is different from normative or substantive goodness (Lichtenstein, Fischhoff, & Phillips, 1977). Calibration is an important aspect of the quality of probability judgments, which has drawn much research attentions. With calibration as a main measurement, calibration study aims to examine whether human beings have the ability of making calibrated probability judgments. If they have, or at least are able to develop such an ability, we will be more confident in using decision analysis techniques, otherwise, we will feel very uncomfortable.

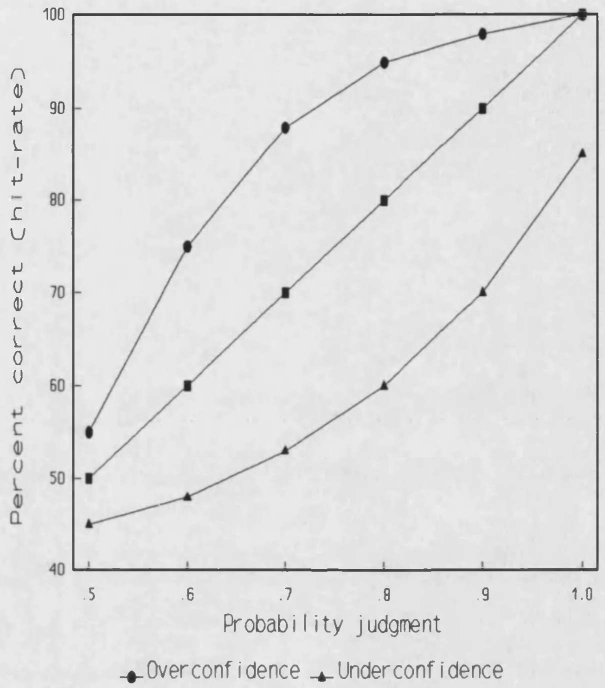

Figure 2.1. Calibration curves

The ability of human beings in making calibrated probability judgments are often tested when they perform two kinds of probabilistic task: using discrete and continuous items. Several different techniques and measures have been developed to elicit and evaluate people's probability judgments. In a typical calibration study of using discrete items, people are asked a number of general knowledge questions like, "Which is longer (a) Panama Canal or (b) Suez Canal ?". Respondents are requested to select the answer which they think is correct, and to write a probability to indicate how sure they are of the correctness of their selection. For a respondent (or a group of respondents) answering these questions, an experimenter may group together all the questions for which the respondent (or respondents) assigned the same probability, and get the percentage of questions they answered correctly in the group. The calibration of probability judgments of a respondent (or respondents) then can be demonstrated with a calibration curve, which is drawn with percentage correct and probability judgment, for all groups, as two variables. Perfect calibration is represented by the diagonal line in Figure 2.1. The curve lying below the diagonal reflects overconfidence: when the percentage correct is less than the correspondent assessed probability. While the curve over the diagonal reflects underconfidence: when the percentage correct is more than the correspondent assessed probability.

There are also several numerical measures of calibration. Murphy (1972) designed a partition of the Brier (1950) score which could be used as a basic measurement of overall accuracy of probability judgments. The smaller the score, the better the performance in a probabilistic task. When only one response per item is scored, Murphy's partition can be expressed as:

$$Brier = Knowledge + Calibration - Resolution$$

$$Brier = c(1-c) + \frac{1}{N}\sum_{i=1}^{M} n_i(r_i-c_i)^2 - \frac{1}{N}\sum_{i=1}^{M} n_i(c_i-c)^2$$

Where N is the total number of responses, n_i is the number of times the response r_i was used, c_i is the proportion correct for all items assigned probability r_i and M is the total number of different response categories used (e.g. $M = 6$ for subjects who limit their responses to the single digits 0.5, 0.6, 0.7, 0.8, 0.9, and 1.0). c is the overall percentage correct.

Calibration measures the mean weighted distance between the calibration curve and the identity line (diagonal). The smaller the calibration score, the better. If in the calibration measure, the differences between c_i and r_i are not squared, then a negative score indicates overconfidence, and a positive score underconfidence. Resolution measures the ability of the respondent to discriminate different degrees of subjective uncertainty by sorting the items into categories whose respective percentages correct are maximally different from the overall percentage correct. The higher the resolution score, the better.

Apart from discrete items, people can also make probability judgments about uncertain continuous quantities, such as, stock price, temperature, etc. There are two techniques which are commonly used for eliciting people's probability judgments about uncertain quantities in calibration study. One is called the fractile method (Alpert & Raiffa, 1969), which presents subjects with several predetermined fractiles of the probability distribution (e.g. 0.01, 0.25, 0.50, 0.75, and 0.99) and asks them to assess values of the uncertain quantity to the fractiles. For the 0.50 fractile, for example, the subject should assess a value of the quantity which he believes that the actual value is equally likely to lie above or below the assessed value; the 0.01 fractile is a value such that there is only 1 chance in 100 that the actual value is smaller than the assessed value. The probability method (Seaver, von Winterfeldt, & Edwards, 1978), in contrast, requires subjects to estimate probabilities for several values of an uncertain quantity, which are specified in the one-alternative questions, such as, "What is the probability that the inflation rate of China in 1992 will exceed 5%?", "What is the probability that the inflation rate of China in 1992 will exceed 10%?", etc. Usually, five such questions are asked for each quantity.

The calibration of the probability judgments about uncertain quantities is measured by two indices. The first one is interquartile index which indicates the percentage of the times when the actual value falls between the 0.25 and the 0.75 fractiles. Calibrated probability judgments, in the long run, should have an interquartile index of 50. The second one is the surprise index which is defined as the percentage of times when the actual values fall outside the most extreme fractiles assessed. If the most extreme fractiles are assessed between 0.01 and 0.99, calibrated probability judgments are expected to have a surprise index of 2. So, a large surprise index indicates overconfidence, as it shows that the value intervals decided by the subjects are often too narrow to contain enough of the actual values. However, if the subjects often set the value intervals to be too wide, they may obtain an interquartile index greater than 50 and a low surprise index, which indicates underconfidence. In comparison with fractile method, the probability method is found to lead to a better surprise index. However, it could be argued that in the fractile method, the subject's judgments may have been affected by the values selected by the experimenter (Lichtenstein, Fischhoff, & Phillips, 1982). Stael von Holstein and Matheson (1979) have also developed an encoding procedure which asks subjects themselves to decide the range of uncertain quantities and to divide it into several subranges. Then like the probability method, subjects assign a probability for every value point so that the real value will not exceed the value. At the end of encoding a cumulative probability curve is produced. This method has some advantages in comparison with previous two methods and has been applied in one of my experiments. I will describe its details later.

Many early calibration studies have investigated the ability in various kinds of subjects by using different probabilistic tasks. Several studies also intended to explore how people really make their probability judgments and to find some way to help people develop such ability.

Overconfidence phenomenon

How good can people be in making probability judgments? Lichtenstein, Fischhoff, and Phillips (1982) have reviewed a number of experimental studies on calibration. An important conclusion from their review is that people are overconfident with probabilistic tasks of moderate or extreme difficulty. With general knowledge questions, Fischhoff, Slovic, and Lichtenstein (1977) used a variety of methods (no alternatives, one alternative, and two alternatives with half range and full range) to test the college students' ability at assessing probability. They found that of the items which were assessed at probability of 1.0, only 72% to 83% were correct. Phillips and Wright (1977, and Wright & Phillips, 1980) found the same overconfidence in British undergraduate students and civil servants, and in Asian students and business managers.

Pitz (1974) also found that very difficult judgments produced most overconfidence. Lichtenstein and Fischhoff (1977) had asked subjects to do some essentially impossible tasks, such as discriminating between European and American handwriting, Asian and European children's drawings, and rising and falling stock prices. They found that calibration curves did not rise at all; for all assessed probabilities, the proportion of correct alternatives chosen was close to 0.5. After using various other stimuli and manipulations that made the discriminations easier, they found much better performance. Christensen-Szalanski and Bushyhend (1981) reported nine physicians' judgments of the probability of pneumonia for 1,531 patients who were examined because of a cough. They found that the calibration curve rose so slowly that for the highest confidence level (approximately 0.88), the proportion of patients actually having pneumonia was less than 0.20. The similar overconfidence was also found by Lusted (1977), with diagnoses of skull fracture and pneumonia, and by Desmet, Fryback, and Thornbury (1979), with diagnoses of skull fracture. In a much recent study, Yates, McDaniel and Brown (1991) have asked undergraduate and graduate students in finance courses to make probabilistic forecasts of the quarterly changes in the stock prices and earnings of publicly traded companies and found surprisingly inaccurate performance, which is consistent with the early result obtained by Stael von Holstein (1972). The graduates made even worse judgments than the undergraduates.

However, many encouraging results which showed good calibration were also reported. Murphy and Winkler's study in weather forecasting is perhaps the most remarkable example (Murphy & Winkler, 1974). They found average deviations of only 0.028 from perfect calibration for credible interval temperature forecasts, more recent results (e.g. Murphy & Winkler, 1977) are even better. Sieber (1974) and Pitz (1974) found good calibration for students taking tests on the subject matter of their courses. Dowie (1976), studying the forecast prices printed daily by a sporting newspaper in Britain, reported good calibration of the forecasts for 29,307 horses with slight underconfidence. Fischhoff and Beyth (1975) asked 150 Israeli students to assess the probability of 15 then-future events, possible outcomes of President Nixon's trip to China and Russia (e.g. "President Nixon will meet Mao at least once"). The resulting calibration curve was quite close to the identity line. Recently, Wright and Ayton (1986) also found that people could do better with future events than with general knowledge questions. Lusted et al. (1980), reporting a very large field study of probability judgments by emergency room attending physicians, found generally good calibration. Consensus judgments of probabilities that R & D projects would succeed show reasonable calibration (Balthasar, Boschi & Menke, 1978), while probability distributions generated by groups of banking experts about future interest rates turned out to be nearly well calibrated, with some tendency toward underconfidence (Kabus, 1976). More recently, Keren (1987) found that expert bridge players were almost perfectly calibrated whereas amateurs were overconfident in assessing the likelihood that a final contract would be made (reached during the bidding phase). Vertinsky et al. (1986) asking members of a women's field hockey team participating in a championship series to forecast scores, found that players generally attained a high level of calibration in their judgments.

The investigation about the human ability of making calibrated probability judgments still seems to be inconclusive. People sometimes can make perfectly calibrated probability judgments, but at other times they can also make very poor ones. The inconsistent experimental results have led researchers to speculate on the conditions under which people are able to make good probability judgments. Several aiding techniques have also been developed and tested aiming to assist people in making probability judgments. Recently, Phillips (1987) has identified several conditions which are required for the making of good probability judgments. For the maker of probability judgment, experts, or a group of experts if possible, should be employed. The characteristic of task should also be considered, and calibration could be better for some tasks, e.g. the future events. People's probability judgments should also be elicited with proper techniques according to the situations. Training can help better probability judgments. Giving feedback (Lichtenstein & Fischhoff, 1980), or asking to provide clear reasons for judgments (Koriat, Lichtenstein & Fischhoff, 1980) can improve calibration. Even so, poorly calibrated probability judgments are still being reported from time to time, and the effectiveness of present aiding techniques is also far from being fully certified. Most importantly, the big obstacle in advancing calibration study remains: we still know little about the human cognitive processes in making probability judgments. There are only a few of researchers who have made efforts to explore this issue in previous study.

Cognitive processes

From the experiments on calibration reviewed above, we could conclude that overconfidence is a pervasive bias of unaided intuitive probability judgment and under some conditions, human ability at assessing uncertainty can be improved. However, the underlying psychological processes are still unclear. To explain the results of these experiments, some researchers have explored how people develop and express feelings of uncertainty and certainty. Tversky and Kahneman (1974) argued that, as a result of limited information processing abilities, people rely on simplifying rules or heuristics. Although generally quite useful, these heuristics sometimes can lead to severe and systematic errors. For instance, when people are asked to make an estimate, they frequently anchor on an obvious or convenient number (e.g. the mean, the mode) and then adjust upward or downward if they feel it necessary to do so. The authors found that in probability judgments people frequently underadjust and thereby produce predictable biases in their numerical estimates. Inability to adjust estimates properly from the anchor values could lead to overconfidence. Overconfidence may also result from the availability effect, that is, people tend to estimate a higher probability for those events for which they can easily generate or recall instances. In the most familiar real world examples, extensive publicity about some atrocious crime or unusual disaster enhances lay judgment of the probability of the event.

Fischhoff, Slovic and Lichtenstein (1977), in explaining the "certainty illusion", have suggested two possible pathways to overconfidence. One is that people may be insufficiently critical of their inference processes. For instance, when people draw a few instances of a category from memory to get an idea of the properties of the category, they may not realize that readily available examples need not be representative of the category (Tversky & Kahneman, 1973). They may also ignore the distinction stressed by Collins and colleagues (Collins et al., 1975) between open worlds where knowledge is incomplete, and closed world where the complete set of objects and relations is known, and apply the procedures and rules of inference which have been developed for dealing with closed worlds to produce an answer to a question of open world. Pitz (1974) also supposed that people tended to treat the results of inferential processes as though there was no uncertainty associated with the early stages of the inference.

Another pathway to overconfidence is that people believe that they are answering directly from memory without making any inferences. People commonly view their memories as exact (although perhaps faded) copies of their original experiences. However, considerable evidence has demonstrated that memory is more than just a copying process (e.g. Neisser, 1967). In his classic studies of reconstructive processes in memory, Bartlett (1932) first found that subjects not only created new material but were often highly certain about that which they had invented. According to this view, people reach conclusions about what they have seen or what they remember by reconstructing their knowledge from fragments of information, much as a paleontologist infers the appearance of a dinosaur from fragments of bone. During reconstruction, a variety of cognitive, social, and motivational factors can introduce error and distortion into the output of the process. The problems with eyewitness testimony indicate the generality and strength of this "certainty illusion" in memory recall (e.g. Loftus, 1974).

Therefore, if people are unaware of the reconstructive nature of memory and perception and cannot distinguish between assertions and inferences (Harris & Monaco, 1978), they will not critically evaluate their inferred knowledge. In general, any process that changes the contents of memory, unbeknownst to people themselves, will keep them from asking relevant validity questions and may lead to overconfidence.

Phillips and Wright (1977) proposed a three-stage serial model to distinguish people who tend naturally to think about uncertainty in a probabilistic way from those who respond in a more black-and-white fashion. According to this model, the cognitive processes of a person in answering a question follow three stages: first, he searches his memory to determine whether or not he knows the answer. If he thinks he knows, a certainty response (i.e. either a "Yes" or "No" answer or a probability estimate of 0 or 1) is given and the processes stop at Stage 1. If the answer is not known or he is not sure, possibly a non-probabilistic set is adopted leading him to a response consequent on a refusal to respond probabilistically (i.e. either a "Don't know" answer or a 0.5 probability estimate) and the cognitive processes stop at Stage 2. While a probabilistic set is taken, this requires some discrimination of the degree of uncertainty, which may lead to a truly probabilistic response (i.e. either a probability estimate between 0 and 1 or a corresponding verbal expression) at Stage 3. Overconfidence which people showed when answering general knowledge questions may be accountable for failing to elaborate judgments to the third probabilistic processing stage (Wright & Wisudha, 1982).

Koriat, Lichtenstein and Fischhoff (1980) also took an information-processing approach. They conceptualized the confidence judgment task as having two cognitive stages. The first stage involves searching one's knowledge; this stage ends when an answer is chosen. During the second stage the evidence is reviewed and confidence in the chosen alternative is assessed. They also suggested two biases in how people elicit and use their own knowledge. In the first stage, people tend to favour positive rather than negative evidence. Their subjects produced more positive reasons than negative, positive reasons also were given higher strength ratings. The bias against negative evidence found here is similar to the difficulties people have in accepting the relevance of negative evidence in logical inference tasks (Johnson-Laird & Wason, 1977) as well as the neglect of negative examples in judgments of correlation (e.g. Smedslund, 1963). In the second cognitive stage, people tend to disregard evidence inconsistent with (contradictory to) the chosen answer. They found that asking subjects to write a supporting reason did not affect their calibration (presumably because they were already thinking of these reasons), whereas asking them to write a contradicting reason did improve the realism of subjects' confidence assessments. These two cognitive stages could be more clearly explained as three stages (Lichtenstein, Fischhoff & Phillips, 1982). First one searches one's memory for relevant evidence. Next one assesses that evidence to arrive at a feeling of certainty or doubt. Finally, one translates the certainty feeling into a number.

Keren (1987), too, assumed that the process of generating confidence ratings, or probability judgments, is composed of two subprocesses. One is the process of (semantic) inference where a person builds a mental model of a situation based on a knowledge base (usually derived from his own experience), and uses this model to generate non-numerical feelings of certainty (e.g. Beyth-Marom, 1982). For instance, these feelings can be expressed as the plausibility of various conflicting scenarios that lead to different outcomes. The nature or quality of this process is mainly determined by two factors: one concerns the extent to which the initial mental model that is constructed is the proper one, and similarly that the appropriate inferential processes are employed. Proper mental model here means that a correct suitable "problem space" (Keren, 1984; Newell & Simon, 1972) for a given situation is adopted. The second factor affecting this process concerns the amount of data, based on experience, that is fed into the mental model. The second subprocess is one in which these feelings of plausibility and uncertainty are translated into numerical estimates, that is, into probabilities. Finally, Keren further assumed that for a subject to be "well calibrated" both processes must be "well tuned."

Levi and Prayor (1987), to identify the cognitive processes mediating the "availability heuristic", proposed two potential mediators, (1) imagery of the event itself and (2) perceived reasons or causes for the event. By using the 1984 presidential debate in the United States as a to-be-predicted event, they showed that debate predictions were affected by the availability of reasons but not by imagery of the outcome, i.e. Reagan or Mondale would win.

In the Einhorn-Hogarth ambiguity model (Hogarth, 1987), people are also assumed to assess ambiguous probabilities by first anchoring onto some value of the probability and then adjusting this figure by mentally simulating or imaging other values that the probability could take. The net effect of this simulation process is then aggregated with the anchor to reach an estimate. The assessment of uncertainty in conditions of ambiguity therefore involves a compromise between "what is" (i.e. the anchor which could be data-based) and "what might or could be" (i.e. the product of imagination). In practical situations, the anchor could be a figure suggested by experience, a third party (e.g. an expert), or simply one that is available (e.g. based on media reports). Two factors are assumed to affect the mental simulation process: (1) the amount of perceived ambiguity; and (2) one's attitude toward ambiguity in the circumstances. Situations likely to be perceived as ambiguous are those where, for example, there is little causal knowledge about the process generating outcomes, data are scarce, or opinions conflict. Attitudes toward ambiguity in the circumstances is reflected in the mental simulation process by the extent to which probability values greater than the anchor are weighted in imagination more or less than those below. This attitude could, in turn, reflect personal factors. such as tendencies towards optimism or pessimism, as well as situational variables, e.g. the sign and size of outcomes or whether the context of the choice situation induces caution (as insurance) or playfulness (as in some forms of gambling).

2.2. Cross-cultural comparison of probabilistic thinking

Cultural differences

In order to distinguish different cognitive processes in dealing with uncertainty, Phillips and Wright (1977) have proposed a conception of probabilistic thinking. By probabilistic thinking they mean the tendency to adopt a probabilistic set for the discrimination of uncertainty, and the ability to express the uncertainty meaningfully as a numerical probability.

In the recent years, some studies have compared accuracy of probability judgments between people raised in different cultures. In chapter 1, I mentioned the cross-cultural comparisons made by Phillips and Wright between several groups of Hong Kong Chinese and British people. In their first experiment, Phillips and Wright (1977) found systematic cultural differences between the Chinese and the British in responding to general knowledge questions. It was reported that British were less extreme and better calibrated than the Chinese. For example, the British students used the probability of 100% about 13 times. However, the average Chinese subjects used it 24 times. A few Chinese subjects even used only 100% and 50%. In the comparison of hit rate of 100% probability judgments, all the Chinese groups fell behind the British students by at least 10 per cent. Calibration curves for the pooled data of subjects in each group are shown in Figure 2.2. According to their three-stage serial model (see above), they supposed that the cognitive processes of the Chinese which were involved in answering a question generally stopped at the first or the second stage, thereby greater overconfidence emerged. Later they

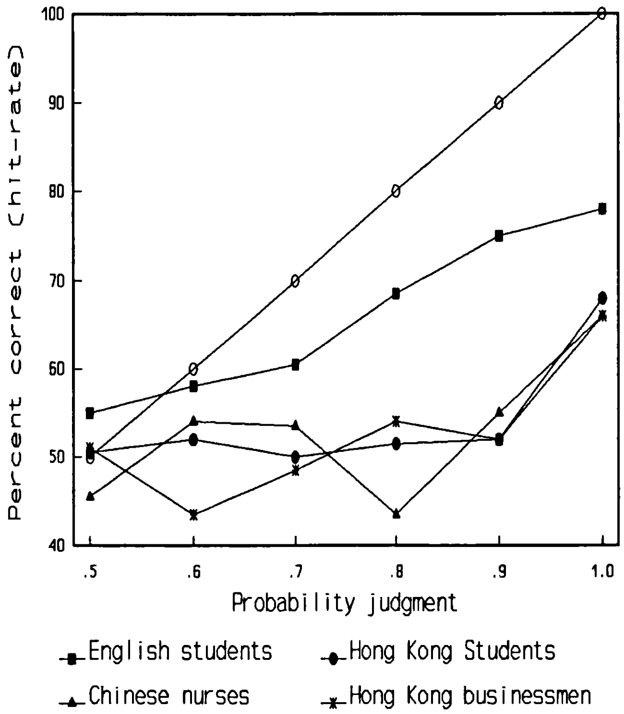

Figure 2.2. Calibration curves: British and Chinese people (Phillips & Wright, 1977)

found similar cultural differences between British and other Asian students, Malaysian and Indonesian (Wright et al., 1978).

In order to test the generality of these findings of cultural differences in probabilistic thinking, Wright and Phillips (1980) collected more data in a wide variety of Asian and British samples including Malaysian students, Indonesian students, British civil servants, Hong Kong managers, Indonesian managers and company directors. Their major conclusion from the study is that strong differences on the measures of probabilistic thinking exist between people raised within British and Asian cultures: these differences outweigh any influence of sub-culture, religion, occupation, arts/science orientation or sex, at least within the contexts studied. From the calibration curves showed in Figure

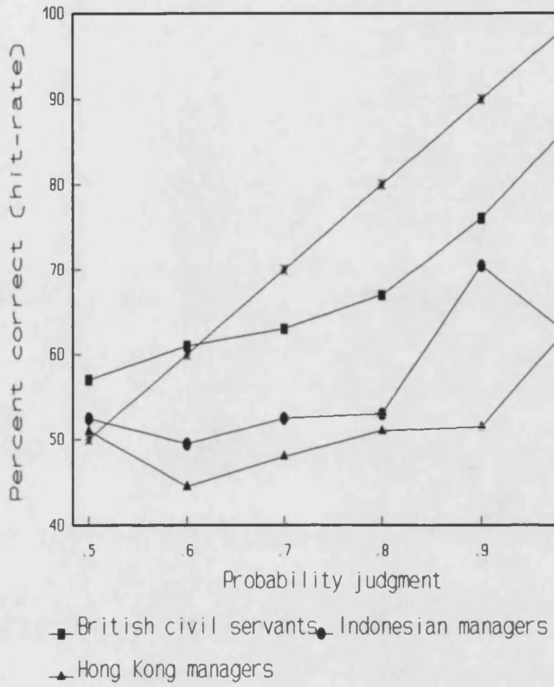

Figure 2.3. Calibration curves: managerial analysis
(Wright & Phillips, 1980)

2.3 and Figure 2.4, we can see similar cultural differences between the British civil servants and Indonesian and Hong Kong managers and between the British students and three Malaysian sub-cultural student groups. These Asian subjects also made much more extreme and less calibrated probability judgments than did their British counterparts. For example, in responding to the total of 75 general knowledge questions, the Hong Kong managers, on average, used 100% probability 37.9 times and the Indonesian businessmen 37.05 times. However, the British civil servants made 100% probability judgments only 20.9 times. From Figure 2.3, it can be seen that the percentages correct for the 100% probability judgments of the Hong Kong managers and the Indonesian businessmen are well below that of the British civil servants.

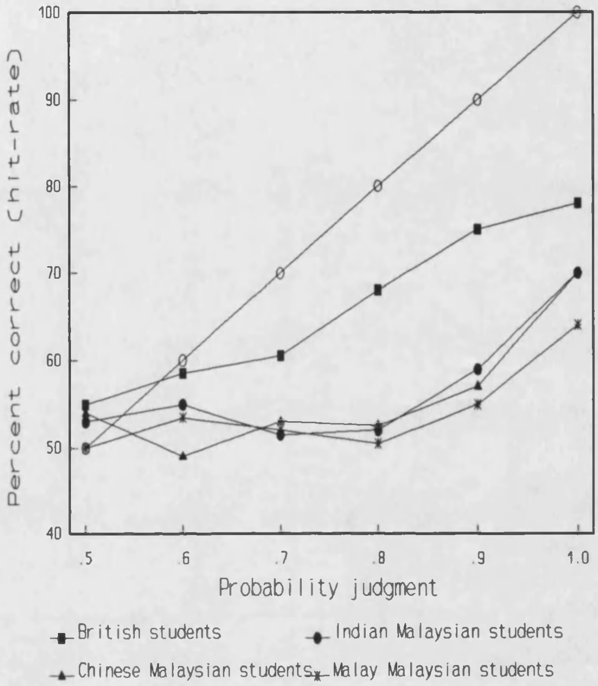

Figure 2.4. Calibration curves: sub-cultural analysis
(Wright & Phillips, 1980)

Yates et al. (1989), in a rather recent study, also found similar cultural differences between Chinese, American and Japanese college students. Their experiments showed that Chinese students were more overconfident than American and Japanese students. In answering general knowledge questions, the Chinese made much more extreme probability judgments (approximately 48%) than other student groups. The calibration curves of these three student groups are shown in Figure 2.5. Moreover, they have generalized the findings to probability distribution judgments for various quantities, such as, the length of the Yangtze River, minimum temperature recorded in Guangzhou (or Miami) a few days hence, and so on. The most important new finding, as the researchers

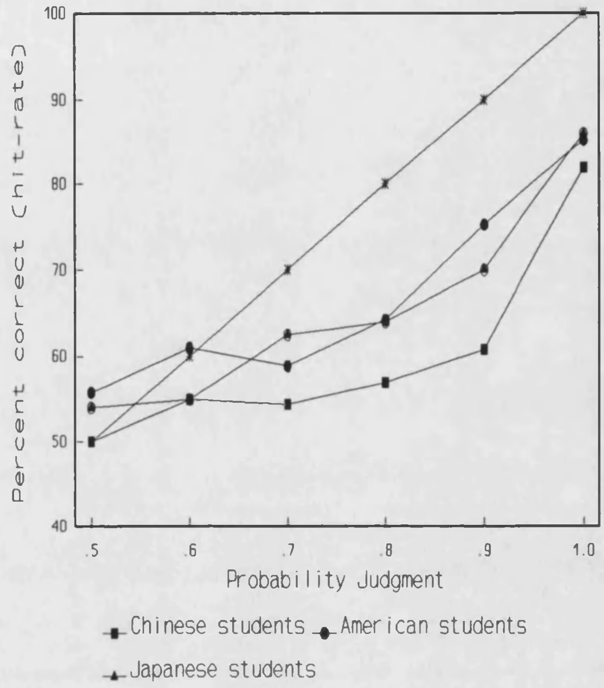

Figure 2.5. Calibration curves: American, Japanese, and Chinese students (Yates et al., 1989)

stated, was that the calibration difference was complemented by a discrimination difference according to the overall accuracy of probability judgment. In particular, the Chinese students' judgments about their answers to general knowledge questions were fairly good with respect to their ability to distinguish occasions when those answers were correct from occasions when they were not.

Lichtenstein and Fischhoff (1977) have considered that a flat (horizontal) calibration curve shows no resolution (or discrimination as Yates et al. used); a steep curve shows good resolution. However, in Figure 2.5, even though the calibration curve of the American students is steeper than that of the Chinese students, the discrimination score of the American students is less than that of the Chinese students. In fact, there are two factors deciding a discrimination score: hit-rate (proportion correct) and weight (n_t/N), while a calibration curve describes only the relation between hit-rate and assessed probability. When the overall hit-rate c is fixed, the more extreme and calibrated probabilities are given, the greater the discrimination score is. Therefore, the higher discrimination score of the Chinese students to a great extent is a result of giving more extreme probability judgments and not bad hit-rate (see the resolution score explained above). Strictly speaking, the cultural difference found in the study of Yates et al. is that Chinese had a tendency to make extreme probability judgments in comparison with their American counterparts. Actually, provided the Chinese make less extreme probabilities (100% judgments), even randomly, the differences would disappear.

From the experiment results of cross-cultural comparison studies reviewed above, it could be supposed that the Chinese and American students have different preferences for two characteristics of probability judgment: extremeness and calibration (von Winterfeldt & Edwards, 1986). Extreme probabilities could give far more useful guidance about what to expect, whereas calibrated probabilities may allow more subtle comparison and balance among possible outcomes. Unfortunately, calibration and extremeness pull in opposite directions. It could be supposed that a stronger desire for extremeness probably may lead the Chinese students to obtain higher discrimination between extreme states at the cost of decreasing calibration, whereas a stronger desire for calibration may lead the British and the American students to be better calibrated at the cost of losing more useful information.

It is also worthy of mention that in the study of Yates et al., the Chinese students still showed more overconfidence when making probability judgments about various quantities, of which a half are then-future items. However, when Wright and Wisudha (1982) asked Indonesian undergraduates to answer 10 two-alternative future event questions designed by content to be specifically relevant to the Indonesian samples (e.g. "When will the Cengkareng airport be operational? (a) before the end of 1978, (b) after the end of 1978"), they found that these students obtained a great improvement in calibration. The inconsistency may account for that they used different experiment material (quantity and event) and eliciting techniques.

Cultural interpretations

To explain the cultural and individual differences, some researchers have supposed a variety of causal relationships between people's performance in dealing with probabilistic tasks and their cultural backgrounds. In chapter 1, I discussed the point of view of Phillips and Wright, which is representative of research in the West. In their early studies (Phillips & Wright, 1977; Wright et al., 1978), they strongly suggested a causal relation between non-probabilistic thinking and the "fate-orientation" of a culture, and supposed that the Chinese fatalistic world-view than the British Laplacean probabilistic world-view were more likely to lead to overconfidence in making probability judgments. It is very natural to suppose such a relation. Indeed, Kluckhohn and Strodtbeck (1961) have pointed out, harmony with nature rather than subjugation of nature seems to have been the dominant orientation in many periods of Chinese history. And, Zhuang Tze, a Chinese ancient philosopher argued, "The winds as they blow differ in thousands of ways, yet all are self-produced. Why should there be any other agency to excite them?" In Chinese Taoists' opinion, nature means what is spontaneous. However, for the reasons given in the previous chapter, I have questioned general soundness of such explanation.

Wright and Phillips (1980) have also supposed that an adoption of Kluckhohn and Strodtbeck's (1961) value orientation concept into a questionnaire form might be one way to test whether these cultural differences in probabilistic thinking are accountable in terms of the relatively general "fatalism" of Asian culture. However, the results of several previous studies using Kluckhohn and Strodtbeck's original questionnaire or a newly derived one (Chang, 1959; Lin, 1978; Liu, 1966; Yang & Chang, 1975) provided little supportive data. Yang (1986), in a recent review, has argued that the value orientations of Chinese students have become rather similar to those of American students as reported in studies by Green (1979) and Nordlie (1968). In Taiwan and Hong Kong, it was found that the Chinese students' dominant value orientations on relational and time were individualism and future. These orientation patterns are at variance with the traditional image of Chinese as a people who typically had a collectivistic and hierarchical (linear) emphasis in human relationships and a past emphasis in time perspective.

As for the man-nature value orientation, Liu (1966) reported that most students in Hong Kong valued a submission-to-nature orientation. However, more recently, Lin (1978) and Yang and Chang (1975) found that Chinese students were predominantly inclined toward a mastery-over-nature orientation. It seems that Lin's 1962 Hong Kong students were distinctly traditional in this regard, whereas, more than ten years later, Liu's and Yang and Chang's Taiwan students tended to be moving away from this traditional characteristic to such an extent that their dominant man-nature orientation was rather similar to that of American students (Nordlie, 1968). It is not clear, however, whether this disparity should be attributed to differences in the type of Chinese society or to social changes over a period of more than ten years.

Bond (1980) and Hoosain (1986) suggested that the findings of cultural difference in calibration study could be understood in terms of the socialization and upbringing of the Chinese, related to other aspects of cognitive style, such as field dependence. Field independence is the ability to separate a perceived item from its context (Witkin et al., 1962). A field-dependent person tends to be global. For instance, in the Rod and Frame test, the ability of subjects to see the rod as horizontal or vertical, without being affected by the orientation of the surrounding frame is measured (see Dawson, Young, & Choi, 1973). Witkin et al. (1979) found that field independence is related to socialization. Societies that encourage autonomy from societal and parental authority in young children tend to produce people who show more differentiated functioning, whereas encouragement of obedience and parental authority are associated with the development of less differentiated functioning. In general, Chinese socialization patterns are considered as conforming to the strict authoritarian variety. It has been reported that Chinese parents exercise more severe discipline than Americans (Scofield & Sun, 1960). The Chinese also emphasize mutual dependence within the family more than American (Ando, 1965). Chinese children are taught to see things in terms of interrelations, more tradition oriented, and live under their ancestors' shadow (Hsu, 1967).

Yang (1981) distinguished between self or individual orientation and social orientation societies. He proposed that Americans may be taken to represent self-orientation and the Chinese social orientation. The Chinese are brought up to remain an integral part of their families throughout their lives, instead of being trained to function independently of the family network. Authoritarianism, parental control, and norms of loyalty would be characteristics of the socially oriented society, with its related cognitive styles. The lower differentiation of uncertainty can be related to social orientation. In such cultures, there is less initiative to act independently and less perceived capacity to influence events and therefore less opportunity to exercise the capacity to assess the outcome of such events.

Boey (1976) investigated the relationship between cognitive complexity and rigidity, and at parental attitudes amongst Chinese subjects studying at a post-secondary college in Hong Kong. Cognitive complexity refers to the number of differentiated dimensions a person has in perceiving or constructing the stimuli in a given domain. A person with greater cognitive complexity is able to see more aspects and relations in any perceptual situation. Rigidity, on the other hand, refers to the persistence of a response or a response set when the demands of the situation have already been changed. Three domains of performance were included: interpersonal, physical and numerical. Subjects were also asked to complete a Filial Piety Scale, which measured authoritarian control. With the Parental Attitude Scale, it was found that overprotection and overcontrol by the mother were related to cognitive simplicity in the interpersonal domain, but not related to the other two domains. Overcontrol and harshness by the father, and the extent to which the father emphasized hardship and repayment of the parents' kindness, were also related to cognitive simplicity in the interpersonal domain. The father's rigid orientation and discouragement of contradictory opinions were related to cognitive simplicity in the physical domain. The parents' attitudes towards filial piety, particularly that of the father, were all positively correlated with rigidity of the subjects as well as cognitive simplicity in the various domains. Not all of these correlations were statistically significant, but they were consistent in the direction indicated. There was some tendency for the subjects' own attitude towards filial piety to be related to cognitive simplicity, but these relations were not significant. In sum, Boey's findings showed that the father's attitudes and authoritarian control have a marked influence on the development of rigidity in the subject's personality and the related lack of cognitive complexity. The general findings of Boey were collaborated by Chan (1979). He examined performance in four areas (verbal, non-verbal, numerical, and general intelligence), and found similar correlations with parental control as rated by the subjects.

Yates et al.(1989), according to their findings, argued that the results for the Japanese subjects indicated that a simple cultural explanation might be untenable. Instead, the differences perhaps rest equally, if not more heavily, on the subject's current socioeconomic situation. For instance, technologically oriented societies, such as those in Britain, Japan, and the United States, might demand more attention to the kind of precision represented by good calibration. They supposed that the good discrimination which the Chinese had in making probability judgments is a reflection of the pervading demands of the society. Good discrimination is possible only if the person reporting judgments fundamentally "knows" what is or is not going to happen. It is conceivable that the reward structure in Chinese society is more generous for outstanding discrimination than it is for proper numerical labelling, e.g. calibration. However, this interpretation perhaps is also untenable for the case of Hong Kong students, because Hong Kong is a developed economic area and is one of the "four Asian little dragons".

Several studies (Wright, 1985) suggested that some personality traits are related to people's probability judgment. Personality as defined by Guilford (1959) is "the interactive aggregate of personal characteristics that influence the individuals' response to the environment." For instance, the people who are high scorers on scales measuring authoritarianism, and intolerance of ambiguity tend to see the world in "black and white", and more likely to make extreme responses (Souief, 1958). As Bochner (1965) notes, the primary characteristics of an individual who is intolerant of ambiguity are "premature closure" and "need for certainty". Rokeach (1960) also noted that there was "relatively little differentiation within the disbelief system" of the high Dogmatism-scale-scoring person.

From these orthodox conceptualizations of the personality/cognitive measures, Wright and Phillips (1979) anticipated strong relationships with their own measures of probability judgment that evaluated the tendency to use numeric probabilities or certainty judgments in response to questions concerning uncertain situations and the realism or calibration of the numeric judgments used. They found that high-scale scoring authoritarianism was related to poor calibration with 100% judgments and to a less fine discrimination in probability assessed numerically, which is shown by small usage of intermediate probabilities. Also, dogmatic individuals were less likely to say that they did not know the answer.

In several comparative studies, it was found that the Chinese people had higher authoritarian tendency than their Western counterparts. Singh, Huang, and Thompson (1962) in their comparative study of Chinese, American, and Indian students found that Chinese scored much higher than their American counterparts on authoritarianism as measured by Sanford and Older's (1950) Authoritarian/Equalitarian Scale. In another study, Meade and Whittaker (1967) gave the English version of the California Fascism Scale to 62 Chinese university students from Hong Kong and five other groups of students of comparable sample size from India, Brazil, Arabia, Rhodesia, and the United States. The Chinese also gave much higher scores than the Americans. Relevant data were also reported in a study by Earl (1969), who administered Rokeach's (1960) Dogmatism Scale in both Chinese and English to 101 Chinese students at the University of Hong Kong and an English version of the same scale to 82 British university students. The results revealed that the Hong Kong mean scores on both language versions were higher than the British mean score. Since dogmatism is conceptually and empirically related to authoritarianism, Earl's finding may be interpreted as indicating that the Chinese group was higher on authoritarianism than the British. All three studies support its view.

The Chinese authoritarianism may also be inferred from a study by Ho and Lee (1974) with 135 Taiwan teachers as subjects. These researchers gave adult Chinese not only a Chinese version of the Fascism Scale but also a scale of attitudes towards filial piety, and obtained a moderately positive correlation between authoritarianism and filial piety. Since Chinese people have long been known for their extremely strong sense of filial piety, it may be inferred from this substantial correlation that they are also high in their authoritarian attitudes. Furthermore, since both authoritarianism and filial piety presumably involve traditionalism, Ho and Lee's finding seems to suggest that socialization factors responsible for the formation of attitudes of filial piety might also be responsible for the formation of authoritarian attitudes.

"Uncertainty avoidance", is also possibly related to people's different preferences for extreme or calibrated probability. Uncertainty avoidance has been identified by Hofstede (1980) as a dimension of national culture, which is concerned with "the extent to which a society feels threatened by uncertain and ambiguous situations". Hofstede's study showed that the British subjects have lower UAI (Uncertainty Avoidance Index) score, that is, they have less difficulty in accepting ambiguity. The UAI for each of the 40 countries was compiled on the basis of the country mean scores for three question about rule orientation, employment and stress. However, according to the results, Philippines, Hong Kong and Singapore all have lower UAI scores, this fact couldn't be used to explain the finding that the students and managers of those countries or region have lower calibrating ability than the British students and mangers in previous studies (Wright & Phillips, 1980). It would be interpreted as that the three questions were designed for the international management research, yet are not suitable to the research of probabilistic thinking.

It was suggested that Chinese culture is a cautious culture, whereas ambiguity is related to risk, thus "risk absorbing" or "uncertainty avoidance" probably is a characteristic of Chinese society. They attach more attention to existing conditions, concrete information and flexible response. For example, Sun Tzu (Griffith, 1963) believed that skilful warriors first should make themselves invincible and await the enemy's moment of vulnerability, because invincibility depends on one's self; the enemy's vulnerability on himself. It follows that those skilled in war can make themselves invincible but cannot cause an enemy to become vulnerable. This seems to be a strategy to avoid losing. Also, from the points of view of some Western scientists mentioned above, the Chinese don't seem to be accustomed to take decisions under uncertain conditions. A demand for certainty would lead to the preference of extremeness of probability judgment, almost either totally certain or totally uncertain. Yet, the Western way of making decisions, decomposition and recomposition, careful balanced between outcomes and possibility, certainly needs calibrated probability judgments.

2.3. Discussion

Most of the studies reviewed above illustrate that making probability judgments is a rather difficult task and people's performance is far from perfect. Reaching a probability judgment from a person's feelings of uncertainty basically depends on the person's intuition. It is still unclear how people differentiate the degree of their feelings about uncertain events or quantities and translate the feelings of uncertainty into probabilities. For instance, even though after being given several training sessions, Lichtenstein and Fischhoff's subjects were still rarely able to describe their cognitions in detail (Lichtenstein & Fischhoff, 1980). A typical report was:"I don't know how to verbalize it, but there's some kind of a compartmentalization trip that's happening in my head about those categories. I'm beginning to feel the categories more than I did before, rather than just a blur from 0.5 on." It seems to suggest that translating feelings of uncertainty into numbers is not a spontaneous process for human beings. In spite of this, some studies have described several probable cognitive subprocesses that may be involved in making probability judgments. Seeking relevant evidence, assessing the evidence and translating feelings of uncertainty into a number may be three major steps which people often follow in probability judgment. Overconfidence can come from any of these three steps. Overestimating accuracy of memory, applying inappropriate inference rules and inability to translate feelings of uncertainty meaningfully into numbers, all can cause overconfidence. The results of some studies also suggested that overconfidence might result from people's underestimating the degree of difficulty in probabilistic tasks. A glaring example is perhaps Lichtenstein and Fischhoff's task of discriminating between European and American handwriting and European and Asian children's drawings. To the subjects, these tasks might seem very simple and the judgments easy to make at first glance. However, they were much more difficult than the subjects had perceived. If people cannot perceive difficulty of a task as it appears to them, then overconfidence is obviously unavoidable. The studies about people's psychological processes of developing and expressing feelings of uncertainty are very significant for improving probability judgment. However, studies are still limited in this aspect. It is farfetched to speak of that we have understood how people make probability judgments.

Some of the studies also revealed that the cognitive mechanisms involving probability judgment also differed with the characteristics of tasks. To be able to evaluate the probability judgments immediately, most of the calibration studies used general knowledge questionnaires. An important characteristic of a general knowledge questionnaire is its form of choice. As there is certainly a 100 percent correct answer in the two (or more) alternatives, subjects need only recall and seek probable evidence to affirm or negate one of the answers. Overconfidence about the accuracy of memory recall and the guessing strategy may be major factors that lead people to be overconfident in answering general knowledge questions. As there is no certain correct answer when subjects answer questions in a future event questionnaire, "only a fool or a clairvoyant tries to predict the future with total confidence" (Wright & Wisudha, 1982). In answering a future event question, the accuracy of memory recall is less important. The imagination of possible outcomes and reasoning about cause-effect relationships are explicitly involved. Some studies have showed that people were better calibrated in answering future event questions than in answering general knowledge questions. It suggested that results of studies of probability judgments that have utilized general knowledge questions may not be generalised to the probability judgment about future events.

Chapter 3. Probabilistic Thinking and Decision Making Style

3.1. Introduction

In the previous chapter, I have reviewed several recent cross-cultural studies in probabilistic thinking and argued that the main differences demonstrated in the experiments are that some groups of Western and Asian people have different preferences for the two characteristics of probability: extremeness and calibration. In making probability judgments, Asian people may feel extreme probabilities more useful, while Western people may consider calibrated probabilities more valuable. In chapter 1, I have stressed their consequences for the application of decision analysis techniques and information technology. From the discussion in chapter 2, we also have seen that several scholars have attempted to relate the differences in probabilistic thinking to some cultural aspects which are believed to have major influence on shaping the manner of probabilistic thinking, such as social orientation, value orientation and socialization patterns. Individual socioeconomic situations are also argued to have parallel influence on probability judgment. However, there are still many questions which need more intensive study. The finding of cultural differences in probabilistic thinking between Western and Asian people in the case of the People's Republic of China has, until recently, been based on only a small number of samples, and so this should be examined further. It is also not clear whether and how cultures influence people's probabilistic thinking, even though some possible cultural explanations have been suggested. More theoretical and experimental studies are required and they will be helpful in revealing certain relationships between culture and probabilistic thinking. In most of the previous experiments, general knowledge questionnaires were mainly used as instruments to create a feeling of uncertainty among the subjects. The generalization of the findings of cultural differences in probabilistic thinking from such an artificial environment cannot be taken for granted. Cultural differences must be investigated in other uncertain situations. In this chapter, I will begin to examine some of the problems and a series of results of experiments will be presented and explained.

Culture and cognition

The lack of an adequate definition of culture is one of the methodological problems in cross-cultural research of probabilistic thinking. Culture has been defined in so many ways that one can find 164 definitions in Kroeber and Kluckhohn's (1952) review of concepts, and new ones still keep on appearing. However, many of these definitions, as argued by Ronen (1986), are not precise enough to allow adequate operationalization of culture, although they may capture the essence of what culture is and how it influences behaviour. Various explanations for the cultural differences in probabilistic thinking is evidence of the confusion in definitions of culture. Thus, a general definition is insufficient when a study focuses on the specific context of behaviour of dealing with uncertainty. Even though some cultural variables can be drawn from such definitions of culture, their relationships with decision behaviour under uncertainty may be remote or indirect. For a specific variable, it may also be more or less important under varying situations of uncertainty. Redding and Wong (1986), in the similar line of argument, point out that many anthropological definitions of culture are too all-embracing, and may not be very fruitful in identifying the basic differences between cultures, nor for studying their impact on managerial behaviour. They suggest that recent rethinking on culture has tended to confine this concept within cognitive domain, and argue that confining culture here, within Keesing's (1974) "rules of the game" or Hofstede's (1980) "collective programming of the mind", permits theoretical progress as it may sponsor more focusing of research.

Cognition, as an important aspect of culture, should not be ignored and many cultural differences in decision making behaviour could expect to be explained clearer in this more basic layer. Redding and Martyn-Johns (1979, and see also Redding, 1980) consider that in constructing and understanding reality, people develop paradigms, or cognitive systems, which then affect their managerial process. They propose a three-stage model to describe the development process of paradigms. According to this model, information is selected and interpreted in the first cognition process - the perception process. The information extracted through perception then enters into the second cognitive process of imagination, thinking, reasoning and decision making. The results of this stage are a set of paradigms which are relatively stable over time. In consequence, cultural differences in managerial behaviour may be due to the fact that people in different cultural circumstances tend to develop different paradigms. By following Maruyama (1974), they further distinguish between a uni-directional causal paradigm and a mutual causal paradigm and argue that the former is typically found in Western societies while the latter is characteristic of Oriental society. They emphasize that one of the important differences between the two paradigms is that Oriental cultures have a less-differentiated view of reality than Western culture. They also speculate on the causal factors leading to the different paradigms of probability, and argue that the logical Western mind values predictions by extrapolation and believes that the future can be "calculated" to some extent, while the Chinese mind might well take a "fatalistic" view of the future and, consequently, be less prone to fine calculation.

In calibration studies, the cognitive processes have also drawn research attention for a number of years. In a review, Lichtenstein, Fischhoff, and Phillips (1982) have recognized that a striking aspect of much of the literature in the field of calibration study is its "dust-bowl empiricism" and stressed the importance of studying the cognitive process of making probability judgments. Some researchers have also proposed several information-processing models to describe the cognitive processes of making probability judgments, which are similar to Redding and Martyn-Johns' three-stage model (see Chapter 2). So, in this sense, Redding and Martyn-Johns' model may be seen as an extension to the cross-cultural study of probabilistic thinking. For cross-cultural study, this model may be more helpful as it emphasizes the cultural effect on shaping the paradigm of probability and enhances better understanding of how culture influences probabilistic thinking. However, Redding and Martyn-Johns did not further describe how culture influence the development of paradigms of probability using their own model, and simply accepted Phillips and Wright's (1977) tentative speculation of a fatalistic causal system within Chinese culture. As it has been argued, fatalism may be one of the factors which affect probabilistic thinking, but its relationship is not very obvious or direct, especially for the case in which a general-knowledge questionnaire is used as a probabilistic task. Even so, these arguments do suggest that cultural influences on probabilistic thinking should be further investigated in a more basic layer, the cognitive processes in making probability judgments to see how culture affects the development of the paradigm of probability.

In a recent study, Tricker (1988) has stressed the cultural impact on the process of transformation from data to information on the basis of the studies of Chinese and Western cultures. It was argued, "... Chinese and Western perceptions of business differ. Consequently the information perceived by decision makers differs; and so must the need for data to inform. In other words, information is culturally influenced: perceptions are culturally determined. In the vernacular - 'what one believes affects what one sees'. Even the data we choose to capture, store, and retrieve is not value-free; our paradigms determine the patterns we preserve - and those we choose to ignore". Here, Tricker emphasizes cultural impact more on information acquisition; that is, people obtain information of value from a stream of data which is influenced by the cultural context. However, in this study I argue that Chinese and Western cultures may have cultivated and shaped dissimilar patterns of information processing. Chinese and Western people are accustomed to their own patterns of comprehending reality and solving problems. In the comparative study of culture, many scholars have identified a number of differences between Chinese and Western people in their way of thinking, which strongly suggest that there are cultural differences in the patterns of cognition or information processing (see chapter 1). Therefore, if we look at making probability judgments as an information process, the cultural differences found between the Chinese and the Western people in probabilistic thinking should be reflected in their patterns of information processing.

Cognitive style method

Several recent investigations have suggested that exploring some specific psychological factors of cognitive processes in making probability judgments is one way of examining the cultural differences in probabilistic thinking. For example, Fischhoff, Slovic and Lichtenstein (1977) have explained that the overconfidence phenomena revealed in calibration studies might be produced from reconstruction of memory and inference processes. Koriat, Lichtenstein and Fischhoff (1980) have demonstrated the effects of positive or negative evidence on evaluation of the knowledge which subjects search for in their memory when answering general knowledge questionnaires. Levi and Prayor (1987) have also made an effort to identify the cognitive processes mediating the availability heuristic and showed that probability judgments were affected by the availability of causally significant reasons or information, rather than imagery of the outcome. Apparently, a cross-cultural study can follow a similar way to inspect whether cultural differences in probabilistic thinking are related to the characteristics of some particular cognitive aspects involved in making probability judgments, such as, memory, reasoning, imagination, and so on.

Nevertheless, the growing interest in the study of cognitive style may also suggest an alternative way to trace the behaviourial differences in dealing with uncertainty to the habitual approaches which people may employ consciously or unconsciously in making judgments or decisions. The cognitive style method emphasizes the decision making process and observes the decision making behaviour mainly as a personality variable, namely cognitive style (Keen & Scott-Morton, 1978). Ramaprasad (1987) has also featured the differences between cognitive process and cognitive style research and expounded, "Cognitive process research focuses on specific influences on a person's cognitive information processing. Its focus is micro on the elements of a person's cognitive information processing, these are, for example: perceiving and recognizing stimuli, remembering and searching information, inducing rules, recognizing patterns, formulating concepts, and applying all these in sensing, formulating, and solving problems. Cognitive style research, on the other hand, focuses on general influences on a person's cognitive information processing. Its focus is macro, on the architecture of a person's cognitive information processing." Similarly, Haley and Stumpf (1989) have contended, "Studies on personality types also bypass some problems that traditional cognition studies may pose: personality-type preferences provide more integrated views of the behaviour of executives than studies focusing on single psychological dimensions." As it has been argued, the processes in which people make probability judgments still remain veiled and presumably people's judgment can be biased by diverse factors in many ways. So, previous arguments intimate that the cognitive style method may have an advantage as it attempts to capture the habitual ways which people may employ in traversing the whole cognitive processes when approaching a probability judgment, rather than to concentrate on single cognitive aspects. To understand the cognitive style method, a brief review is given in the following paragraphs.

Review of cognitive style study

Many researchers in different disciplines have developed various frameworks to capture the dispositions of decision makers in perceiving information, generating alternatives, and making a choice between available alternatives. In management research, an early classification of cognitive style can be found in Barnard's (1938) essay "Mind in Everyday Affairs", published as an appendix to his Functions of the Executive. Barnard contrasts the logical and non-logical processes in decision making, and expounds, "By 'logical processes' I mean conscious thinking which could be expressed in words or by other symbols, that is, reasoning. By 'non-logical processes' I mean those not capable of being expressed in words or as reasoning, which are only made known by a judgment, decision or action." In Barnard's view, an executive relies on intuition or judgment as well as on rational analysis to make decisions. Although Barnard characterized the differences between logical and judgmental styles of decision making, he did not further explicate how to make a formal distinction.

Huysmans (1970) has distinguished between two cognitive styles according to the "way of reasoning", which are called "analytic" and "heuristic", in an experiment aiming to examine whether the cognitive style of the adopting manager constrains the actual use or implementation of management science recommendations. Individuals of analytic reasoning tend to simplify problem situations to a set of underlying causal relationships in order to model a decision problem. An explicit model, often in a quantitative form, built up on the basis of these causal relationships and other decision parameters, is used to choose among alternative courses of action and find an optimal solution. Individuals of heuristic reasoning emphasize pragmatic solutions to total problem situations rather than optimal solutions to simplified problems. They rely on searching for analogies with familiar solved problems to find solutions. Common sense, intuition, and unquantified "feelings" about future developments play an important role for the heuristic decision makers. Huysmans measured the cognitive styles of the subjects through observing their behaviour in solving two analytic puzzles and a business case with no strict analytic solution.

McKenney and Keen (1974) have also developed a model of cognitive style to classify individuals along two dimensions: information gathering and information processing. Information gathering concerns the perceptual processes by which the mind organizes verbal and visual stimuli. At one extreme of this dimension, perceptive individuals focus on relationships between data items and look for cues in attempt to grasp the pattern of the problem. Data are filtered by their preconceptions. At the other extreme, receptive individuals focus on details of data rather than relationships. They are sensitive to the stimulus itself and tend to examine directly the attributes of the information.

Information evaluation refers to individual's sequence of analysis of data. At one extreme, systematic individuals tend to follow a structured approach which leads to a likely solution. At the other extreme, intuitive individuals do not commit themselves to any one single method and tend to use trial-and-error strategies. They respond to the cues that they may not be able to identify verbally.

Adopting the notion of an "information complex", Driver and Mock (1975) have proposed a cognitive style model of two dimensions in terms of the amount of information used and the use of a single or multiple focus. A minimal data user is satisfied with just enough data to make a decision. A maximal data user, on the other hand, tends to process all the data which are perceived to be of use for the decision. There are also two extremes of focus dimension. At one extreme are individuals who view all data leading to a single solution, whereas at the other extreme are individuals who view solutions as multiple. Combining these two dimensions, Driver and Mock derived four independent styles: decisive style (single focus, low usage), flexible style (multiple focus, low usage), hierarchic style (single focus, high usage) and integrative style (multiple focus, high usage).

In the research of cognitive style, a more widely accepted framework perhaps is the Jungian typology (Jung, 1971). Following Jung, several researchers have developed similar models of cognitive or decision style and the instruments which operationalized Jungian typology, particularly the Myers-Briggs Type Indicator - MBTI (Myers & McCaulley, 1985), have also been extensively applied to the investigation of cognitive style.

Jung's (1971) psychological type theory, in essence, is based on the belief that much apparently random variation in human behaviour is actually quite orderly and consistent, which is due to the basic differences in the way that individuals perceive or acquire information and make decisions or judgments. Information acquisition and decision making form two fundamental dimensions in Jung's categories. Jung characterized two opposite preferences in information acquisition, sensation (S) and intuition (N). Individuals who prefer sensation perception apprehend realities of a situation or a problem as they actually are in the present moment. They search for facts, evidence, and detailed information. Their perception primarily relies on the five senses. In contrast, individuals who prefer intuition perception focus on possibilities, relationships and insights which go beyond what is actually perceived. While sensing individuals concentrate on particularity of a situation, they concentrate on its totality. They value imagination, inspiration and holistic information.

Jung also identifies two opposite ways of making decisions or judgments after information perception, thinking (T) and feeling (F). Thinking individuals tend to approach a decision or judgment along the way of logical analysis. They prefer to make decisions objectively and on the basis of cause and effect. Feeling individuals, on the other hand, consider social and personal values as more important and tend to decide subjectively.

As the two ways of acquiring information and the two ways of making decisions are considered to be independent, they can be combined into four basic styles: Sensation-Thinking (ST), Sensation-Feeling (SF), Intuition-Thinking (NT), and Intuition-Feeling (NF). Jung also emphasized that each style had its own strengths and limitations and this classification did not, in any sense, imply superiority or inferiority of cognitive style.

In addition to the two major dimensions, Jung has also described two opposite preferences according to the world where people like to focus their attention, called as extraversion (E) and introversion (I). Extravert individuals tend to focus on the outer world of people and external environment, while introvert individuals concentrate on their inner world of ideas and concepts. In developing the MBTI, Myers and Briggs also made explicit differentiation between two preferences for the way of dealing with the external world: judgment (either thinking or feeling) and perception (either sensation or intuition), which were implied in Jung's work. Individuals taking a judgmental (J) attitude, are thought to tend to make a decision quickly and clearly. Their perception is shut off as soon as they believe they have got enough information. In contrast, individuals adopting a perceptive (P) attitude, prefer to adapt to observed notions of reality. They like to keep their options open, aiming to miss nothing.

Most of the studies using the MBTI employed only the two basic dimensions in their models of cognition style, perhaps because it was believed that the two, information acquisition and decision making, were that was mostly needed to understand the cognition processes and because of the need of simplicity in experimental study. Mason and Mitroff (1973), for example, suggested a model to categorize cognitive style of a person along the two basic dimensions of Jung's system. However, Nutt (1986a) argued, "Traditionally, management theorists have used the MBTI scales that measure preferences for acquiring and processing data to define what can be termed a 'choice frame'. The choice frame provided a window through which to view the cognitive make-up of managers, which has proved to be insightful in its ability to illuminate distinct styles of choice making. This formulation, however, excludes half of the classification categories that Jung considered important, fails to deal with the sequential nature of choice making, and does not account for implementation preferences implicit in Jungian theory." Nutt proposed a model of two frames, choice and action frames, which draws on all of the Jungian categories. The choice frame concerns individual's preferences for the way of information perception (Sensation or iNtuition) and information evaluation (Thinking or Feeling), while the action frame pertains to an individual's predisposition for action focus (Extraversion or Introversion) and preferred action type (Judging or Perceiving). By combining the four dimensions, Nutt derived 16 decision making styles in total:

procedural (ESTJ), evaluative (ENTJ), ordered (ISTJ), intellectual (INTP), political (ESFJ), mediator (ENFJ), flexible (ISFP), committed (INFP), traditional (ESTP), relational (ESFP), empirical (ISTF), anecdotal (ISFJ), visionary (ENTP), proselytizing (ENFP), iconoclast (INTJ), and cooperative (INFJ) styles.

Many investigators have made efforts to relate some differences in decision behaviour to the cognitive style of decision makers. The performance of people of different cognitive styles have also been compared. In such studies, the MBTI was often used to measure the cognitive or decision style of the decision makers. Casey (1980) used the abridged version of the Myers-Briggs Type Indicator to discriminate decision styles. He considered that individuals categorized as "sensors" preferred to analyze isolated, concrete details in making a decision, whereas "intuitors" focused on relationships, or gestalt. In Casey's study, bank loan officers made "predictions" of the possible corporate failure for each of 30 firms based on the information contained in six financial ratios, such as net income/total assets for each firm. The ratios were real ones, belonging to 15 firms that had already filed for bankruptcy and to 15 randomly chosen non-bankrupt firms. Casey confirmed his hypothesis that Jung's information-processing styles were related to the performance on his task as he found significant association between overall accuracy and subject classification on the Myers-Briggs Type Indicator. As expected, intuitors performed better than subjects classified as sensors.

Davis (1982) also utilized the Myers-Briggs instrument to differentiate individuals' performance on a computer simulation of a production function. Individual decision makers acted as operations managers. One of the tasks faced by his subjects was to develop a production plan for a 5-week production period with the objective of minimizing the firm's total costs. Davis found that sensing subjects obtained significantly lower costs than intuitive subjects. He argued that this was because his decision task was analytical and moderately well structured, and hypothesized that other tasks involving tactical and strategic decisions would tend to favour good performance by intuitive types as they are less well structured.

Recently, Nutt (1986b) has expanded an earlier study (Henderson & Nutt, 1980), to investigate the influence of decision style on strategic decisions of top executives. He used all of the four scales of the MBTI to make a finer distinction of decision style and divided 137 top executives into 16 types along his model of two frames (Nutt, 1986a). The subjects were presented 8 capacity-expansion scenarios, which were systematically manipulated in the uncertainty level (low or high range of return of investment), environment (compatible or incompatible to the cognitive style of executive) and information source (model or interaction) and then were asked to indicate their likelihoods of adopting each scenario and their perception of risk in this action.

The results of analysis by the ANOVA (analysis of variance) and ANCOVA (analysis of covariance) techniques showed that the decision style was a significant factor in explaining the adoptability and perceived risk for strategic decisions. For the choice frame, it was found that the ST executives tended to reject all the projects, while SF executives were likely to adopt these same projects. The NT and NF executives took nearly identical and intermediate positions. The typical ST executive found considerable risk in the projects, the NT and NF nominal risk, and the SF little risk. However, the influence of the action frame was less than the experimenter's expectation. After combining the choice and action frames, Nutt also found that executives with a STEJ style took the most conservative posture toward strategic action. Executives with SFEJ and SFEP styles were action oriented, but SFEP style saw far more risk in strategic action-taking than did the SFEJ style. The SFIJ executive was distinctly different from the other SF styles and made decisions that were nearly as conservative as the ST. Executives with a NF style were inclined toward action except for the NFIP who were undecided about whether to act. Executives with a NTEJ style had a proactive posture that was viewed as having less than the typical level of risk. Executives with a NTIJ and a NTIP style were somewhat action oriented, but saw more risk in the decision than did the NTEJ.

Decision style-uncertainty and decision style-environment interactions were also found to be significant. When uncertainty was low, nearly all of the executives, regardless of their styles, were prepared to act. When uncertainty was high, however, the SF executive still leaned toward adopting the high-uncertainty projects, the ST executive wanted to reject them, and the NT executive leaned toward rejecting. The action frame added still more insights. The STEJ executive seemed paralysed when uncertainty was high. Executives with a NFIP and a NTEP style also become quite conservative when uncertainty was high. The SFEJ executive, however, was inclined to act no matter what the level of uncertainty. It was also found that environments consistent with decision maker's style seemed to encourage action taking by executives with a ST style, and incompatible environments appear to encourage action taking by the other styles.

More recently, Haley and Stumpf (1989) have tried to build the connections between some decision heuristics and biases, and personality type of manager measured by the MBTI. Based on the proposition that managers' personality types connote implicit decision heuristics and biases, they made a series of hypotheses: STs tend to use anchoring heuristics, and succumb to functional-fixedness and regularity-and-structure biases; NTs tend to use perseverance heuristics, and succumb to positivity and representativeness biases; SFs tend to use availability heuristics, and succumb to social-desirability and fundamental-attribution biases; NFs tend to use vividness heuristics, and succumb to reasoning-by-analogy and illusory-correlation biases. These hypotheses were tested in a pilot study. The participants were 43 managers from four corporations. They took part in four runs of a simulation revolved around hypothetical, commercial bank with assets of $1.5 billion. After selecting managerial roles, participants received information on the financial service industry, the bank, their roles, and policy issues. Then, participants managed the bank as they saw it. The results of this experiment provided some preliminary support for their hypotheses. For the two dominant types, ST and NT, chi-square tests were conducted. One chi-square test, asymmetric lambda, with anchoring as the dependent variable, revealed an association of 50 per cent with personality type. The second chi-square test, asymmetric lambda, with perseverance as the dependent variable, revealed an association of 53 per cent with personality type. For the SF and NF managers, although small numbers of subjects precluded further tests, the results of descriptive statistics were consistent with the hypotheses about the associations between these two personality types and heuristics and biases.

White (1984) has also used MBTI to explore the influence of team composition on team effectiveness. There were two project teams participating in the experiment. The homogeneous team consisted of only ST and NT members, and the heterogeneous team all four MBTI types. Both teams were asked to complete an unstructured task of developing an order-entry system and a timed programming task considered as structured. White found that no one team was always superior to the other and concluded that heterogeneous teams were "optimum" when solving unstructured tasks while homogeneous teams were "optimum" when solving structured tasks.

Apparently, the major concern of most of the researchers in the literature reviewed above, is individual characteristics in process behaviour. Their research pursuits are to conceptualize the distinct approaches which individuals may follow consciously or unconsciously in dealing with information and in making judgments or decisions; to develop instruments that can measure individual preferences for the different approaches; and finally to explore whether individual characteristics have influences on decision behaviour. Can the methodology of cognitive style, which is mainly developed for the study of individual differences, be extended to examine cultural differences? Although it is naive to say that all Chinese people take completely different approaches from Western people in perceiving and evaluating information, the previous comparisons between thought processes of Western and Chinese people do suggest that Chinese and Western people do not perceive reality nor make decisions in the same way (see chapter 1). Thus, whether the methodology of cognitive style can be used in this study depends on two conditions. First, the conceptual characterizations of distinct cognitive styles should also depict some of such cultural differences between Chinese and Western people. Second, there are available instruments which can be used validly in both Chinese and Western cultures.

Indeed, Taggart and Robey (1981) have traced the basic distinction between the rational and holistic ways of information processing back to the different philosophical traditions of East and West. They argued, "The philosophy of Wu Wei contrasts sharply with the Western attitude that some action must be taken to achieve a desired result. Conceptually, the Western stress on action aligns with the left hemisphere rational processing style. Conversely, the Eastern acceptance of things as they are corresponds to the right hemisphere." The authors considered that the Taoist symbol of overlapping light and dark (yin and yang) suggested a holistic, integrated information processor. Taggart and Robey's arguments imply that there are similarities between the distinctions of individual and cultural characteristics of process behaviour, and some of the available instruments also can be used to probe the preferences of Chinese and Western people for the ways of perception, analysis and interpretation of information in decision making.

In Chapter 1, I have mentioned Chiu's (1972) work in cross-cultural comparison of cognitive style between Chinese and American children. In the study, Chiu followed the categorization of cognitive style developed by Kagan, Moss, and Sigel (1963) to examine the cultural differences in cognitive style through observing how Chinese and American children deal with tasks of conceptual classification. The Chinese and American children were given 28 items of three pictures representing human, vehicle, furniture, tool, or food categories and were asked to select any two out of the three objects in a set which were alike or went together, and to state the reason for his choice. It was found that in comparison with the American children, the Chinese children scored higher in the relational-contextual style, but lower in the descriptive-analytic style and in the inferential-categorical style. That is, the Chinese children preferred to categorize external stimuli on the basis of their interdependence or relationships, while American youngsters preferred to differentiate or analyze the components of the stimulus complex as well as to classify stimuli on the basis of inferences made about the stimuli which are grouped together.

Most of the cross-cultural studies of cognitive style have adopted the perception tests such as the Embedded Figures Test (EFT) and the Rod and Frame Test (RFT), to contrast the "field-independent" and "field-dependent" styles (Witkin, Dyk, Paterson, Goodenough, & Karp, 1962). In chapter 2, it has already been illustrated how the cultural differences between Chinese and Western people in probabilistic thinking are related to the different cognitive styles of Chinese and Western people exhibited in such tests. However, for most of the cross-cultural studies on field-independence, the main research interest was not in the cultural differences itself, but in the cultural influences on cognitive style, such as socialization, acculturation, social attitude and so on. Many researchers on field-independence in both Western and non-Western cultures have tested the theory of Witkin and Berry (1975) about culture and cognitive development, which hypothesizes that the more dependent cognitive style is widespread in structurally tight societies which enforce social conformity, whereas the more independent style is prevalent among societies which encourage autonomy. Most of the results of these studies supported the hypotheses (Werner, 1979). However, it was not confirmed in Japanese children, as Bagley, Iwawaki, and Young (1983) found that the scores of the children's version of EFT for the Japanese children were significantly higher than their English counterparts, but Japan is thought to be a tight and group-oriented culture. They speculated that the EFT might be better interpreted as an ability test rather than a measure of socialized cognitive style.

In the Hong Kong Chinese, Dawson, Young and Choi (1973) found that field-independence was also related to social attitude. Those who held a more traditional attitude tended to be field-dependent, whereas those who had a more modern attitude were more likely to be field-independent. Yet, there were few studies which made direct comparisons between Chinese and Western people or related field-independent or field-dependent styles with decision behaviour, although Bond (1980) presumed an indirect relationship between probabilistic thinking and field dependence in terms of the socialization and upbringing of the Chinese.

This study

The previous review has shown that cognitive style is one of the factors which can heavily influence decision makers' behaviour. A variety of connections between decision behaviour or performance and cognitive style of decision makers have already been found in many experimental studies. However, to my knowledge, there are no comparable studies yet in the field of probabilistic thinking, neither theoretical or empirical, which have made an attempt to investigate human probabilistic thinking from the angle of cognitive style. Although cross-cultural comparisons of cognitive style have demonstrated that people raised in different cultures do not perceive reality and deal with problems in the same way, few efforts have been made to examine cultural differences in probabilistic thinking by relating to the ways of perceiving information and making judgments. As argued before, making probability judgments has often been presumed as an information process passing through several subprocesses of cognition. Cultural differences in probabilistic thinking could be traced to some particular aspects of information processing, but it is at least equally reasonable to conjecture that people make probability judgments differently is partly because they follow different ways, as revealed in the study of cognitive style, to perceive and analyze information in approaching a judgment. Conspicuous differences between Chinese and Western thought processes illustrated by many scholars have strongly suggested that Chinese and Western people have different preferences for the way of perceiving information and making judgments. Every preference thus may lead people to deal with uncertainty in some way that is different from others. This present study starts an examination of the relationship between people's probabilistic thinking and their style of information processing. It is hoped that the method of cognitive style, in comparison with the study of concentrating on single psychological factors, can provide a more integrated view of understanding how people develop their own probability paradigms and why they make probability judgments differently. It is also hoped that this study can give better explanations of how culture influences people's probabilistic thinking than does the study of seeking specific cultural factors connected with probabilistic thinking. This experiment may provide some clues for seeking particular cultural factors which have impact on the development of probability paradigms.

To examine cultural differences in probabilistic thinking and their relationship with cognitive style, an experiment was conducted in the United Kingdom and the People's Republic of China. Jungian classification of cognitive style was adopted in this study to measure the preferences for the ways of perceiving information and making judgments. This experimental study firstly aims to make a comparison of probabilistic thinking between Chinese and British people in a larger sample of subjects, and secondly to investigate whether cultural differences in probabilistic thinking can be traced to a more basic level, the ways of perceiving information and making judgments in terms of cognitive style. In the rest of this chapter, I will first report the results of the experiment and then discuss their implications.

Before stepping into detailed explanation, I would like to give a reminder that this study is concerned with an examination of the differences in behaviour when dealing with uncertainty. That is, only what people, raised in different cultures, actually do is observed, rather than what they could do. So, no suggestions about cultural inferiority or superiority in capacity can be derived from this study. Each way of dealing with uncertainty may have its strength and weakness.

Hypotheses

The hypotheses of this study were proposed as follows:
H1. It is first hypothesized that probabilistic thinking will be related to cognitive style. The dimension of information perception is perhaps most closely related to probabilistic thinking. Sensation perception has been characterized as focusing more on hard facts and the particularity of a situation, while intuition perception as leading to seek possibilities and the totality of a situation. Sensing individuals may tend to be more uncomfortable with uncertainty and less tolerant of ambiguity. Sensing managers were found to make decisions more clearly. When facing capital expansion projects, they adopted or rejected them (Henderson & Nutt, 1980; Nutt, 1986b). Hellriegel and Slocum (1980) also found that sensation type managers dislike coping with unstructured problems that contain considerable environmental uncertainty more than do the intuitive-thinkers. So, it is expected that the subjects who prefer sensation perception will tend to make more clear-cut distinction in uncertainty and thus use less probability vocabulary and make more extreme probability judgments, while the subjects who prefer intuition perception will tend to make a finer distinction in uncertainty and thus employ a richer probability vocabulary and make better calibrated probability judgments.

For the dimension of information evaluation, it is expected that the subjects of thinking type make finer distinctions in uncertainty in both words and numbers than those of feeling type, as it is believed that the way used by thinking individuals in approaching a judgment, is more likely lead to logical, rational, quantitative analysis and thus finer distinction in uncertainty; and numerical expressions of uncertainty are more meaningful for them. It is also expected that a judgmental attitude will reinforce the subjects in making more extreme probability judgments, as it tends to lead people to make judgments clearly and quickly, than does a perceptive attitude which is more likely to guide people to keep their options open. In fact, it has already been reported that sensing individuals tend to take a judgemental attitude in making judgments or decisions, and intuitive individuals are more likely to be perceptive (Myers & McCaulley, 1985). However, this study does not expect that probabilistic thinking has any significant connection with Extraversion-Introversion. Indeed, Wright and Phillips (1980) have found strong similarities between Moslem and Christian Indonesians in the differentiation of numerical probability, although the former is presumed to be more passively external than the latter.

H2. It is also hypothesized that the Chinese and the British people will show different preferences for ways of perceiving information and making judgments. It has been argued that the Chinese way of thinking tends to be concrete and single dimension oriented, with less interest in the imaginary, abstraction, and logical reasoning. In contrast to Westerners, the Chinese concentrate their attention more on what is immediately apprehended through the senses, and on particular instances (Northrop, 1946; Nakamura, 1960; Hsu, 1970; Zhang & Wang, 1988). So, it is expected that the perception of the Chinese tends to be more sensing, and that of the British people more intuitive. "Sensation perception" will be the dominant type in the Chinese, while "intuition perception" will be dominant type in the British. Also, Chinese culture has been characterized as socio-oriented in contrast to the individual-oriented of Western culture (Hsu, 1981; Yang, 1981). Chinese people tend to see the world from the basis of a network of relationships. They may care more for the feelings of other people and attach importance on personal value. It is thus expected that, in making judgments, the Chinese people prefer feeling and the British people prefer thinking. The dominant type for the Chinese people will be "feeling" and for the British people will be "thinking". It is appropriate to note here that the Jungian conception of feelings does not refer to emotions, but to make decisions based on value judgments. Furthermore, considering the positive correlation between "sensation-intuition" and "judgment-perception", it is also expected that the Chinese people are more likely to take a judgmental attitude in dealing with the external world, whereas the British people are more likely to take a perceptive attitude. The "judgment" type will be dominant in the Chinese and the "perception" type in the British.

H3. Cultural differences in probabilistic thinking between the Chinese and the British people are partly accounted for by the differences in the ways of perceiving, evaluating information revealed by conception of cognitive style.

3.2. The experiment

Instruments

Three instruments were administered to all subjects, the View of Uncertainty Questionnaire, Probability Assessment Questionnaire, and Myers-Briggs Type Indicator. The first two questionnaires were used to measure the probabilistic thinking of subjects. The last one identified the cognitive style of subjects. The Chinese subjects were given the Chinese versions of these three questionnaires, and the British subjects the English versions.

1. The View of Uncertainty Questionnaire (VUQ) asks 20 questions about possible future events, such as "Will you catch a head cold in the next three months?". The instructions asked respondents to "Write in the space provided a reasonable and appropriate response to the following questions." In comparison with an earlier version (Phillips & Wright, 1977), the present VUQ does not include the questions about facts, such as "Is Baghdad the capital of Iraq?".

Responses on the VUQ were classified into five categories: (1) number of yes/no responses; (2) number of don't know responses; (3) number of probability responses; (4) number of different probability responses used by that subject, and (5) catch-all responses (e.g. "I hope not").

2. The Probability Assessment Questionnaire (PAQ), as detailed in Phillips and Wright (1977), presented 75 questions with two choice alternative answers, such as:

Which is longer?
(a) Panama Canal
(b) Suez Canal

Subjects are asked to choose the right answer and also to indicate how sure they are by writing a percentage between 50 and 100.

To examine extremeness of probability judgments, several measures were taken from the PAQ: the number of 100 per cent judgments, percentage correct (hit-rate) for any 100 per cent judgments given, and the number of 50 per cent judgments, percentage correct for any 50 per cent judgments given. An entropy measure, H, was calculated to measure the distribution of the 75 probability judgments given on the PAQ. Specifically,

$$H = -\sum_{i=1}^{M} \frac{n_i}{N} \log_2 \left(\frac{n_i}{N}\right)$$

where n_i is the number of judgments of a given probability, M is the number of different probability judgments made by the subject, and $N = \Sigma n_i = 75$. The H measure is relatively large when many different judgments are given, and when they are made equally often. The H measure would be relatively small for an individual who gave only judgments of 50 per cent and 100 per cent, particularly if most of the judgments were just one of those probabilities. To measure the accuracy of probability judgments (Murphy, 1973), calibration (C) and resolutions (R) scores were also calculated:

$$C = \frac{1}{N}\sum_{i=1}^{M} n_i (r_i - c_i)^2$$

Where r_i is the probability judgment and c_i is the proportion correct for all items assigned probability r_i. The calibration score is smaller when subjects make more accurate probability judgments. A group of perfect probability judgments can make calibration reach zero.

Resolution measures the ability of the respondent to discriminate different degrees of subjective uncertainty by sorting the items into categories whose respective percentages correct are maximally different from the overall percentage correct. The higher the resolution the better. Resolution scores are computed by the following formula.

$$R = \frac{1}{N}\sum_{i=1}^{M} n_i(c_i - c)^2$$

Where c is the overall percentage correct.

3. Myers-Briggs Type Indicator (MBTI)

The Myers-Briggs indicator follows the psychology of types developed by Jung (1971), which is primarily concerned with the differences in the ways in which people perceive or acquire information and make decisions or judgments with the information which has been perceived. MBTI is composed of four indices, Extraversion-introversion (EI), Sensation-Intuition (SN), Thinking-Feeling (TF), and Judgment-Perception (JP). In this experiment, the Form G of the Myers-Briggs Type Indicator (Myers & McCaulley, 1985) was employed to determine subject's cognitive type or information-processing style and to calculate continuous preference scores.

The MBTI is considered as valid and reliable (Tzeng et al., 1984) and has been widely used in many fields. Previously in this dissertation, we have seen many of MBTI applications in studying managerial decision making. The MBTI also has been used in cross-cultural studies and is also considered as a valid instrument. For example, Carlson and Levy (1973) successfully tested Jungian theory with subjects who were black college students. Myers (McCaulley, 1977) developed a scale to predict success in medical school internships. The scale was developed on mainly black physicians from the Howard Medical School and cross-validated on mainly white physicians from the University of

New Mexico. Ohsawa (1975; 1981) reported on data with the Japanese version of the MBTI. In Japan as in the United States ST types are found in production management, SF types in sales, and NT types in long-range planning. TJ types are in top executive jobs in both societies.

In this study, the MBTI was carefully translated into Chinese by using the back-translation method (Brislin, 1970). It was first translated into Chinese from English by the author and sent to some Chinese graduate students of an English language department in China to seek comments. A Chinese professor in English was then asked to translate the first Chinese version of MBTI back to English. Through several iterations, the inconsistencies were checked and the Chinese version was finally settled.

Subjects

97 Chinese university students (47 women and 50 men) studying in Peking and 105 British university students (46 women and 59 men) studying in London volunteered to take part in this experiment. They were paid for their contributions. Most of them were undergraduate students but a few were graduate students, and they were studying a diverse set of major subjects.

Procedure

For convenience, this experiment was administrated in groups. Each subject was first given the VUQ and PAQ questionnaires, and then the MBTI. Before answering the questions, the subjects were asked to read carefully the instructions, which made no reference to probabilistic thinking and its relationship with information-processing style. There was no time limit, though the subjects were encouraged not to think too long when answering the questions in the MBTI.

Results

Two Chinese and five British subjects failed to answer the questionnaires in accordance with the requirements, and so their data were excluded from the following analyses.

VUQ

The means and standard deviations for measures derived from the VUQ are given in Table 3.1. Three significant differences were found between the Chinese students and the British students. It can be seen that in responding to the VUQ, the Chinese students on average gave more "yes or no" answers than did the British students, whereas the British students were more likely to employ their vocabulary of probability than their Chinese counterparts. The Chinese students offered "yes or no" answers in over 14 of the 20 questions in the questionnaire, whereas the British average was just about 10. In contrast, the British students used a richer vocabulary of probability to describe the degree of uncertainty in their feelings about their choices. The number of probability word responses for the British students were twice as many as that of the Chinese students. All these differences were statistically significant. However, no significant difference was found in the measure of the number of "don't know" responses between the two groups of students, although the British students answered "don't know" slightly more often.

These results replicated the previous findings of Phillips and Wright (1977), that there are cultural differences between Chinese and British people in giving verbal responses to uncertain events. It seems to be that when facing such uncertain situations, the Chinese are more likely to give unambiguous replies and the British more often keep their feelings of uncertainty to themselves and tended more to describe them with the vocabulary of probability. However, it should be emphasized here that this experiment used only the questions about future events in the VUQ, the results show little differences from those of Phillips and Wright's study. These results do not provide any evidence to support that time-orientation of questions has obvious impact on the verbal responses of subjects to the uncertain events.

Table 3.1. Comparisons on verbal responses

Measure		Sample: Chinese Students (N=95)	British Students (N=100)	t
1.Number of Yes/No responses				
	Mean	14.38	10.43	5.56**
	Std.Dev.	4.83	5.08	
2.Number of Don't know responses				
	Mean	0.95	1.12	N.S.
	Std.Dev.	1.59	1.66	
3.Number of probability word responses				
	Mean	4.68	7.58	-4.34**
	Std.Dev.	4.47	4.85	
4.Number of different probability word responses				
	Mean	1.56	3.30	-7.17**
	Std.Dev.	1.53	1.86	

Two-tailed significance ** $p < 0.01$

PAQ

Table 3.2 gives the means and standard deviations for measures taken from the PAQ. The results explicitly showed that the Chinese students and the British students made quite different probability judgments. In this experiment, the strong tendency to make extreme probability judgments was demonstrated among the Chinese sample by the fact that they made much more probability judgments of 100% than did the British students. Not surprisingly, they were wrong more often when they were absolutely sure about their choices. It was also found that the Chinese made less probability judgments of 50%. However, a quite different tendency was found among the British student samples. In comparison with their Chinese counterparts, they used a wide choice of probabilities rather than focusing on one or two extreme probabilities, that is, the British students showed finer differentiation in expressing uncertainty. The British students also exhibited

Table 3.2. Comparisons on extremeness and calibration of judgment

Measure	Sample: Chinese Students (N=95)	British Students (N=100)	t
1.Number of 50% judgments given			
Mean	13.22	17.99	-3.22**
Std.Dev.	9.51	11.16	
2.Percentage correct for any 50% judgments given			
Mean	48.9	50.5	N.S.
Std.Dev.	19.9	16.2	
3.Number of 100% judgments given			
Mean	38.39	17.04	11.64**
Std.Dev.	14.52	10.71	
4.Percentage correct for any 100% judgments given			
Mean	78.62	82.3	-2.16*
Std.Dev.	10.11	13.3	
5.Entropy H			
Mean	1.75	2.20	-6.28**
Std.Dev.	0.58	0.40	
6.Calibration			
Mean	0.0592	0.0396	4.40**
Std.Dev.	0.0332	0.0283	
7.Resolution			
Mean	0.0272	0.0270	N.S.
Std.Dev.	0.0180	0.0159	

Two tailed significance * $p < 0.05$ ** $p < 0.01$

a lower (better) mean calibration score than the Chinese sample. The British students obtained a higher mean entropy (H) measure which further indicated that they made a wider range of probability judgments. All of these differences between the two cultural groups were statistically significant. However, no significant differences were found in the measures of percentage correct for 50% judgments and the resolution score.

In the above analysis, the parameters were calculated on the basis of individual data, that is, all the parameters were first calculated for every subject, then mean scores were obtained. However, in the comparative study, these parameters were more often calculated at group level by pooling together all the data of individuals of one group. As a comparison with previous results, several group-determined parameters were also calculated in this study.

Figure 3.1 shows two calibration curves drawn on the basis of the data from the two cultural groups. The gap between the two curves of the Chinese and British groups illustrates the same cultural differences in calibration as those revealed in above analysis of individual subjects. That is, the British students as a whole made better calibrated probability judgments than did their Chinese counterparts. Several group-determined parameters also supported above analysis. The calibration measure for the British group as a whole was 0.0223, whereas with the Chinese group it reached 0.0414. The H measure for the British group was also higher than the Chinese group (2.52 for the British and 2.07 for the Chinese). The discrimination of probability judgments measured by resolution score for the Chinese group was found better than their British counterpart. The resolution score of the Chinese group was 0.0140, which was slightly higher than that of the British group, 0.0127. This result was similar to that of Yates et al. (1989), although the resolution score for the Chinese group in this study was not as good as theirs (0.0205). The higher resolution score of the Chinese group meant, as Yates et al. (1989) argued, that the Chinese people had better capability in discriminating between right and wrong alternatives. However, this difference was not corroborated by the analysis of individual subjects which was completed earlier, since there the students of the two groups had almost the same mean resolution scores. It should be emphasized here that both the two Chinese student groups in the study of Yates et al. and the present one showed the same patterns in making probability judgments. Their group-determined calibration curves are similar and the distributions of their probability judgments are also almost the same. These results also confirmed earlier findings of Phillips and Wright in the English and the Hong Kong Chinese students, although there are slight differences between the two Chinese groups in calibration of probability judgments.

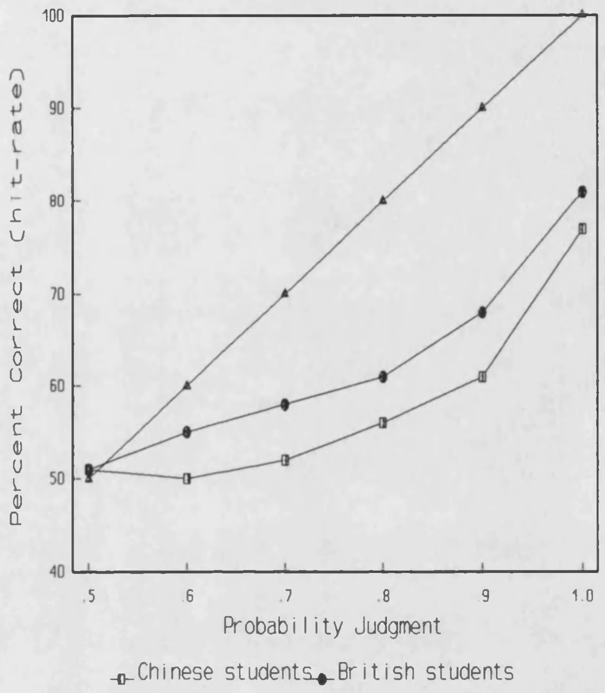

Figure 3.1. Calibration curves: British and Chinese students

ANOVA tests were performed for all the measures of the VUQ and the PAQ to see if the sex of the subjects had a more significant effect on probabilistic thinking than their cultural background. However, the results presented in Table 3.3 showed that the sex of the subject was not significant for most of the measures derived from the VUQ and the PAQ. The sex of the subject was found to have a significant effect only on the number of yes/no responses, the number of probability word responses, and the number of 50% judgment given. However, even for all three of these measures, the effect of sex was apparently less significant than that of culture. In comparison with sex, culture achieved a much higher F value and reached a higher significance level. Also, for all the measures, the interaction effect of culture and sex was not statistically significant. Therefore it suggests that the differences found in this study should be mainly explained as the effect

Table 3.3. Effect of culture and sex on probabilistic thinking

	Culture Effect	Sex Effect	Interaction
VUQ			
1.Number of Yes/No responses			
F	33.99^{**}	7.72^{**}	N.S.
2.Number of Don't know responses			
F	N.S	N.S.	N.S.
3.Number of probability word responses			
F	21.19^{**}	8.50^{**}	N.S.
4.Number of different probability word responses			
F	52.47^{**}	N.S.	N.S.
PAQ			
1.Number of 50% judgments given			
F	11.61^{**}	4.75^{*}	N.S.
2.Percentage correct for any 50% judgments given			
F	N.S	N.S.	N.S.
3.Number of 100% judgments given			
F	135.17^{**}	N.S.	N.S.
4.Percentage correct for any 100% judgments given			
F	4.4^{*}	N.S.	N.S.
5.Entropy H			
F	38.77^{**}	N.S.	N.S.
6.Calibration			
F	19.11^{**}	N.S.	N.S.
7.Resolutions			
F	N.S.	N.S.	N.S.

Two-tailed significance * $p<0.05$ ** $p<0.01$

of culture. In other words, they are mainly the differences between different cultural groups of people, but not the differences between male and female groups. As expected, there was no interaction effect between culture and sex.

To examine if the verbal and numerical response processes are related, I looked at intercorrelations between the two sets of the measures which were respectively derived from the VUQ and the PAQ. From the correlation matrix given in Table 3.4, we can see that the number of yes/no responses for the VUQ were associated with more frequent use of the probability of 100% and less use of different probabilities for the PAQ. Correspondingly, the number of probability word responses, and particularly the number of different probability word responses, were associated with less use of the probability of 100% and more use of different probabilities. These results are inconsistent with the previous study of Phillips and Wright (1977), as they found no correlations between the two sets of measures. However, neither study found any correlations between the number of "don't know" responses and any measure for the PAQ.

The correlations between the VUQ and the PAQ seems to suggest that people have a consistent habitual way of dealing with uncertainty, no matter if it concerns future events or not. It is also consistent with the early analysis about the results of the VUQ which showed that, excluding for the present-oriented, questions about facts have no evident effect on the subjects' verbal responses to uncertain events. Wright and Wisudha (1982) have found that people improved the calibration of their probability judgments in responding to then-future events. It is not clear whether better correlations could be found between future-oriented VUQ and future-oriented PAQ, and so further study is needed.

The same procedure of analysis was also separately performed for the data of the two cultural groups. Similar interrelations between the two sets of measures of the VUQ and the PAQ were revealed in both the Chinese and British groups. Although some of them were not statistically significant, they were consistent with the above results, at least in the directions of correlation.

Table 3.4. Correlations between VUQ and PAQ.

	VUQ			
	1	2	3	4
PAQ				
1	-.1079	-.0408	.1202	-.0704
2	-.0010	-.0673	.0341	.0284
3	.3729**	-.0644	-.3152**	-.4072**
4	-.1020	-.0161	.0837	.1798
5	-.2799**	.0651	.2516**	.3099**
6	.1225	.0079	-.0952	-.2208*
7	-.0530	-.0903	.0952	.1282

Two-tailed significance * $t < 0.01$ ** $t < 0.001$

To verify the first hypothesis that cognitive type or information-processing style is related to probabilistic thinking, the correlation analysis between the continuous scores of cognitive type and the measures for the VUQ and the PAQ was carried out. Several moderate correlations can be found in the correlation matrix presented in Table 3.5. For the measures of the VUQ, the SN score shows a negative correlation with the number of yes/no responses and positive correlations with both the number of probability word responses and the number of different probability word responses. For the measures of the PAQ, SN has a negative correlation with the number of 100% judgments and a positive correlation with the measure of the entropy H. Similarly, the JP score exhibits a positive correlation with the number of different probability word responses in the measure of the VUQ and a negative correlation with the number of 100% probability judgments in the measure of the PAQ. Surprisingly, no significant correlations were found between the TF scores and the two sets of measures for probabilistic thinking. As expected, the EI scores were not correlated with any measure of probabilistic thinking.

Table 3.5. Correlations between cognitive types and VUQ and PAQ

	MBTI			
	EI	SN	TF	JP
VUQ				
1	.0902	-.2612**	-.0289	-.1002
2	-.0405	.0319	.0609	.0670
3	-.0777	.2126*	-.0071	.0316
4	-.0130	.3543**	.0852	.2219*
PAQ				
1	-.0097	.0550	.0128	.0552
2	-.0874	-.0010	-.1233	-.0611
3	-.1068	-.3417**	-.1185	-.2956**
4	.0770	.0876	.0426	.0927
5	.0803	.2220*	.1206	.1553
6	-.0361	-.1634	-.0891	-.1724
7	.1218	-.0707	-.0127	-.0876

Two-tailed significance: * $t < 0.01$ ** $t < 0.001$

These results suggest that the differences in probabilistic thinking which were exposed between the subjects in this experiment are in some way associated with their preferences in information perception and decision making. The preferences for the way of information-perception have a major influence on probabilistic thinking. The subjects who preferred intuitive perception and perceptive attitude were more likely to make fine differentiation in face of uncertainty. They tended to employ a wider vocabulary of probability in the verbal responses and to use a range of probabilities in the numerical expressions. In contrast, the subjects who preferred sensing perception and judging attitude were more likely to make clear-cut discrimination to eliminate their feelings of uncertainty. They tended to offer unambiguous answers in the verbal responses and to focus on extreme probability judgments in the numerical expressions. The tests also suggest that the subjects' preference in information perception were more closely related to their performance in facing probabilistic tasks as the SN score was more systematically correlated to the measures of probabilistic thinking than the JP score.

Because normally classification of the type of subject is considered by Myers-Briggs to be more important than their continuous scale, the measures of probabilistic thinking were also calculated for individual cognitive types. Table 3.6 gives the means and standard deviations by grouping the S, N, J, and P subjects. It shows that there are noticeable differences between the S and the N subjects or between the J and the P subjects. They are consistent with the previous results of correlation analysis using continuous scores. Furthermore, the differences between the S and N subjects in the H and calibration measures are also statistically significant (at least, $p < 0.05$), as well as those included in the previous correlation analysis.

By combining differences in information perception (S and N) and the use of perception or judgment (P and J), four cognitive types can be partitioned: SJ, SP, NJ, and NP. From previous results, it is reasonable to expect the SJ and NP subjects to have greater differences in probabilistic thinking, and this was confirmed by further analysis. Table 3.7 gives the means and deviations by the four cognitive types. For the VUQ, the greatest difference in the number of different probability words was found between SJ and NP types. The SJ subjects on average used only 1.75 different probability words, much less than did the NP subjects (3.17). Similarly, for the PAQ, SJ and NP had the greatest differences in all the measures except the percentage correct for any 50% judgments given. In comparison with NP subjects, SJ subjects on average made more extreme probability judgments and used less different probabilities and had a better ability to discriminate both the wrong and correct occasions. The probability judgments of NP subjects were better calibrated and less extreme. It is easily seen that these differences are more significant in the corresponding measures than those given in Table 3.6 between S and N types, or between J and P.

Table 3.6. Results by cognitive types: S and N, J and P.

	S (N=79)	N (N=116)	J (N=105)	P (N=90)
VUQ				
1.Number of Yes/No responses				
Mean	13.47	11.59*	12.88	11.74
Std.Dev.	5.15	5.34	5.53	5.04
2.Number of Don't know responses				
Mean	1.10	0.99	0.88	1.22
Std.Dev.	1.64	1.62	1.49	1.76
3.Number of probability word responses				
Mean	5.18	6.84*	6.03	6.33
Std.Dev.	4.77	4.86	5.08	4.67
4.Number of different probability word responses				
Mean	1.82	2.88**	2.13	2.82*
Std.Dev.	1.55	2.02	1.79	1.99
PAQ				
1.Number of 50% judgments given				
Mean	14.62	16.38	14.58	16.93
Std.Dev.	9.79	11.16	10.84	10.31
2.Percentage correct for any 50% judgment given				
Mean	0.49	0.50	0.50	0.49
Std.Dev.	0.18	0.18	0.20	0.16
3.Number of 100% judgments given				
Mean	33.05	23.62**	31.19	23.07**
Std.Dev.	17.18	15.09	16.91	15.15
4.Percentage correct for any 100% judgments given				
Mean	0.79	0.81	0.80	0.81
Std.Dev.	0.10	0.13	0.11	0.13
5.Entropy H				
Mean	1.88	2.06*	1.93	2.05
Std.Dev.	0.55	0.53	0.57	0.50
6.Calibration				
Mean	0.056	0.044*	0.053	0.047
Std.Dev.	0.033	0.031	0.032	0.033
7.Resolution				
Mean	0.0284	0.0262	0.0287	0.0252
Std.Dev.	0.0175	0.0165	0.0186	0.0145

** $p<.01$ * $p<.05$ otherwise, non significant

Table 3.7. Results by cognitive types: SJ, SP, NJ, and NP.

	Cognitive type			
	SJ (N=53)	SP (N=26)	NJ (N=52)	NP (N=64)
VUQ				
1.Number of Yes/No responses				
Mean	13.36	13.69	12.38	10.95
Std.Dev.	5.63	4.09	5.44	5.21
2.Number of Don't know responses				
Mean	0.81	1.69	0.94	1.03
Std.Dev.	1.53	1.72	1.45	1.75
3.Number of probability word responses				
Mean	5.75	4.00	6.31	7.28
Std.Dev.	5.33	3.11	4.83	4.87
4.Number of different probability word				
Mean	1.75	1.96	2.52	3.17
Std.Dev.	1.59	1.48	1.90	2.07
PAQ				
1.Number of 50% judgments given				
Mean	13.66	16.58	15.52	17.08
Std.Dev.	9.60	10.06	11.99	10.48
2.Percentage correct for any 50% judgments given				
Mean	0.50	0.48	0.51	0.50
Std.Dev.	0.18	0.19	0.21	0.15
3.Number of 100% judgments given				
Mean	35.94	27.15	26.35	21.41
Std.Dev.	17.31	15.61	15.17	14.77
4.Percentage correct for any 100% judgment given				
Mean	0.79	0.80	0.81	0.82
Std.Dev.	0.10	0.11	0.13	0.13
5.Entropy H				
Mean	1.80	2.03	2.05	2.06
Std.Dev.	0.61	0.33	0.51	0.55
6.Calibration				
Mean	0.060	0.048	0.046	0.043
Std.Dev.	0.032	0.033	0.029	0.033
7.Resolution				
Mean	0.0291	0.0270	0.0283	0.0244
Std.Dev.	0.0189	0.0144	0.0186	0.0146

Therefore, the first hypothesis has been confirmed by both the descriptive statistics along cognitive styles and correlations between the continuous scores of cognitive style and the measures of probabilistic thinking. People's probabilistic thinking is partly affected by their way of perceiving information and reaching a judgment.

Sensation perception and intuition perception, and judgmental attitude and perceptive attitude seem to push people in opposite ways of making probability judgments. However, the dimension of information evaluation was found to have no significant effect on probabilistic thinking. Perhaps, a preference for a logical, rational, and quantitative way of decision making does not definitely lead to calibrated probability judgments, and similarly a preference for making judgments more on the basis of personal value does not assuredly result in extreme probability judgments.

The same procedure of analysis was also performed for each cultural group. Similar patterns were found in both of the Chinese and the British groups. In the correlation analysis, similarities emerged between cognitive type and the measures of probabilistic thinking in the British group. However, with the Chinese group, the coefficients for the SN score and the three measures of the VUQ were nearly zero. The results of cognitive type analysis also showed the same differences between the S and the N subjects and between the J and the P subjects. Similarly, in the Chinese group, no significant differences were found between the S and the N subjects or between the J and the P subjects in responding to the VUQ. Perhaps it is because the PAQ more easily inspired the Chinese students of particular cognitive types to differentiate uncertainty as it suggested a probabilistic space by asking them to give a probability between 50% to 100%, but there was no such suggestion in the VUQ.

The second hypothesis predicted that the Chinese and the British subjects would show different preferences in the way of perceiving information and making judgments. Table 3.8 gives the means and deviations of continuous scores for all the MBTI scales. Two significant differences in SN and JP scales were found between the Chinese and the British students. The Chinese students on average obtained much lower SN and JP scores than did the British students. The statistics of cognitive type show that sensation type (53) were dominant in the Chinese group, while intuition type (74) were dominant in the

Table 3.8. Comparisons on MBTI.

Continuous score of		Sample: Chinese Students (N=95)	British Students (N=100)	t
EI				
	Mean	102.54	103.16	N.S.
	Std.Dev.	17.05	22.97	
		(E:40 I:55)	(E:43 I:57)	
SN				
	Mean	95.93	115.54	-7.01**
	Std.Dev.	17.63	21.34	
		(S:53 N:42)	(S:26 N:74)	
TF				
	Mean	88.29	92.16	N.S.
	Std.Dev.	19.71	20.15	
		(T:65 F:30)	(T:64 F:36)	
JP				
	Mean	88.37	110.64	-6.42**
	Std.Dev.	22.43	26.00	
		(J:68 P:27)	(J:37 P:63)	

Two-tailed significance ** $p < 0.001$

British group. Also much more judgment type students were found to be Chinese and much more perceptive type students were found to be British. However, no significant difference was found between the two cultural groups in the TF scores. It is a surprise, because the observations of many scholars about the Eastern and Western cultures have consistently predicted that Chinese are more socially oriented than Westerners. It is not clear whether it is due to the fact that all the Chinese subjects were university students and following the recent "open-door" policy of Chinese government, had become more westernized than general Chinese populations.

These results partly confirmed the second hypothesis that Chinese and British people do not follow the same way of comprehending reality and making judgments or decisions. In their self-report, the Chinese students expressed a strong tendency of sensation in perceiving information and tended to take judgmental attitudes in dealing with the external world. In contrast, the British students' perception was more intuitive and they were inclined to a perceptive attitude.

To see whether cognitive type has a significant effect on probabilistic thinking in comparison with culture, an analysis of variance would be helpful. Unfortunately, in this experiment, the distribution of types was so uneven that it became difficult to use this analysis technique properly, as balanced design was needed. In the Chinese group, 42 students were found as SJ types, but only 11 as SP types. In the British group, there were 48 NP types, but only 11 SJ types.

Even so, considering the connections between cognitive type and probabilistic thinking which were shown previously, the results of descriptive statistics given in Table 3.8 still present explicit evidence to support the third hypothesis. We have found that SN and JP continuous scores were correlated with some measures of probabilistic thinking and there were significant differences in some measures of probabilistic thinking between the SJ and NP types. So, the marked differences revealed by the MBTI between the Chinese and the British students implied that the cultural differences between the two cultural groups in probabilistic thinking should be partly accounted for by their basic differences in the way of perceiving reality and dealing with the outer world. The extremeness orientation of the Chinese subjects in probabilistic thinking could be related to their preference for sensation perception and judgmental attitude, and the calibration orientation of the British subjects could be partly explained as they preferred intuitive perception and perceptive attitude. So, the third hypothesis is roughly established too.

3.3. Discussion and conclusion

This study, in larger student samples, has further confirmed the previous findings that there are regular cultural differences between the Chinese and the British. In facing uncertain situations, the Chinese wished to make clear-cut judgments, whereas the British people were inclined to keep their feelings of uncertainty and were able to make fine differentiations. In verbal responses, "yes" or "no" answers were more likely to come from the Chinese, whereas answers such as "possibly or probably" were more likely to come from the British. In numerical responses, extreme probabilities such as 100% were more attractive to the Chinese, whereas the probabilities between the two extremes were more appealing to the British. The sharp contrast between the extremeness orientation and calibration orientation leads us to conjecture that the Chinese and the British may follow different ways to reduce and to deal with uncertainty.

Certain relationships between the measures of the VUQ and the PAQ were also found in this study. The unambiguous answer, such as "yes or no" was related to the application of extreme probability judgment. The subjects who tended to utilize the vocabulary of probability in responding to the VUQ were more likely to assign different probabilities to describe their feelings of uncertainty in reacting to the questions of the PAQ. The connections between the verbal and numerical responses seems to suggest that the VUQ and the PAQ stimulated similar cognitive process and consistently revealed the differences in probabilistic thinking.

In the present study, it was also found that there were significant differences between certain cognitive types in performing the two probabilistic tasks. Therefore, a preliminary conclusion could be derived from the finding of the linkage between cognitive type and probabilistic thinking, that is, people's preferences in information perception and decision making may affect their cognitive process stimulated by the VUQ and the PAQ. According to the explanation of psychological type theory, persons oriented toward sensing perception may tend to focus on immediate experience and often develop characteristics associated with this awareness, such as enjoying the present moment, realism, acute powers of observation, memory for details, and practicality. In contrast, persons oriented toward intuitive perception may become so intent on pursuing possibilities that they may overlook actualities. They may develop the characteristics that can follow from emphasis on intuition and become imaginative, theoretical, abstract, future oriented, or creative. For this study, it suggests that the process of making probability judgments may have been affected by cognitive style in several ways. For example, in searching for knowledge from memory, the subjects who preferred sensing perception may more often overestimate the exactness of their memory, which leads to extreme probability judgments. Overconfidence in exactness of memory actually has been identified as a bias of causing "certainty illusion" (Fischhoff, Slovic, & Lichtenstein, 1977). Whereas the subjects who preferred intuition perception more possibly imagine a probabilistic set and avoid focusing on extreme judgments (Phillips & Wright, 1977). Similarly, the subjects who were attuned to a judgmental attitude offered more extreme probability judgments, probably as their perception tended to be shut off as soon as they thought that they knew enough to make a judgment. Whereas, the subjects who attuned to perceptive attitude made better calibrated judgments probably because their mind tended to be open to more possibilities and were more cautious and did not like to take a chance.

The results of MBTI showed significant differences between the Chinese and British peoples in information perception and decision making, as SJ types were found to be dominant in the Chinese students, whereas NP types were found to be dominant in the British. SJ people have been described as realistic decision makers: they tend to solve problems by reliance on past experiences and to dislike ambiguity (Myers & McCaulley, 1985). In comparison with SJ people, NP people tend to focus more on possibilities for the future and are unconventional, independent spirits. In fact, many behaviourial differences between SJ and NP people described here have been argued as cultural differences between Chinese and Western people for a long time by a number of scholars in the comparison study of anthropology, philosophy and psychology. To illuminate this, a few recent studies are given here. Liu (1986) has observed that Chinese children have developed more skills for memorizing than Western children, as Western children lack the opportunity which Chinese children have to practise memorizing skills in their early childhood. Also, Chen et al. (1982) found that students attending Chinese universities and high schools did not give high difficulty ratings to the memory items selected from several intelligence tests as did their Australian counterparts. They also speculated that the difference was attributed to possible cultural differences in nurturing and providing opportunities to practice the different skills. It has also been argued that the traditional Chinese way of thinking tended to consider and solve problems from one dimension and to seek consistency and unity (Zhang & Wang, 1988). So, if the Chinese people were more sure about their memory of knowledge, they may also be more overconfident about the correctness of their choices, and hence gave higher probabilities.

And if they disliked ambiguity, they may try to make clear-cut distinctions between possible and impossible or totally certain or totally uncertain. If they preferred to concentrate on a particular decision problem, a probability may not be very meaningful for them. Similarly, as the British tended to seek possibilities, they may easily imagine a probabilistic set in their mind before making probability judgments. They were also more likely to appreciate probability theory as it may be valuable in the sense of dealing with a series of decision problems.

In consequence, the cultural differences between the Chinese and the British people in probabilistic thinking could be partly explained by the fact that Chinese and Western cultures cultivate different probability paradigms in the practice of dealing with uncertainty. This study of cognitive style reveals that there are many cultural factors which have roles to play as they can somehow influence the development of probability paradigms, and cultural differences in probabilistic thinking should not be simply explained as single factors, such as fatalism or others. Howard (1988) recently emphasizes the usefulness of decision analysis and contends, "Accepting decision analysis requires a brief in the value of systematic, logical thought as a basis for decision making. This cognitive style will not be natural to people who prefer to be guided primarily by feelings rather than thought. Research based on the Myers-Briggs Type Indicator shows how people differ in the way they like to perceive and the way they like to judge. Decision analysts should realize that not everyone sees the world as they do. They should appreciate the special insights they provide that can eliminate the 'blind-spot' of those who rely mainly on feelings." This study may have presented a more complicated picture through a cultural comparison, as it reveals more aspects of cognitive style which lead the people raised from other non-Western cultures to deal with uncertainty differently and thus may reject the validity of some Western techniques, such as decision analysis.

In order to make comparisons with previous studies, this study continues to use the general knowledge questionnaire. Thus, it should be emphasized that we must be cautious about the generalization of the conclusions of this study. Future study should make further investigations in other uncertain situations with less artificial instruments.

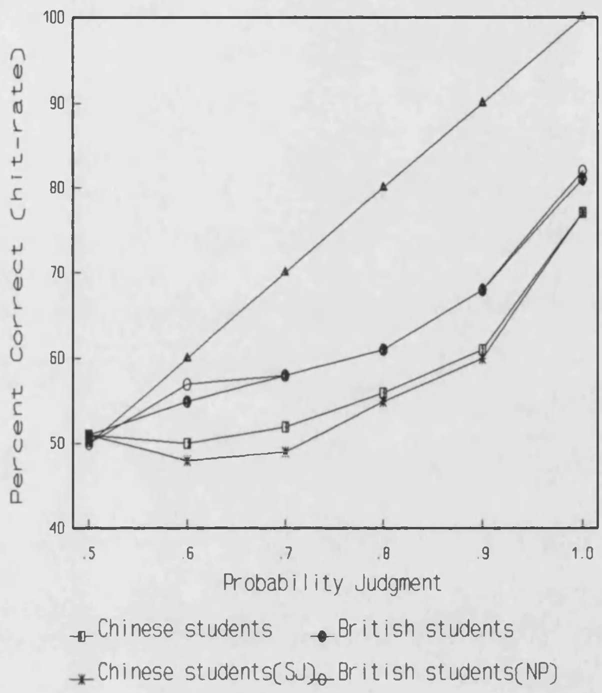

Figure 3.2. Calibration curves: integrated effect of culture and cognitive type

In addition, this study does not suggest that cognitive style is the only factor which is related to probabilistic thinking. In fact, the differences between the groups of cognitive type are not more than those found between cultural groups, which implies that there are other factors that should be considered in future study, such as the type of uncertain situations and the degree of uncertainty. Nevertheless, it could still be expected that the cultural differences in probabilistic thinking can be highlighted by making a comparison between certain cognitive types from different cultures. I end this chapter with Figure 3.2 which clearly shows the effect of the style of information-processing by the widened gap between the two group-determined calibration curves of the Chinese SJ subjects and the British NP subjects. The group determined calibration curve of the Chinese SJ students apparently became lower and the curve of the British NP students became slightly higher. Moveover, group determined parameters for the Chinese SJ students exhibited conspicuous changes in expected directions. Their calibration score rose to 0.0462, which indicated the decrease of hit-rate of probability judgments. The resolution score rose to 0.0154, which meant the improvement of discrimination of probability judgments.

Chapter 4. Cultural differences: A general phenomenon?

4.1. Introduction

In the study reported in chapter 3, the cultural differences in probabilistic thinking between Chinese and British students have been further confirmed. By relating them to the basic differences in the habitual ways in which people perceive information and make judgments or decisions, the present work also makes these findings more convincing and easily understood. These results, consistent with many other experiments, leave little place to question the reliability of the findings that Chinese people display more self-confidence than British and Americans in their judgments under the uncertainty created by a general knowledge questionnaire, and that Chinese people tend to make a clear-cut discrimination between certainty and uncertainty, between true and false, and between possible and impossible. This sharply contrasts with British and Americans who prefer fine differentiation about uncertainty. However, even so it is still too early to say such findings have completely revealed the cultural differences between Chinese and Western people in probabilistic thinking. It may have already been noticed that this study has not made any attempt to draw general conclusions from the present findings. Actually, I have emphasized many times that these differences should not be regarded as general phenomena before more extensive investigations have been undertaken. Similar or different patterns of cultural differences may emerge in other uncertain situations or among specific groups of people, such as experts in a field. This chapter will discuss further some of the issues about the generalization of findings of cultural differences in probabilistic thinking, and will make careful investigations through two experiments. The relationships between probabilistic thinking and decision making behaviour remain unclear, and no direct evidence until now has been provided in previous cross-cultural studies. This chapter will also try to examine such linkages (if any exist) with the hope that they can lead us to discover how people's probabilistic thinking influences their decision making behaviour and why in different cultures people make decisions differently, which is a major concern of this study.

Although people may be born with different abilities for dealing with uncertainty, they mainly develop their probabilistic thinking through learning from experiences and interacting with the environments in which they are situated during their lives. Various experiences and environments may cultivate diverse ways of dealing with uncertainties. It is also true within an individual culture. In the West, it has already been exhibited that even for homogeneous groups of people, performances may vary substantially under different uncertain situations and some groups of people may be more capable of making probability judgments about a specific task than others. For example, weather forecasters, the champions in making calibrated probability judgments, showed the same overconfidence in responding to a general knowledge questionnaire as did other groups (Keren & Varey, 1984). Students who were often overconfident in their judgments when answering general knowledge questions could present calibrated probabilities for then-future events, like the possible outcomes of President Nixon's much-publicized trips to China and Russia (Fischhoff & Beyth, 1975). It was also found that the same groups of people were overconfident in performing an intellectual task and were underconfident in performing some perceptual tasks, such as judging the areas of circles and squares (Dawes, 1980). Calibrated probability judgments were found more among experts in specific fields (e.g. Balthasar, Boschi, & Menke, 1978; Kabus, 1976; Vertinsky, Kanetkar, Vertinsky, & Wilson, 1986; Keren, 1987; Tomassini, Solomon, Romney, & Krogstad, 1982). Certain elicitation techniques may yield better calibration than others; being asked to present probability distributions of uncertain quantities, people could give better calibrated judgments with a "probability method" than with a "fractile method" (Seaver, von Winterfeldt, & Edwards, 1978).

These examples reveal that people cannot be expected to perform consistently well in making probability judgments, when they are faced with different uncertain situations. Different probabilistic tasks may stimulate quite different uncertain feelings and evoke different cognitive processes. People also cannot be expected to perform well when the content of a task is far beyond the reach of their knowledge. Previous studies also suggest several factors which should be considered in a future cross-cultural study of probabilistic thinking. First, the performances of different cultural groups should be further investigated in uncertain situations other than those created by general knowledge questionnaires. Second, the level of knowledge or expertise of people must be considered as a factor which can influence probability judgments. The judgments of Chinese experts in a specific field should be compared with their Western counterparts. In addition, elicitation techniques should be as impartial as possible for all the cultural groups concerned.

The present study, for the reason I have argued before, will investigate the quality of the probability judgments made only by subjects who are capable of dealing with the probabilistic task given by an experimenter, and elicited only with proper techniques, so task characteristics become the major concern of this study. In order to explain my design and choice of experimental tasks, first I must discuss the issue of task taxonomy.

Multi-task experiments

For different purposes, a number of studies have utilized a variety of probabilistic tasks among the subjects. Adams and Adams (1961), for example, asked their subjects to perform several tasks in a period of five days to determine whether transfer of training might occur. These tasks included making decisions about the percentage of blue dots in a set of blue and red dots and the percentage of total length a blue line is of a blue and red line, deciding on the truth or falsity of general statements, lifting weights while blind-folded, and deciding upon the original position of the weight in the series, and making decisions as to the synonymity, anonymity, or unrelatedness of word pairs. To investigate the impact of knowledge of subjects on their accuracy of probability judgments, Lichtenstein and Fischhoff (1977) have designed a series of probabilistic tasks. They required subjects to choose between two alternative answers of general knowledge questions; to decide whether certain paintings were the work of Asian or European children; to estimate the closing prices of stocks; and to judge whether certain Latin phrases were handwritten by European or by American adults. In these experiments, several characteristics of tasks, along with the characteristics of subjects, have been tested as the factors which may affect probabilistic thinking. The effect of the degree of difficulty of tasks, which is to some extent related to the degree of uncertainty, has also been considered.

However, most previous studies show no attempt to test the characteristics of tasks through classifying uncertain situations. Perhaps this is because experimenters were influenced by the Bayesian view that all the uncertainties reflect mental states, and thus they ignored the impact of differences between uncertain situations on probabilistic thinking. As in many previous studies there is no operational taxonomy of uncertainty, factors were often confounded and when some factors were controlled by experimenters some other factors sometimes were neglected.

Distinction between GKQ and others

Several scholars have made attempts to distinguish the general knowledge questionnaire from other instruments, depending on different characteristics of the tasks at hand. Wagenaar and Keren (1985), for example, have analyzed the differences between almanac-type and meteorology-type questions. They argue that the probability judgments made by subjects for the almanac-type questions and for the meteorology-type questions are not the same thing. A probability judgment made in answering an almanac-type question, like "is absinthe (a) a precious stone; (b) a liqueur?", in fact, expresses the confidence of a subject about whether he has chosen the correct answer. However, a judgment of the probability of rain is about the uncertainty which resides in the probabilistic nature of meteorological models. When a meteorologist assesses a probability of 70% of rain, he means that tomorrow belongs to a class of days about which nobody knows more than that it will rain in 70% of the cases. Such a probability thereby is not a confidence rating about a judgment. Wagenaar and Keren suggest that a meteorologist could probably express how confident he is that tomorrow belongs to that class by assessing a second-order probability. They argue that it is reasonable to say "There is a 70% chance of rain tomorrow, I am 100% certain of it", but people can never say that "In outside world absinthe is 30% precious stone, and 70% liqueur." Wagenaar and Keren consider that the confidence rating is more like the second-order probability in the rain prediction because the uncertainty is only in the heads of the respondents. They believe that if overconfidence is caused by some reluctance to admit a lack of knowledge, subjects would become less overconfident when responding to meteorology-type questions, as for such questions the probabilities reflect lack of system in the available information, not a lack of personal knowledge.

The distinction between the two types of questions, by Wagenaar and Keren, actually are closely related to a more general distinction between internal and external uncertainties, which will be discussed soon. However, one point needs to be added here. In the argument of Wagenaar and Keren, a probability judgment made for an almanac-type question is interpreted as a confidence judgment, but I cannot see any reason why a probability of 70% which a subject has assessed for a judgment (choosing an alternative answer) may not mean that the judgment belongs to a class of judgments which he may make or has made wrong for around 30% of the cases in similar situations. In fact, such understanding is just what experimenters normally expect from subjects, when they use general knowledge questionnaires. The problem is that most subjects probably may not perceive the experiment in such a way. If they do, overconfidence may reduce. Indeed, Gigerenzer, Hoffrage, and Kleinbolting (in press) found that overconfidence disappeared in 80% to 90% of the subjects, when they also asked the subjects to estimate the frequencies of correct answers which they have chosen after answering every 50, for example, questions.

Keren (1987) later also proposes to distinguish between different types of calibration tasks based on whether the items are related or not. Keren's concept of relatedness is certainly a subjective one. It is defined according to the extent to which the subjects' mental processes are similar when they react to a series of items. In some situations, it is easy to determine the relatedness of a group of items, as similar cognitive processes are clearly involved in responding to them. For example, weather forecasts obviously form related items. In forecasting rain, a meteorologist quite possibly goes through almost the same cognitive processes in making the probability judgments. Present weather condition described by barometer readings, wind directions, satellite pictures, etc. are considered, previous judgments made in similar situations may also be recalled, and somehow, a probability of 70% that it will rain tomorrow is finally decided. Even though we are not able to describe very clearly the cognitive processes which a meteorologist may go through in making weather forecasts, there seem to be few possibilities that the cognitive processes can become very different from case to case.

The general knowledge questions, in contrast, are apparently unrelated, in the sense that they do not stimulate similar cognitive processes. Keren argues that in answering the questions like "What is the population of Peru?", "What is the capital of Nepal?" or "What is the longest river in the world?", the subjects' knowledge of one item is independent of their knowledge of another item, and no information (knowledge) can be inferred from one item and transferred to another. For unrelated items, people cannot use their knowledge about the occurrence (or nonoccurrence) of some items for assessing the probability of other items in the same set. Keren believes that well calibrated probability judgments are more likely to be achieved for related items. It is argued that with related items, groups, like meteorologists, can benefit from their previous experience, as learning may take place. However, with unrelated items, good probability judgments become less likely, as each item may require different cognitive processes and so feedback is ineffective in calibrating those processes, unlike related items, for which there are grounds to develop inferential processes that would lead to probabilistic notions in terms of relative frequency and long-run considerations. Keren considers that such conditions are necessary (though not sufficient) for subjects to be well calibrated.

Most importantly, with this distinction of tasks Keren has revealed how the relationships between items can influence the formation and adjustment of cognitive processes in making probability judgments. The concept of relatedness of items also seems to be more strict than some previous ones, such as homogenous or repetitive items. When Keren speaks of the relatedness of items, he probably means that they are diagnostically related, that is, he does not mean that there may necessarily be some cause-effect relationships between the items. Of course, they could be causally related, or even independent. The interpretation of subjective probability, in essence, concerns only individual occasions, not a sequence of outcomes. However, in calibration study the human ability of making probability judgments is often tested with a group of experimental items which are not necessarily associated to a same uncertain event, although they could be perceived by a subject as strictly or loosely related in some way. In contrast, the objective interpretation of probability is based on a series of outcomes of an uncertain event. Within the concept of objective probability, probability is defined on the basis of a sequence of outcomes of an uncertain event, which are often viewed as independent. For example, Mises (1964) has used the term "collective" to describe a sequence of outcomes obtained from a particular experiment which can be repeated indefinitely often. A collective contains all the possible outcomes and the occurrence of every outcome in the collective is independent from the others. Keren's unrelatedness between items may be seen as subjectively independent and could be more broadly used to describe a kind of relationship between a group of quite different items.

Cross-cultural study

Only two cross-cultural studies are found to have utilized more than one probabilistic task, which compared the probabilistic judgments of the Asian and Western cultural groups when they responded to the questionnaires of general knowledge and then-future events. Wright and Wisudha (1982) asked Indonesian and the British students to assess probabilities about both general knowledge questions and then-future events, such as "When will the Cengkareng airport be operational? (a) before the end of 1978, (b) after the end of 1978" for the Indonesian students. The British students were asked equivalent but different questions. They found that both the two groups made quite different probability judgments in responding to general knowledge questions and then-future events. For the then-future events, the calibration curve of the British group changed from being overconfident to underconfident, with the exception of the 100% probability judgments. The calibration curve of the Indonesians made a similar upward movement too, although in most of the cases it was still overconfident. The experimenters concluded that the results of studies of probability judgment that have utilized general knowledge questions may not be generalised to most real-world decision making where uncertainty is located in the future. However, it is very interesting that even for the then-future events the gap between the two calibration curves of the Indonesian and the British students did not disappear. That is, the Indonesian students, in comparison with their British counterparts, were still more confident about their judgments and gave more probability judgments of extremeness. While the British students reduced their proportion of 100% probability judgments for the future-events to 21% from 29% for the general knowledge questions, the Indonesian students reduced the same proportion to 30% from 49%.

The authors have also cited two differences between these two tasks. First, they suppose that inferences are more clearly involved in predicting a future event than in answering a general knowledge question. The uncertainty is explicitly contained in the judgments about the likelihood of future events, because there are no answers available to either subject or experimenter. However, in responding to a general knowledge question, people may regard themselves as searching for the answer directly from memory without making any inference. Another difference, which the authors suppose, is that people may perceive uncertainty more explicitly when being required to predict a future event than when being asked to answer a general knowledge question. It is argued that although for a future event question, subjects are also given two alternative answers, they may be able to imagine several different scenarios of act and event sequences which could result in an outcome presented as an alternative answer. The recognition of equifinality, that different paths involving many different causal relationships could produce the same outcome, may lead people to have greater feelings of uncertainty, and thereby influence their subsequent probabilistic processing for future event questions. The authors emphasized that this tendency might be especially reinforced by the culture which has a positive social utility encouraging the expression of certainty in situations where there is known to be an answer, but viewing those who try to predict the future with total confidence as fools or clairvoyants.

The second study was undertaken by Yates et al. (1989), who observed similar phenomena among American and Chinese students. Using a fractile method, they elicited the distributions of probability for about 20 different quantities from their subjects. Half the items concerned quantities about future states, such as the minimum temperature recorded in a city a few days hence. For both cultural groups, the 2% surprise indices (the percentage of actual values which fall into the predicted value intervals with below 1% of probability or above 99%) became smaller in responding to the quantities about future states, indicating an improvement in making extreme probability judgments greater than 99% or less than 1%. However, for the American group, the index was reduced substantially, from 53.8% to 41.4%, whereas for the Chinese, the same index was reduced only from 59.8% to 53.2%. Clearly, even for the future items there was still a gap between the two 2% surprise indices of the Chinese and the American student groups. So, these experiments do not indicate the disappearance of cultural differences, in the sense that the Indonesian and the Chinese students still made more extreme probability judgments. However, they do suggest that the probability judgments of individual cultural groups may vary under different uncertain situations, and timing of uncertain events may be one of the factors which influences probability judgments. Therefore, cultural differences in probabilistic thinking require more systematic investigation.

Task taxonomy

Although several differences between probabilistic tasks, especially in comparison with general knowledge questions, have been discussed, classification schemes are still lacking in the studies of probabilistic thinking and in cross-cultural studies. Uncertainty is ubiquitous and varies dramatically in form and content. It is unnecessary, if not impossible, to investigate probabilistic thinking through exhausting all the cases. Proper categorization of uncertainties would be very helpful for this study, because we may be able to understand people's decision behaviour under uncertainty in general, with the investigations to a manageable size of categories of uncertainty. Although it is badly needed, with a few exceptions systematic classification of uncertainty has not drawn enough attention in the study of probabilistic thinking.

A theoretical distinction between uncertainties has been made by Kahneman and Tversky (1982) in discussing the variations of uncertainty, although their main concern is to analyze the linkage between the conceptions of probability advanced by different schools of thought. They distinguish internal from external attributions of uncertainty and sketch four modes of judgment that people may adopt in assessing uncertainty. The primary distinction they refer to are two loci to which uncertainty can be attributed: the external world or our state of knowledge. It is argued that we attribute to causal systems in the real world the uncertainty associated with the tossing of a coin, the drawing of a hand of cards from a pack, the outcome of a football game, and the behaviour of the St. Helens volcano. These causal systems have dispositions to produce different events, and we judge the probabilities of these events by assessing the relative strength of the competing dispositions. In contrast, such statements as, "I think Mont Blanc is the tallest mountain in Europe," or, "I hope I spelled her name correctly," reflect an uncertainty that is attributed to one's mind rather than to a mountain or a woman. The distinction between almanac-type and meteorology-type questions made by Wagenaar and Keren, as reviewed above, is obviously consistent with the distinction between internal uncertainty and external uncertainty. Almanac-type questions clearly fall into the category of internal uncertainty, and meteorology-type ones the category of external uncertainty.

Kahneman and Tversky also emphasized that the attribution of uncertainty about an event to dispositions or to ignorance depends, among other things, on timing. Uncertainty about past events is likely to be experienced as ignorance, especially if the truth is known to someone else, whereas uncertainty about the future is more naturally attributed to the dispositions of the relevant system. It has been noticed that people exhibit different attitudes to the outcome of a coin toss, depending on whether or not the coin has already been tossed. These arguments are supported by the findings in several experiments using future items, as seen before.

A more thorough classification of uncertainty perhaps was developed by Howell and Burnett (1978) in their proposal of a taxonomy of tasks used to measure cognitive uncertainty. Howell and Burnett point out that people depend on a variety of cognitive options in making uncertainty judgments, which include reliance on prior generator knowledge, use of stored event frequency records, simplification rules or heuristics, and systematic biases. They argue that the cognitive basis is heavily influenced by task characteristics. In their classification, Howell and Burnett propose several ways, with which uncertain events can be fundamentally distinguished according to their differences in three basic characteristics. They classify uncertain events into several categories depending on whether they are frequentistic or nonfrequentistic, whether they are generated from an unknown process or from a process with known stochastic properties, and whether the processes which their occurrence relies on are within or beyond the control of the observer.

Howell and Burnett first distinguish between frequentistic and nonfrequentistic uncertain events based on the characteristic of repetition. Frequentistic uncertain events are those which happen in a repetitive fashion. Many examples can be found among well-known laboratory and gambling tasks, like drawing colour balls from a bag, tossing a coin, throwing a dice, or playing some card games, which can be repeatedly performed. Nonfrequentistic uncertain events, according to Howell and Burnett, are those which are for all intents and purposes nonrepetitive and unique. A nuclear attack upon the United States, for example, should be categorized as a nonfrequentistic uncertain event, as it has neither a "track record" nor much promise of future repetition.

The main difference between frequentistic and nonfrequentistic uncertain events is that the repetition of frequentistic uncertain events allows the accumulation of historical data and may provide people with a normative basis for predicting the future under some conditions. When frequentistic events are generated from stochastic processes, for example, by following the "strong law of large numbers," it may be assumed that the relative frequency of an outcome calculated from the accumulated samples can be viewed as the approximate value of its probability with the expansion of samples. Such events could simply be produced by chance-based generators as we have illustrated above or could involve a measure of (asymptotic) skill.

Obviously, it could be argued that many more real uncertain events, such as the movement of stock market and the state of weather, are not generated from such well-known processes as cards or dice, although they have frequentistic nature. Howell and Burnett, then, make their second distinction depending on the knowledge which people may have about the generating processes of uncertain events. With the term "knowledge", they do not refer to accuracy, rather to people's belief in the generator process. It is quite possible that people may persist in their erroneous beliefs about generators. Indeed, Nicks (1959) has shown how gamblers can persist in erroneous beliefs about generators. It is also suggested that to think of known and unknown generators as end points on a continuum of belief strength can heavily affect people's processing of evidence (outcome data). Howell and Burnett argue that unknown generators may encourage people to focus their attention on the occurrence of each event or piece of diagnostic evidence, while known generators may discourage or bias such processing. Thus, the distinction of unknown and known would be meaningful for both internal and external generators, but it would not be appropriate to make such distinction for nonfrequentistic events.

The third distinction is made based on whether the processes are within or beyond the control of the assessors of probability. In many situations, people may believe that they are able to impose some kind of control on the outcome of uncertain events. For example, the performers of some so-called "skill" tasks may hold the belief that the possibilities of individual outcomes or level of performances are partly or even entirely under their own control. In facing such tasks, people's inference about generator characteristics are mainly dominated by their previous success-- failure experience (or historical data), that is how successful they have been in performing similar tasks until now. Howell and Burnett, thereby, consider that during the period of skill acquisition, "internally generated" events appear more comparable to those produced by unknown rather than by known external generators (see, for example, Brown & Bane, 1975). However, known external generators would become more appropriate for the situation, in which people may have already developed very stable beliefs in their own capability for highly practised skills where performance is at an asymptotic level.

Howell and Burnett further stressed that causality parameters, real and attributed, have not received sufficient attention in the literature of behaviourial decision theory in comparison with that of social psychology and personality theory (see, for example, Phares, 1976; Weiner, 1974). They believe that source of control should be treated as an important event characteristic in uncertainty judgment.

Following the classification of Howell and Burnett, eight possible kinds of uncertain events could be distinguished depending on the three characteristics: repetition,

Table 4.1. Taxonomy of uncertain events

Parameter	Frequentistic	Knowledge	I-E Causality
1.	Frequentistic	Known	External
2.	Frequentistic	Unknown	External
3.	Frequentistic	-	Internal
4.	Nonfrequentistic	-	External
5.	Nonfrequentistic	-	Internal

generator knowledge, and source of uncertainty. However, as discussed above, only five are plausible, which are summarized in Table 4.1.

In addition, Berkeley and Humphreys (1982) have also proposed a classification of uncertainty, but their concern is far beyond a classification of the uncertainty of task. This classification almost covers all the uncertainties in the processes of decision making, the uncertainties about the outcomes of events, about the decision makers, and even about the means of making decisions. They have described seven different types as follows.

(i) Uncertainty about the probabilities of outcomes of subsequent events, conditional on what has preceded them in the act-event sequence between immediate acts and consequences.

(ii) Uncertainty about the probabilities of subsequent events, conditional on the occurrence of other events extraneous to the sequences in (i).

(iii) Uncertainty about how to incorporate prior information (e.g. results of prior sampling, base rate in a reference population) in determining the probability of a subsequent event.

(iv) Uncertainty about how to conceptualize the worth of consequences: assessing a consequence's utility requires the generation of a single number describing its holistic (and entire) "moral value." When more than one criterion of worth is involved, uncertainty can arise about how to combine these criteria.

(v) Procedural Uncertainty, which Hogarth et al. (1980) describe as "Uncertainty concerning means to handle or process the decision." e.g. specifying relevant uncertainties, what information to seek, and where, how to invent alternatives and assess consequences, etc.

(vi) Uncertainty about how the decision maker (or the persons he or she is deciding for) himself or herself will feel, and wish to act having arrived at a subsequent act (choice point) after intervening events have unfolded "for real."

(vii) Uncertainty about the extent one possesses agency for inducing changes in the probabilities of subsequent events (conditional on acts yet to be taken, as in (i), above) through being able to alter relations between states of the world (Savage, 1954).

The choice of this study

The investigation of present study will not go as far as Berkeley and Humphreys have suggested, because the major concern here is the task characteristics. Howell and Burnett's classification of uncertain events thus provides more useful guidance for the design of experimental tasks. First, this classification suggests that a cross-cultural study of probabilistic thinking must consider task characteristics as they may influence the cognitive options upon which uncertain judgments are made. Second, it provides us with guidance to trace cultural differences in probabilistic thinking between Chinese and Westerners to their cognitive options. Following this classification, the probability judgment of Chinese and Western people should be compared under five different uncertain situations before a general conclusion about cultural differences can be reached. Obviously, an ideal design of an experiment is to construct five different types of uncertain events and ask subjects to make probability judgments. The similarities and differences between the judgments of Chinese and Western cultural groups can then be compared and analyzed. Previous cross-cultural studies in probabilistic thinking have extensively used general knowledge questions as tasks to stimulate uncertain feelings among subjects. According to Howell and Burnett's classification, a general knowledge questionnaire could be categorized into nonfrequentistic uncertain events with internal generating processes. So, four other types of uncertain events may require further investigations in future cross-cultural study. In the rest of this study, I will focus only on external uncertainty to compare the probability judgments made by Chinese and other Western cultural groups of people.

Several probabilistic tasks are immediately available as choices. Many laboratory and gambling tasks (those involving coins, cards, dice, wheels of fortune, etc.) can be used as frequentistic tasks with known or unknown generating processes. However, such tasks are hardly capable of being used to stimulate uncertain feelings among subjects, as most people may already have experiences and knowledge about the distributions of the outcomes of such events. For example, there may be a few persons who believe that the chance of heads turning up is higher than the chance of tails when tossing a fair coin. In most of real-life decision problems, many different uncertainties can be involved. Even for a similar case, such as gambling on horse-racing, several different uncertainties may need to be considered. The appearance of a black horse, the weather which may affect the field, and the future performances of the individual horses and riders, for which the gamblers may still remember their past records, can be categorized into different types and are mixed up. It seems to be difficult to find some real probabilistic tasks which contain only one type of uncertainty. Another difficulty in designing the experiments comes from the knowledge parameter. It seems to be difficult to construct an uncertain event which we can identify as one with known or unknown generators, because it depends on the beliefs of subjects. Indeed, Howell and Burnett have suggested that we should think of known and unknown generators as end points on a continuum of belief strength. For these reasons, I will not strictly follow this classification to design the probabilistic tasks, although they contain some uncertainties which may have similar characteristics with one particular standard type in the classification of Howell and Burnett.

In this study, I do not try to construct some standard uncertain situations, for the reasons I have discussed above and will confine the investigation to the subjective probability judgment about the outcomes of uncertain events. I seek to derive the probabilistic tasks from typical decision situations, as I believe people's probabilistic thinking should be investigated in normal decision situations. This will also make it easier to relate decision makers' probabilistic thinking to their decision behaviour.

Present design of probabilistic tasks is closely related to a general classification of decision problems, which depends on the characteristics of the involved uncertainty. Generally speaking, decision tasks can be categorized into three types: (a) Risk decisions, (b) Competition decisions, and (c) Uniqueness decisions. "Risk" here refers to the situations under which a decision maker may have met similar problems for many times and may have frequentistic records about them, but still cannot be sure about what will happen this time. The uncertainties involved in risk decisions have the characteristics of frequentistic uncertainty described in Howell and Burnett's framework. By "uniqueness" I mean the situations in which decision makers have little information about the decision problem which they faced, even though they may have some beliefs about what will happen. The uncertainties involved in uniqueness decisions are nonfrequentistic and have unknown generating processes. In a competitive environment, a decision maker may face uncertainties which are deliberately created by rivals. This kind of uncertainty may fall into some type of Howell and Burnett's classification, but this study treats it as a specific type as it is so widespread that it makes one kind of decision problem apparently distinct from others. In principle, I should construct several decision tasks which involve these three types of uncertainty in order to explore cultural differences in dealing with different uncertainties. However, within limited time, it is very difficult to extract sufficient probability judgments about future unique events and then to measure their accuracy. Therefore, this study will concentrate only on the uncertainties involved in risk and competition decisions.

4.2. Two Experiments

4.2.1. Experiment 1: Playing the game of bridge

The first experiment aims to investigate the characteristics of probability judgments under uncertainty involving competition, and to see whether the pattern of cultural differences, which has been found in previous cross-cultural studies of probabilistic thinking, will vary or not.

Probabilistic task

This study supposes that some aspects of decision makers' behaviour in dealing with uncertainty under competition situations may be examined by observing how they play competitive games. Indeed, like in the West, in Chinese history there were many famous generals and politicians who were fond of playing the game of "Go" and often related the tactics developed for dealing with the reality, in particular war, with those for playing the game. Of course, it can be argued that such a "perfect information" game is too simple to compare with most of the real uncertain competitive situations, as it involves much fewer uncontrollable factors. However, the principal characteristics of uncertainties, which both players and decision makers face, do have some factors in common and these are among the major concerns in this study. For example, such uncertainties all partly stem from the existence of a competitor or a rival.

At first glance, there would seem to be many Chinese games which could be used as the probabilistic task. For example, the games of "Go", Chinese chess, or "Ma-yong", are all still widely played by Chinese, even today. However, after a close look at these games I ruled them out, because in such games it is hard to find any occasion when I can ask players to present their probability judgments properly in a form suitable for the purpose of this study. When these games are being played, uncertain situations can change greatly at different times and for different players, and are difficult to control by the experimenter.

Keren (1987) recently has used the game of bridge as the probabilistic task in a calibration study, which provided the experimenter with a perfect opportunity to extract the card players' probability judgments. In comparison with those Chinese games cited above, the game of bridge has a major merit in that it is clearly divided into two phases: bidding and playing, and so the card players can be asked to estimate the probability that a final contract will be made after bidding but before actually playing the hand. For this reason and for making cross-cultural comparison easier, this experiment used bridge, a Western game, as the basis of one of the probabilistic tasks.

To make this clearer and to make the experiment understandable, I need to give a brief explanation for some aspects of the game, which are considered relevant to this study. Basically, the game of bridge is played by four players consisting of two teams. It starts with bidding, by which players follow certain sequences and use a limited vocabulary to communicate with their partners and opponents in order to discover more about card distributions and then to declare a favourable contract for themselves. A contract is a bet made by one team on wining a certain number of tricks (with a particular suit as trumps) while playing the game. In the game of bridge, trick means the cards (one from each player) won by one team in one round. Through several rounds of bidding, the final contract is reached, and the bidding phase is over. The team who declare the final contract will play in the offensive position, with the other team in the defensive position. After bidding, one of the defenders leads a card, and then the offense player who has not declared the contract, lays down all his cards on the table and they become the dummy. Finally, the players begin to play. Both teams attempt to take as many tricks as possible during play of the game. The offense team tries to take enough tricks to fulfil the declared contract, while the defense team tries to prevent the fulfilment of the contract.

In the bidding phase, all players attempt to reduce the uncertainty as much as they can, but it can never be eliminated completely. Before any trick has been played, the players still don't know the exact card combination of their partners, nor that of their opponents. They also still don't know how their opponents are going to play. Obviously, the final outcome of a game is determined by both the card distribution and the way in which the two teams play. The task in this experiment is to ask the players to present their probability judgments about the outcome of a game before dummy has been displayed, which creates the uncertain situation described above.

As the game of bridge was originated in the West, one may doubt if this task is suitable for the Chinese subjects. However, this worry is unnecessary, since the game of bridge is very popular in China today, and has even become one of the most prevalent hobbies, especially among intellectuals.

Subjects

The subjects were 14 pairs of amateur players from a bridge club in a governmental organization of several thousand staff members. Most of them had played the game for four or five years, but none of them had experience of national or international competitions.

Procedure

The experiment was conducted in a tournament organized by the manager of the club and the experimenter. The players were first divided into two groups of 7 pairs. During the whole competition, the players in one group would always play in the east or west positions, and the others would always play in the south or north positions. Twenty eight decks of cards were distributed on seven tables (four decks for each table). Each deck of cards constituted a game, which was divided in advance into four "hands" of 13 cards each, and remained the same for the entire tournament. So, the 28 decks were divided into seven rounds of four games. Each pair from one group played a round (four games) against each of the seven pairs from another group according to a predetermined order. Each of the 28 players played 28 games. Financial prizes were awarded to the first three pairs of each group according to the final scores.

The players were given instructions before the tournament started. They were required to estimate the probability that the final contract would be made at every time after the bidding ended and before any card had been played. They were allowed to use any number between 0 and 100 (percentages) to express their beliefs about the outcome of a game. It was suggested that they should use 100 only when they were absolutely sure that the contract would be made and should use 0 only when they were absolutely sure that the contract would fail. Similarly, low probability meant that they believed that the contract was likely to fail and high probability meant that they thought the contract was likely to be made. A probability of 50 meant they believed there was an equal chance of success or failure of the contract. For recording their probability judgments, each player was also given a form with the games numbered 1 to 28 and was asked to provide a probability judgment immediately after the bidding phase of each game. The players were required to make their probability judgments independently and any exchange of information which violated the bidding rules was disallowed. The players were also asked to note the position of the declarer (who declared the final contract), so I could get to know the role of players (offense or defense). After all the players had completed this task, they went on to play. The final score was recorded on a separate form for deciding who would be the prize winners.

Analysis of Results

All the 784 probability judgments made by 28 Chinese card players were grouped into 11 categories: 0-4%, 5%-14%, 15%-24%,..., 85%-94%, 95%-100%. On this basis, the calibration curve was drawn and is shown in Figure 4.1. It can be seen that the curve for the Chinese group is quite near the diagonal which indicates perfect calibration, especially for probability judgments above 40%. The ups and downs in the range of 0-40% may be of less importance, as they are due to the small number of observations in this range. Less use of probabilities under 40% is quite natural. Generally speaking, a player who bets on a contract should think that it is more likely to be made than to fail. In fact, of 196 games played, 127 (65%) contracts were finally made. The closeness between the calibration curve and the diagonal means that the Chinese players as a whole made rather good probability judgments about the uncertainty which they faced in playing the game of bridge. Such good performance of these Chinese players is further supported by their very small value of calibration (0.0053), which was also calculated on the basis of group data (see the definitions of calibration, H and resolution in chapter 2). From the frequency distribution of probability judgments, it was also found that the Chinese players did not concentrate solely on extreme probabilities, but also very often used other probabilities. Out of the total of 784 judgments, 100% was used only 115 times, not more than 15 percent. It also resulted in a high entropy H (3.00) and a good resolution score (0.0390), which indicate better discrimination of the probability judgments.

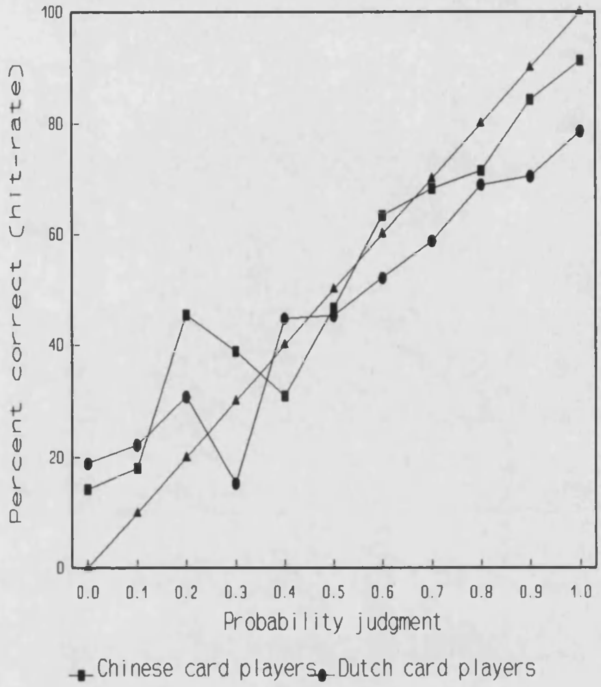

Figure 4.1. Calibration curves: Dutch and Chinese card players

Within the limited time, I could not carry out a similar experiment in a British cultural group as was the procedure in the previous study. However, the comparable data collected by Keren (1987) among Dutch amateur card players may be borrowed to serve the purpose of cross-cultural comparison. To study the cognitive processes of repeated probability judgments, Keren collected data from 28 Dutch amateur players who were members of a sports club and had been playing the game of bridge for a long time. The calibration curve of the Dutch player group is also shown in Figure 4.1. In Keren's experiment, the last 4 games were omitted since the amateur players were not able to finish all the games within the arranged time, and so the calibration curve is based on a total of 672 observations, not on 784 as in this experiment. One may note that there is also a slight difference in the methods of grouping the data between the two studies. However, there were few cases in which the Chinese players provided their probability to the second decimal place (or unit's place in percentage) and so actually the two methods are almost the same. The two cultural groups are also comparable in the sense that they all had played the game of bridge for some time, but had no experience of taking part in national or international competitions.

The pair of curves presents a very different picture from previous cross-cultural studies, in which general knowledge questionnaires were employed as probabilistic tasks. From Figure 4.1, it can be seen that the Chinese card players as a whole made better probability judgments than their Dutch counterparts. Although Keren did not report the calibration measure of the performance of the Dutch card players, we still can find that in most of the cases the Chinese were less overconfident than the Dutch. The Chinese did not show a strong tendency for making extreme probability judgments, in contrast the Dutch made more extreme judgments. From the frequency of probability judgments made by the two groups, we also can see that the Dutch offered 196 (29%) probability judgments of 100%, whereas the Chinese used 100% only 115 (15%) times. Even considering all the judgments above 80%, the Dutch still used them more frequently and were more often wrong. Another interesting phenomenon is that the Chinese used 50% much more often than the Dutch. It showed that in more cases the Chinese liked to leave the "door" open, because giving any probability under or over 50% would, to some extent, have expressed that they already judged the outcomes, success or failure of a contract. The Dutch also used 0, another extreme point, slightly more often.

Besides the cross-cultural comparison, I also compared these results with those obtained in our previous experiment which asked the Chinese university students general knowledge questions. I have already pointed out the differences between the characteristics of uncertainty involved in these two probabilistic tasks and later I will provide a further discussion. The two tasks also have some other differences in the form and requirement of the experiment. Previous experiments presented a general knowledge question with two alternatives from which the subjects could choose and they were required to use the probability only between 50% and 100%. However, in this experiment the card players had only one alternative, that is, whether a contract would be made or not and they were allowed to use any number between 0 and 100% to express their beliefs about the outcome of a game. So, in order to make a comparison between the two studies, it is first necessary to transform the data collected by this study into a comparable form with those from the previous experiment. As we knew at the beginning of this experiment, the card players had been instructed that they should use 0 only when they were absolutely sure that a contract would fail. So, we may transform

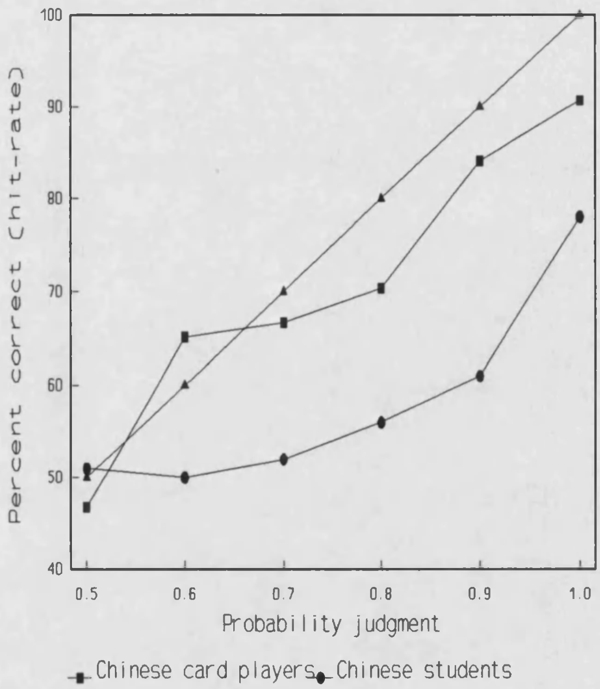

Figure 4.2. Calibration curves: Chinese students and card players

a probability of 0 for predicting a success of a contract into a probability of 100%, but for predicting a failure. Similarly, a probability of x less than 50% can be transformed into 100%-x. After this transformation, the data of this study can be regrouped into 6 categories as I did in the previous study. This transformation, of course, can be criticized as it assumed that the sum of a card player's subjective probabilities that a final contract would be made and failed equals 1. I will make no further defense of this, even though I have tried to extract consistent probability judgments from the card players. However, since most of the probability judgments in this experiment are not less than 50%, this transformation will not have a significant impact on the analysis.

From the transformed data, I drew a new calibration curve for the Chinese card player group. It is shown in Figure 4.2, along with the calibration curve obtained in the experiment using a general knowledge questionnaire. The two calibration curves form a sharp contrast: in answering the general knowledge questions, the Chinese students made many more overconfident probability judgments; in playing the game of bridge, the Chinese amateur card players made much better calibrated probability judgments. The calibration measure for the Chinese card player group is 0.0046, which is much lower than the 0.0414 of the Chinese student group in my own study and the 0.0289 in the study of Yates et al (1989). Other group-determined parameters also indicate good performance of the Chinese card players. In comparison with the student group, the card player group made much less extreme but more calibrated probability judgments. The H measure also increases to 2.55 from 2.07 and the resolution measure increases to 0.0219 from 0.0140, which means better ability in being able to discriminate probability judgments into significant different categories of probability. However, in comparison with the resolution score of the Chinese student group in the study of Yates et al (1989), 0.0205, this increase is not impressive.

Similar analysis was also made on the basis of individual data. Table 4.2 presents general results. Significant differences were found in five measures between the two groups. The Chinese card players on average offered only 16.45 percent of 100% probability judgment, whereas the Chinese students used it over half of the time, but it can be seen that they were wrong more often. The measures of calibration, H entropy and resolution consistently show that the card players on average had made much better probability judgments in playing the game of bridge than the Chinese students in answering the general knowledge questions. The card player group has a lower calibration measure and higher H and resolution measures than the student group, and all of these differences are statistically significant. However, no significant differences were found in the measures of the percentage of 50% judgments and the percentage correct for any 50% judgments.

The differences between the two groups of Chinese people in making probability judgments could be related to the characteristics of the probability judgment makers and the characteristics of the tasks. In playing the game of bridge, card players made repeated probability judgments for a same uncertain event, that is, whether a contract would be made, and so they could get the feedback after every game. It may suggest that the card players in this experiment may have this advantage over the students. To look at the effect of feedback on probability judgment, I divided the 28 games into two groups: game 1 to game 14 are in one group, and game 15 to game 28 in the other. This

Table 4.2. Comparisons between two probabilistic tasks

Measure	General knowledge (N=95)	The game of bridge (N=28)	t
1.Percentage of 50% judgments given			
Mean	17.63	21.30	N.S.
Std.Dev.	12.7	10.4	
2.Percentage correct for any 50% judgments given			
Mean	48.85	44.43	N.S.
Std.Dev.	19.9	25.4	
3.Percentage of 100% judgments given			
Mean	51.19	16.45	10.84**
Std.Dev.	19.4	13.3	
4.Percentage correct for any 100% judgments given			
Mean	78.62	89.19	-2.42*
Std.Dev.	10.11	22.5	
5.Entropy H			
Mean	1.75	2.22	-6.58**
Std.Dev.	0.58	0.20	
6.Calibration			
Mean	0.0592	0.0452	2.04*
Std.Dev.	0.033	0.031	
7.Resolution			
Mean	0.0272	0.0570	-3.92**
Std.Dev.	0.018	0.039	

Two tailed significance ** $p < 0.01$ * $p < 0.05$

division was more or less arbitrary. Insufficient numbers of observations impede me from dividing them into further groups. Nevertheless, a rough analysis may still provide us with some clues. The calibration curves for the two groups are together presented in Figure 4.3. Surprisingly, almost no significant improvement can be seen from these two calibration curves. The only finding was that the card players became more cautious from their less frequent use of 100% and more use of 50%. The number of 100% judgments has been reduced to 47 from 68 in the second half of the tournament, but the exactness

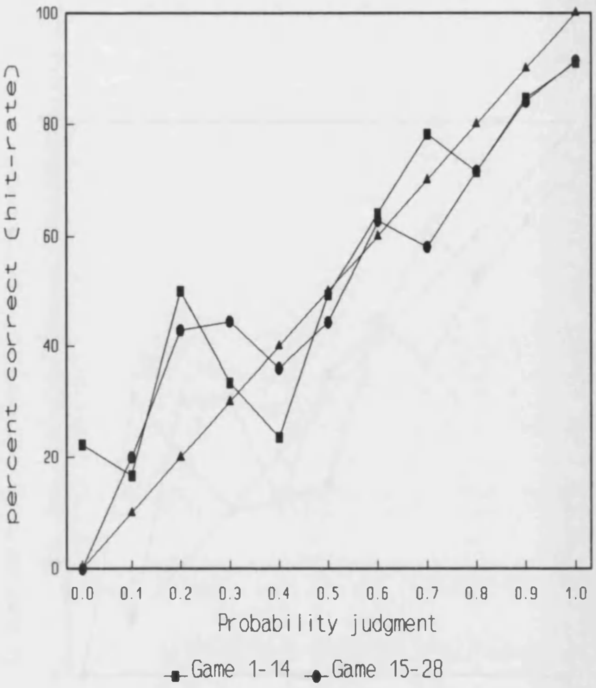

Figure 4.3. Effect of feedback

of probability judgments of 100% has not changed. However, the group-determined parameter does show certain improvement in calibration of judgments, perhaps as the weight, the proportions of probability judgments, has been taken into account in the calculation of calibration parameter. In the last 14 games, the calibration measure reduced to 0.0063 from the previous 0.0073, but no significant changes are found in the other measures. Another factor which I supposed may affect probability judgments is the card players' role in playing the game. To look at this, I separated the probability judgments made by the card players when they were in defense position from those made when they were in offense. As in previous analysis, I first compared the calibration curves which are drawn based on defense data and offense data respectively. From Figure 4.4, it can be seen that in some cases, the defense players were more likely to be underconfident than the offense players. This is further evidenced by the big difference between the two groups of data in overconfidence measures (see chapter 2) after weights have been taken into account, -30.10 for the offense data and 1.4 for the defense data. A negative sign here indicates overconfidence, and a positive sign underconfidence. More careful analysis reveals that when the card players were in the offense position they were

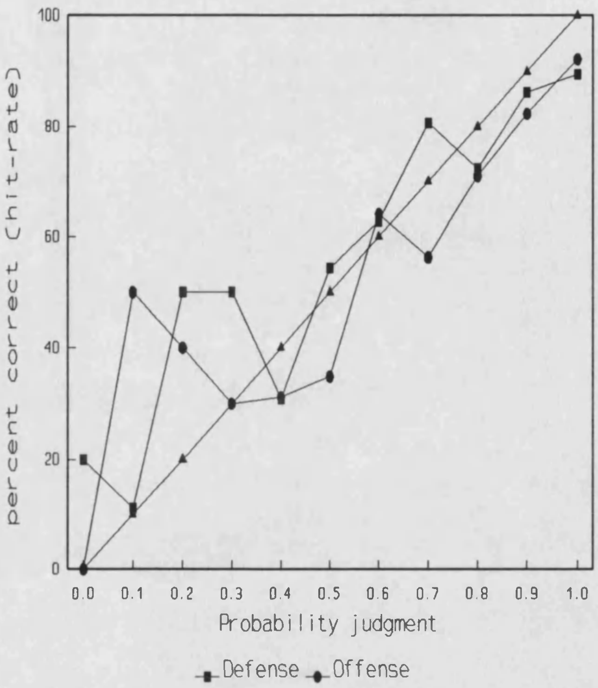

Figure 4.4. Effect of role

more overconfident in using the probability above 50% and when they were in defense position they were more likely to be underconfident in using the probability under 50%.

4.2.2. Experiment 2

The second experiment aims to examine the characteristics of probability judgments made by Chinese experts under a risk decision situation and to see whether there will be any cultural differences in probabilistic thinking between Chinese and Western decision makers.

Subjects

Twenty one economists working in several governmental departments in Beijing participated in this experiment. Their daily work includes making an analysis of the national economic situation, predicting the trend of future economic development and finally presenting recommendations on economic policy to the government, to be considered in governmental decision making. All this work is closely related to making forecasts of economic indices. In doing this work some of the economists depend more on econometric models, others depend more on their subjective judgments, which they themselves often describe as "striking numbers". All the subjects have a minimum of three years' experience of such economic forecasting.

Task and procedure

A forecast meeting was organized by two officials on behalf of two governmental departments in September, 1990. The economists were invited to discuss some issues in the forecast of the national economic situation and were told that a new method would be introduced. At the beginning of the meeting, the officials and the economists first selected 24 economic indices which they considered necessary for further analysis of the national economic situation. These indices involve many economic areas, such as industry, agriculture, trade, and so on. Then each economist was required only to make forecasts of 6 indices which were in his or her everyday survey. Each index was required to be forecast for the three months ahead, that is, October, November and December. One of the two officials then remarked that a new method would be tried this time to see whether it could improve their work in economic forecasting and analysis or not. Instead of making "single-value" forecasts, this time they were required to present their forecasts with a type of cumulative probability distribution. After that, each subject was given a booklet describing the procedure of the new forecasting method (see below). The experimenter then explained the method (elicitation technique) and answered the questions from the subjects. Following the procedure, every economist made a tentative forecast of an index in a warm up session. The economists then started to make their real forecasts, until both the experimenter and the economists themselves were confident that they could apply this method properly. The subjects were allowed to retrieve statistical data and to consult other information as they usually did, but not to exchange opinions about the probability judgments they were making. They were asked to return their results within one week. There were communications between the subjects and the experimenter in that period of time. The experimenter answered further questions from the subjects about the method, and consequently he asked several subjects to correct their errors in drawing the probability distribution curves.

In this experiment, the uncertainty that the subjects faced is about the value of an uncertain continuous quantity, rather than several discrete outcomes of an uncertain event. In chapter 2, two widely used methods (the fractile and probability methods), for eliciting such probability judgments, have already been briefly discussed. In this experiment, the SRI (Stanford Research Institute) method developed by Stael von Holstein and Matheson (1979) was followed, although several sub-procedures were simplified or modified. In order to collect enough data within limited time, it was not possible to elicit the probability judgments through a face-to-face interview with every subject for every economic index. Instead, the subjects were taught the method and made their own judgments. The subjects were asked to follow five steps in presenting their probability judgments about an economic index through drawing a cumulative probability distribution curve with a probability scale already drawn on the vertical axis of the graph. Each subject was given 18 such probability graphs (six indices for three months).

In the first step, the subjects were asked to decide a range by giving upper and lower assessments of an uncertain quantity so that the actual value would fall outside this range only in extreme and very surprising circumstances. They were also instructed to make the range as small as possible, in order to make the forecast more meaningful. To check whether the range was decided as required, the second step asked the subjects to construct possible scenarios in which the index could reach the upper or lower boundaries. If they were in any doubt, they should make proper changes until they were satisfied. Then, in the third step the subjects started to draw the curve of cumulative probability distribution in the provided probability graphs (see a sample in Figure 4.5). The lower and upper assessments were first plotted on the horizontal axis as the left and right ends of the curve. The whole range was then divided into several equal sub-ranges with 5 to 7 value points on the horizontal axis. For every point, except the lower end, the subjects were asked to assess a probability that the index would not exceed the value. After 6 to 8 coordinates were plotted, a smooth curve was drawn freehand in pencil.

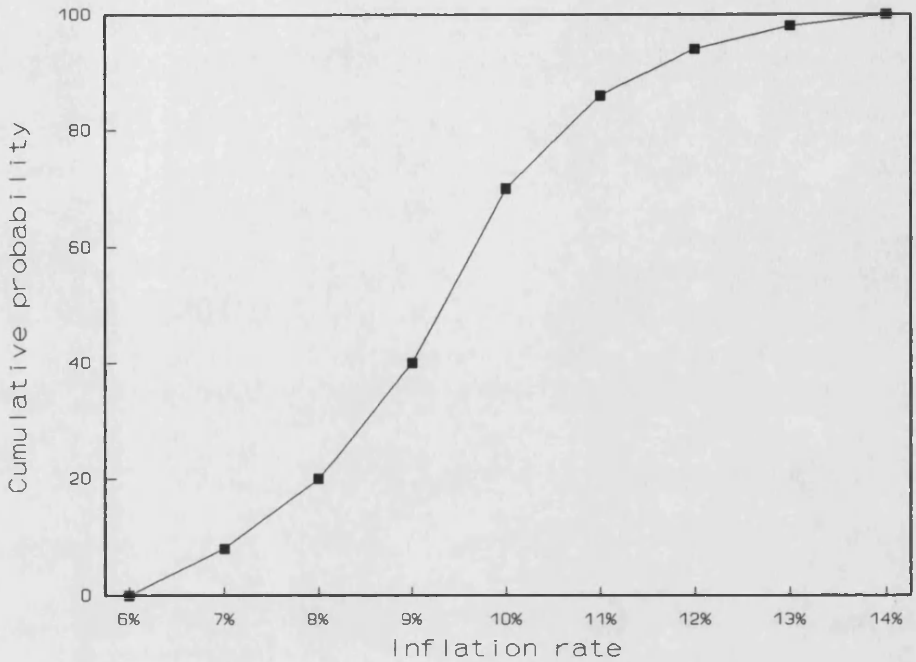

Figure 4.5. Cumulative probability distribution

They were reminded that the curve expressed cumulative probability and so it must ascend and reach 100% at the upper boundary. The fourth step was to check the consistency of the probability judgments. The subjects were instructed to find the two value points in the horizontal axis which corresponded to probability 0.33 and 0.67. These two points with the upper and lower boundaries thus divided the whole range into three parts. The subjects were asked to think whether they really believed the actual value had the same possibility of falling into the three sub-ranges. To test it, it was suggested that they suppose that they gamble and bet on the three sub-ranges. If the actual value falls into the sub-range they bet on, they will win, otherwise they will lose. They then asked themselves whether, or not, they were reluctant to let other people bet before them or not. If they were reluctant, it meant that they did not believe that betting on any one of the three sub-ranges had the same chance of winning, and so they should recheck the already drawn curve and continue the same procedure until they were no longer reluctant. In step 5, the subjects were asked to make a final check and refinement for the whole cumulative probability curve. For the last result, they should make sure that they would like to make their own decisions based on it.

I chose the SRI method because it has some obvious advantages in comparison with other methods. First, it does not present subjects with available values as does the probability method, but instead asks subjects to determine the range of value themselves. So, it can avoid the disliked impact of the experimenter on the subjects' judgments. Second, it stresses the importance of imagining possible scenarios, which can push the subjects to think carefully about their forecast. Finally, it provides a simple way of checking the consistency of judgments.

Analysis of Results

This task was familiar to the subjects, except now they were required to express their judgments in terms of probability. Actually, the subjects who participated in this experiment should be considered as experts in economic forecasting, however, their performances were not encouraging.

A total 378 (21x6x3) curves of cumulative probability distribution were collected from this experiment. The second histogram of figure 4.6 shows the frequency that the value actually fell into the 8 intervals of the curves drawn by the subjects. In comparison with perfect calibration (indicated by the first histogram), it can be seen that there were too many cases (as high as 299 times) where the actual value fell outside, or very nearly outside, the prediction range given by the subjects, and only in much fewer cases, the actual value fell into the middle of the range. The 2% surprise index reached as high as 80, which means that when 2 of the predicted values were expected to fall into the two extreme intervals for calibrated judgments, 80 arrived. Most surprises happened in the interval above 0.99 (277). Perfect calibration results in the subjects' judgmental interval between 0.25 and 0.75 should have contained about 186 actual values, yet in fact contained only 21. The basic result of this experiment was that the judgments of the economists were "too tight", that is, their judgmental prediction ranges were very often

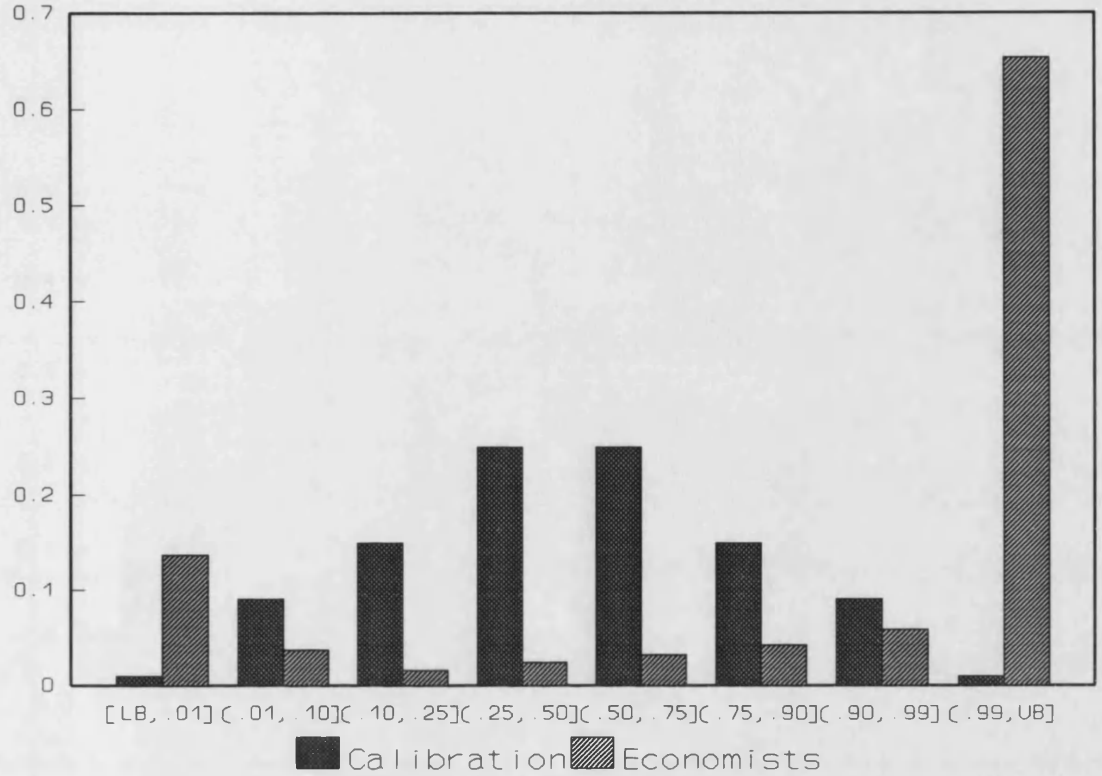

Figure 4.6. Comparison with calibrated judgments

too narrow to contain the actual value of the indices. It indicates a very strong tendency of overconfidence in the Chinese economist's judgments.

The results here are quite similar to those obtained by Yates et al. (1989), although the subjects and probabilistic tasks of the two experiments are different. In the experiment of Yates et al., sixty Chinese university students were asked to make judgments about 10 quantities about the future, for example, the minimum temperature recorded in Guangzhou a few days hence. The two results were compared in Figure 4.7. The first histogram indicates the student group and the second the economist group. As the report of Yates et al. does not provide individual data, I am not able to make further statistical analysis. However, from Figure 4.7, it is clear that there are no conspicuous differences

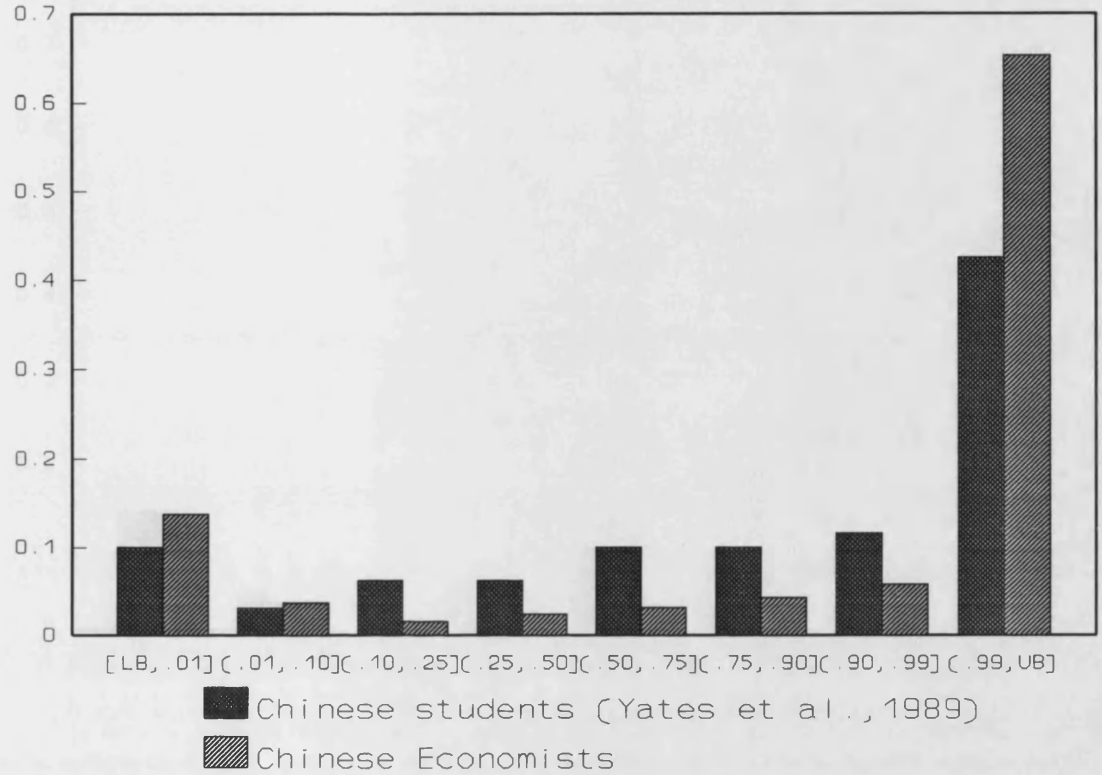

Figure 4.7. Comparison between Chinese students and economists

between the two judgmental patterns. Both of their judgments were "too tight" and overconfident. Perhaps the only significant difference is that more often the economists' forecasts were far below the actual values, which resulted in very high 1% surprise index of above 0.99.

As the subjects were asked to make judgments about the economic indices three months ahead, it may be possible to look at the effect of timing on their probability judgments. Figure 4.8 shows the separated judgments of the subjects for the three months. No obvious differences can be found. There are only slight increases from October to December in the 1% surprise index of above 0.99 boundary and corresponding decreases in the 1% surprise index of below 0.01. Further statistical analysis confirmed these

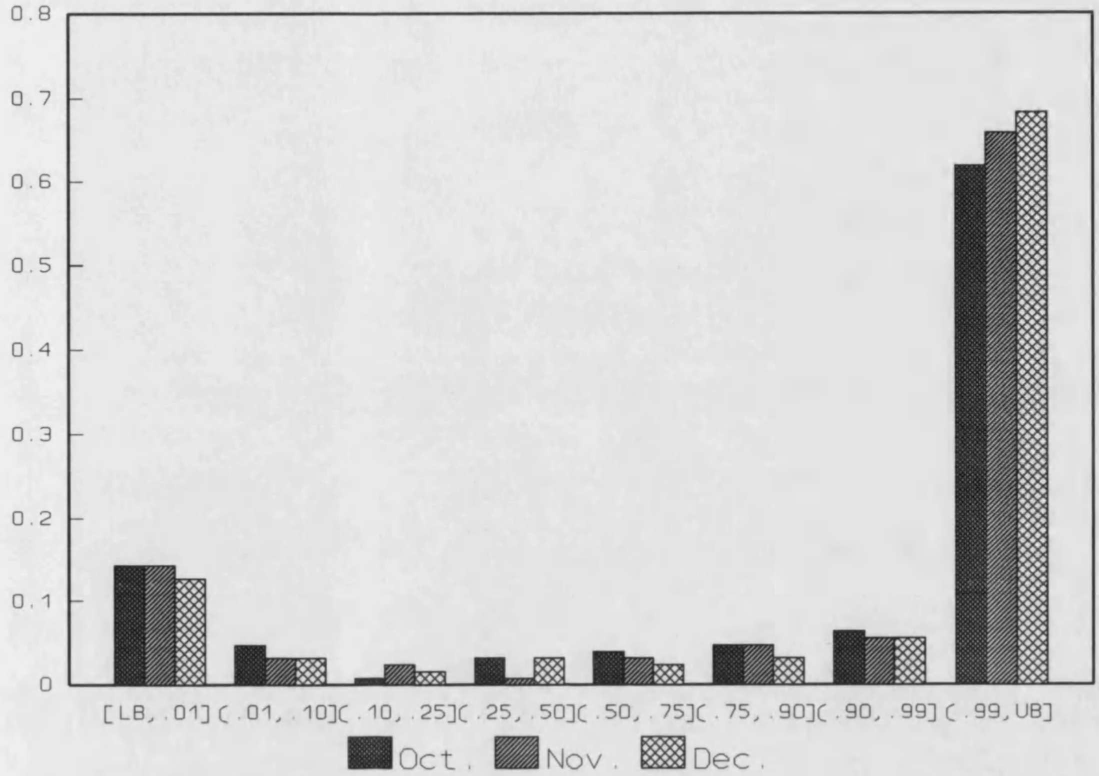

Figure 4.8. Effect of timing

observations. None of the differences between every two month's data were found to be statistically significant. In this experiment, the length of the period of forecast did not seem to have any obvious impact on the probability judgments of the economists.

For this experiment, making a proper cross-cultural comparison becomes more difficult. First, it is very difficult to have a chance of making a similar experiment with British economists. Second, even if it were possible, the comparison probably still could not be carried out on a fair basis, because forecasting the Chinese economy and forecasting the British economy have great differences. Perhaps this is the price of my choosing such a real task. Finally, inconsistent results are still being reported in Western cultural groups, although good performances were sometimes found, and this makes a cross-cultural comparison more complicated. Nevertheless, I have found a few experimental results

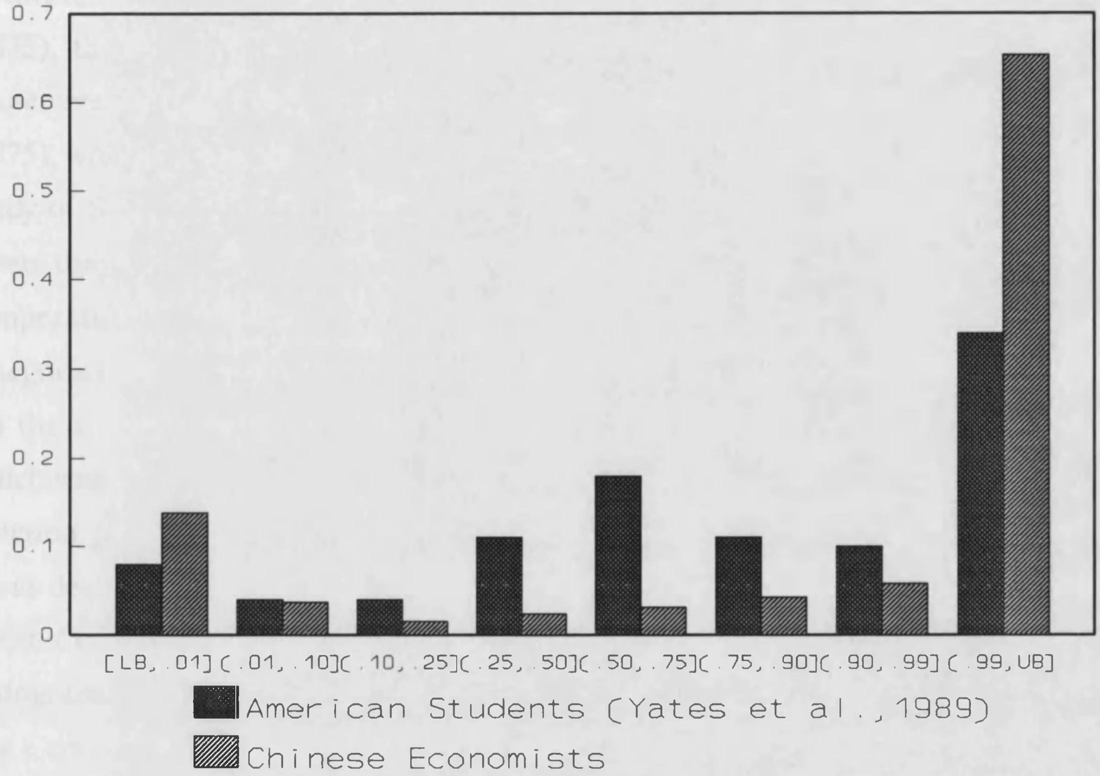

Figure 4.9. Comparison between Chinese economists and American students

about Western people reported in earlier studies which can be used as a comparison. It is hoped that such comparisons at least can lead to deeper understanding about cultural differences in probabilistic thinking. Yates et al. (1989) asked a group of American students to estimate 10 uncertain quantities (e.g. the temperature) in the future, and used the fractile method. I compare the probability judgments of the Chinese economists with those of the American students in Figure 4.9. It clearly shows that the Chinese economists were surprised in many more cases than the American students, although both groups were overconfident in their probability judgments. Even considering that the Chinese economists might face much more complicated situations than the American students, the differences between the two cultural groups in the characteristics of probability judgments are still impressive. The 2% surprise index for the American students is about 41, while for the Chinese economists it is as high as 80.

The probability judgments elicited from Western experts were often found to be good. In the United States, the probability judgments of the weather forecasters were excellent. In forecasting tomorrow's high temperature with five fractiles (0.125, 0.25, 0.5, 0.75, and 0.875), the two groups of forecasters in Murphy and Winkler's (1974; 1977) studies respectively obtained 27 and 21 for the 25% surprise index (below 0.125 and above 0.875), which nearly reached the level of perfect calibration. However, the subjects in the study of Stael von Holstein (1971) made quite poorly-calibrated probability judgments when they were asked to make forecasts for three fix-value events: (a) the average temperature tomorrow and the next day (dividing the entire response range into eight categories), (b) the average temperature 4 and 5 days from now (eight categories), and (c) the total amount of rain in the next 5 days (four categories). The surprise index, which was calculated by Lichtenstein, Fischhoff, and Phillips (1982) based on the density function produced from the experiment, was found to be too high. It reached 30 when 2 was demanded. The study which was carried out by Kabus (1976) in Morgan Guaranty Trust Company perhaps is the most comparable study with this one. Kabus utilized histogram techniques to elicit the bankers' predications about the interest rate on a 90-day Certificate of Deposit (CD) at some future date. The percentages of the bankers' subjective chances (probabilities) over the possible interest rates were expressed by the heights of the histograms. It was found that individuals and the group as whole had performed very well. The forecasted values of the 90-day CD rate were fairly close to the actual values and never fell outside the 75% confidence interval. The direction was also always forecasted correctly. The results sharply contrast with present findings among the Chinese economists.

The present results showed that the Chinese economists had a very strong tendency of extremeness in making probability forecasts. Very often, the actual values of the economic indices even exceeded the highest values that they could imagine as possible. In previous studies, a quite different phenomenon was found among several Western cultural groups. These may suggest another pattern of cultural differences in making probability judgments. However, it is still too early to derive any serious conclusions. The evidence is very limited, and the comparisons have not been carried out on too sound a basis. There are obvious differences between the probabilistic tasks that were used in the different cultural groups, and this might have some impact on the results. In this experiment, the Chinese economists seemed to face a very difficult task. Even compared with the bankers in Kabus' study, who were also asked to make forecasts of an economic index, the interest rate, the Chinese economists might have met more difficulties as their forecasts were more complicated and involved much more uncertain factors.

It may be argued that the cultural differences analyzed above were partly caused by the different elicitation methods employed in the studies. However, such obvious differences do not seem to be explained away by this reason alone. Moreover, with the SRI method, which is superior to other methods in several aspects, better results should be expected. Nevertheless, it is possible that the economists did not use the SRI method properly, as they were unable to get used to it within such a short period of time. From the graphs presented by the economists, the experimenter found that they might follow some steps carefully, but might not take sufficient care with some others. It can be seen that most economists checked the consistency of probability judgments, but it is not clear whether they had put enough effort into the construction of scenarios, because no scenarios were recorded.

4.3. General Discussion

The main findings of the experiments are that the Chinese do not deal with different uncertainties in a consistent way and so there may be no general pattern of cultural differences in probabilistic thinking between Chinese and some Western cultures. The cultural differences may vary for particular groups of people or under specific uncertain situations. First, let us analyze why the Chinese students and the card players made probability judgments differently.

Previous studies using general knowledge questions as tasks showed that the Chinese students had a strong tendency of pursuing the extremeness of probability, and of ignoring the calibration when they were choosing between the two alternative answers. It contrasted with the American and British students who were found to prefer calibration to extremeness. However, the results of the second experiment described a quite different picture. They demonstrated that while playing the game of bridge the Chinese amateur players became very cautious in predicting the outcome of a game. They changed, now avoiding extremeness of probability and preferring its calibration. The Chinese card players performed so differently from the Chinese students that the cultural differences previously found between Chinese and Western students did not repeat at all between the Chinese and Dutch card players. In fact, the probability judgments of the Dutch card players had expressed much more extreme tendency, and so the differences found between the Dutch and Chinese card players in making probability judgments have almost reversed previous findings of cultural differences in probabilistic thinking between several Western and Chinese student groups.

Why did the Chinese students and the amateur card players perform the probabilistic tasks so differently? And why did the pattern of cultural differences change so dramatically? Several factors appear to be related to such changes. For example, one may attribute such changes to the superiority or inferiority of people's ability in dealing with uncertainty. There is no doubt that the amateur card players as a self-selected group may have more occasions to train themselves in dealing with uncertain situations through regularly playing the game than do the students who did not play the game at all. Thus, perhaps, they tended to think of uncertainty more in a probabilistic way. Even so, can we expect the Chinese amateur card players, if they were asked to answer the same general knowledge questionnaire as the Chinese students, to present the same performance as they did in playing the game of bridge? Unfortunately, due to the limited experiment time, I was not given the opportunity to ask the Chinese card players to answer a general knowledge questionnaire.

At present there is no experimental data that rejects such expectation. Some observations, however, do suggest that the Chinese card players might not be able to keep such good performance, if they were given a general knowledge questionnaire. Firstly, as mentioned before, the game of bridge is a very popular sport in Chinese university campuses and therefore it is very possible that many of the 95 Chinese students attending the previous experiment also had some experiences in playing the game, although I did not make a formal record of this. Secondly, many of the Chinese amateur card players taking part in the tournament were the students who had recently graduated from universities. These seem to suggest that the difference between the students and card players in the experience of playing the game did not contribute very much to the variations which have been found in this experiment. At most, they can only be part of the explanation. Another reason which could be supposed as leading to the changes is that this experiment and those using the general knowledge questionnaires did not apply the same method to extract subjects' probability judgments. Allowing the full use of range of probability (0 - 100%) in this experiment, for example, could be argued to stimulate card players to present more discrete probability judgments. However, Fischhoff, Slovic and Lichtenstein (1977) have found no supportive evidence in their experiments which used a variety of methods, such as, no alternative, one alternative, and two alternatives with half range (50%-100%) and full range.

Regarding the variation in cultural differences, it could also be argued that the results from the two cultural comparisons were incomparable, since they were not based on the same two cultural groups. Certainly, there is no way that the Anglo-Saxon and Dutch cultures are the same. Even so, it seems quite impossible to repeat previous cultural differences between Chinese and British card players, as the probability judgments made by the Chinese card players are significantly different from the students. In the calibration of probability judgment, the curve of the Chinese card players is far closer to the diagonal than that of the Chinese students. The Chinese card players also made far fewer extreme probability judgments than did the Chinese students. Thus, even if it is supposed that the probability judgments of British card players could be better calibrated and less extreme than those of the Dutch, the differences of probability judgments between them and the Chinese are not as significant as those we found between the British and Chinese students. Of course, it is also possible that the cultural difference between the Chinese and British card players could have developed into another pattern. For example, the probability judgments of the Dutch amateur card players have been found to be less calibrated and more extreme than the Chinese. In addition, from Keren's (1987) report that the Dutch amateur card players had played the game for "a long time", so the Chinese amateur card players also did not possess any advantage in expertise, as they mostly had 4 or 5 years of experience. In fact, this experiment has employed a very Westernized instrument, so the Dutch must have benefitted more from this than their Chinese counterparts.

The main reason behind the variations, I consider, should be partly located in the differences of the characteristics between the two uncertain events. More particularly, the general knowledge questions and the game of bridge created considerably different uncertain situations among the students and the card players. In the terms of Howell and Burnett (1978), the uncertainty, for the case of general knowledge questionnaire, was internally generated. That is, the subjects did not perceive the uncertainty as entirely beyond their control. A general knowledge questionnaire simply asked subjects the facts. The students knew that there were already correct answers there and they must be among the alternatives given by the experimenter. They felt uncertain because they could not exactly remember most of the facts asked by the questions, but not because there were any external processes which could lead to different dispositions. So, such uncertainty reflected the beliefs that the students had about their exactness of memory and the reliability of their heuristic inference. This was the uncertainty about the subjects' mind but not about the changes in the external world.

In estimating the success or failure of a game, however, the card players faced quite different situations. They felt uncertain because they could not know the exact distribution of cards and they could not foresee the way in which their opponents were going to play. The cards were dealt randomly and the distributions changed every time. The card players may know that every card has the same possibility of going to one of the four hands. However, they could never know the exact distribution of cards for any particular deal. Meanwhile, exactly how the opponents would play could also never be known for sure in advance, as they were dependent entirely on the opponent's judgments and decisions. In contrast to the uncertainty created by the general knowledge questionnaire, these uncertainties were generated by external processes which were apparently beyond the control of the card players.

Such clear distinction between the two uncertain events, however, became more intricate with the involvement of bidding. The communication with the partners or opponents, although rather limited, could substantially increase card players' confidence in their beliefs about the distribution of cards. After the bidding, in the card players' mind uncertainty was further gauged on the fragmentary information and on the heuristic inference. So, the uncertainty may vary with the card players' beliefs about the perfection of the information and the completeness of their inference. In that time, internal generating processes have crept in and mixed with external ones. Even for the intention of the opponents and the tactics which they would possibly take, the card players could have some prediction after the bidding phase. They may expect their opponents would play as "rational men" and feel to some extent that the progress of the game was under their control or within their expectation. Once again, internal generating processes could be involved.

Another important distinction between the two uncertain events was whether they were "frequentistic" or not. The general knowledge questionnaire which was used in the first experiment included 75 questions involving a variety of fields, such as astronomy, geography, biology, physics, history, philosophy. The contents of these questions, in general, were not related, and so every question could stimulate specific uncertain feelings among the students depending on the beliefs which the students had about their knowledge in a specific field. In other words, these uncertain events did not occur in a repetitive fashion and the subjects had to deal with them separately. Almost nothing could be learnt from their early performance. In the terms of Howell and Burnett (1978), a general knowledge questionnaire has nonfrequentistic nature. However, the card players had played the game of bridge for many many times before the competition. They dealt with similar uncertain situations again and again. In a strict sense, these uncertain events did not fall into the category of frequentistic events classified by Howell and Burnett (1978), except the dealing of a pack of cards which may follow a stochastic process. The opponents were shifting and the information got from bidding was variable. However, the characteristic of repetition could steer the cognitive processes of the card players quite differently from the general knowledge questions. The uncertainty involved in the game of bridge may have a similar nature as frequentistic events, although it is only in the sense of analogy. Frequency records about outcomes for different situations may already stored in the minds of card players. Another significant advantage which the card players had is that they could get immediate feedback from previous success and failure, and adjust their later performance.

I believe that people do not think and deal with such different uncertainties in the same way. Even if we assume that people go through a similar cognitive process in dealing with different uncertainties, their cognitive subprocesses of making uncertainty judgments may not be equally involved. The significant differences between the uncertainties contained in the two tasks discussed above, may be used to interpret the findings of this experiment in following ways.

One significant difference between the two probabilistic tasks, as argued above, is that in using a general knowledge questionnaire to create uncertainty among the students, internal generating processes were much involved. The accuracy of choices of alternative answers depended almost entirely on the processes within the students. If the students tended to overestimate the exactness of their memory, they would be more overconfident in their probability judgment. Similarly, if they trusted their "rules of thumb" or heuristics as complete, they would tend to judge with greater certainty than the evidence warrants. The previous study about the relationship between probabilistic thinking and cognitive style have revealed that overestimation of memory could lead to overconfidence in judging the correctness of choosing answers for general knowledge questions. The cultural differences found in previous studies could also partly account for the high self-confidence of the Chinese students in their memory. However, in playing the game of bridge, the card players were faced with a very different situation. The card players clearly knew that they could neither control the distribution of cards nor control the way in which their opponents played the game. They thus may perceive these uncertainties more tangibly in such uncertain situations. This would in turn decrease the strength of their beliefs in a particular outcome of a game.

In the above discussion, I have also emphasized the repetition characteristics of the task of playing the game of bridge. The results of the effect of feedback demonstrated that even in a short period of time card players might have consciously or unconsciously improved their calibration. It was observed by the experimenter that the card players often had a quick look at the probabilities which they had made earlier. Perhaps more important is that the card players had been playing the game for a long time and might have a rough record about the frequency of success or failure for several different situations in their mind. However, it is definitely not the case for the students answering the general knowledge questions. Unrelated questions and the lack of feedback about their performance provided the students with no information to improve the accuracy of their probability judgments. How could it? It is possible that the students could also have cumulated rough frequency records of their success and failure from watching "Master Mind" on the TV or attending a quiz competition. However, they may still be overridden by the students' strong beliefs in the exactness of memory when choosing individual alternative answers.

The variations of cultural differences perhaps can also be explained as the changes of uncertain situations. Particularly, they might have striking impact on the Chinese cultural groups. The Chinese have been found to give low difficulty ratings to the memory items in the intelligence tests (Chen et al., 1982), indicating high self-confidence about their memory. So, they were probably more sensitive to the difference between the two tasks.

Previous analysis of the effect of role has also uncovered similarity or relationship between two probabilistic tasks, answering the general knowledge questions and playing the game of bridge. The fluctuations of the two curves in Figure 4.4 demonstrated that the card players were more overconfident when they played in an offensive role than in a defensive role. It further confirms the above analysis that people tend to offer a higher probability judgment than they should when perceiving themselves as exerting some measure of control. The card players tended to believe that they could make a contract when they were in offense and tended to believe that they could prevent the fulfilment of a contract when they were in defense. Although Keren's (1987) study provides no corresponding curves which can be used to make a comparison with present study, from the statistical data listed in Table 4.3, it still can be found that the Chinese amateur card players were more likely to offer extreme probability judgments than the Dutch. For the Chinese group, especially, the difference of the proportions of above 80% probability judgments between the offense and defense roles is much more significant than that for

Table 4.3. Effect of role

Probability judgment	Dutch		Chinese	
	Offense	Defense	Offense	Defense
.20 or less	20	35	11	25
.80 or more	185	165	211	150

the Dutch. Once again it demonstrated that the property of internal generating processes of uncertain events has a heavier impact on the probability judgment of the Chinese. However, such an impact became relatively trivial on judging the outcome of a game than on choosing an alternative answer for a general knowledge question, because internal generating processes were not dominated.

Previously, I have tried to explain why the students and the card players made probability judgments very differently. It is emphasized that people do not develop and follow the same way when dealing with different uncertainties. The characteristics of the task can have significant impact on people's selection of cognitive options. The earlier analysis suggests that a repetitive task of externally generated uncertainty is likely to invoke calibrated probability judgments from Chinese people and a heterogenous task of internal generated uncertainty inclines to lead them to make extreme probability judgments. The performance of the Chinese economists, however, has portrayed another picture which does not seem to support this conjecture fully. On the one hand, the economists presented much more poorly calibrated probability judgments than the card players, although the two probabilistic tasks they performed had several obviously similar characteristics. However, on the other hand, even though answering the general knowledge questions and forecasting economic indices are quite different tasks, the probability judgments made by the economists and by the students both exhibited a strong tendency of extremeness. What do these results suggest? How should these seemingly inconsistent results be explained? In the rest of this section, I will analyze the similarities and differences in the probability judgments made by the economists and those made by the students and the card players.

The two tasks, judging the success or failure of a contract and forecasting economic indices in terms of probability, are similar in two primary aspects. First, all the main uncertainties which the economists and the card players faced are externally generated, that is, they are generated from the processes outside the economists and the card players. Second, both of the tasks asked the subjects to make probability judgments about the same or homogeneous uncertain events, which were similar in their problem structures and contents as well. Like the card players, the economists had dealt with similar problems for a long time and were able to accumulate mental records about the past fluctuations of the economic indices. However, several noticeable differences also exists between the two tasks, which may be attributed to the differences in the performances between the card players and the economists.

An obvious difference between the two tasks is that in judging the success or failure of a contract, the card players needed only to estimate the possibility of a contract being made, while the economists who were asked to predict continuous quantities had to imagine the possible outcomes themselves. The results from the economists have shown how often the actual values of the economic indices were outside the outcomes they were able to imagine. In many cases, the economists failed to foresee the rapid increase of the national economy in the fourth quarter of 1990. The task of forecasting the continuous economic indices, I suppose, might have led the Chinese economists to anchor on the earlier data and unwillingly to make a great upward or downward adjustment, even if it was necessary under the present situation. However, this phenomenon could not happen in judging the success or failure of a contract. To examine this, we need to know how the probability judgments of the economists were made.

After the experiment, I discussed with some of the economists about how they made their forecasts, in an attempt to understand their cognitive processes in forecasting economic indices. It was revealed that the economists felt it very difficult to give up their habitual way and to follow the way suggested by the experimenter, even though they quite understood the principle of the method. It was discovered that the economists often adopted a way of "linear extrapolation" to forecast the future values of an economic index. This way was typically described as two phases: first to average the values of the index in the previous three quarters; and then to estimate its future values by making some adjustments to the mean. The outcome was the best estimate to the index. Based on this best estimate, the range of all possible values was then decided. Nevertheless, the economists were rarely able to describe the process of adjusting in great detail. It was understood that such adjustments were sometimes affected by their previous experiences. For example, in the past several years, some of the indices usually had a greater increase in the fourth quarter than in the previous three, and so the indices in that quarter should have a higher speed of increase from month to month. It was also found that the economists often seemed to make the adjustments on, or partly on, their feelings and beliefs about the associations and impacts between various economic factors in the complicated economic activity. Some economists did make some arguments about why they made a high or low forecast, but it does not mean that they were able to explain any adjustment in numerical terms. Also the arguments made by individual economists were not always consistent, and sometimes could be quite different.

Therefore, the first reason, I consider, is that when the Chinese economists were asked to create alternative outcomes, they failed to make sufficient adjustment to the initial value extrapolated from previous data. The way of forecasting described above has been very useful in the past several years and thus has made the economists reluctant to present estimates that they feel too far from the anchors. Unfortunately, in the fourth quarter of 1990, the Chinese national economy turned out to have a great increase with unexpected fast speed. Some of the economists afterwards did recognize that they had ignored some factors or their possible significant impact on the forecast. For example, they had expected a longer period of time before some new economic policies actually took effect. Of course, if the "best estimate" had already been biased, a "biased range" was very likely to be produced. And if they were reluctant to make a big adjustment to the initial value, the range could not be made wide enough to encompass the actual values. I also suppose that the Chinese economists were more confident of their best estimates from the fact that there were too many cases, in which the 100% confidence interval of the judgments did not encompass the actual values. The sudden changes in the economic situation further aggravated the cognitive preference. It was suggested that the Chinese economists might not like to make the estimates of the highest and lowest values which were far from their best estimates.

The second difference between the two tasks is that the economists faced with a far more complicated uncertain situation than the card players. Unlike the game of bridge, the national economy is an open system. Forecasting economic indices involves much more uncertain factors than judging the success or failure of a contract. In playing the game of bridge, the card players clearly knew the distribution of cards and the way of playing of their opponents were uncertain, but the economists might not always be able to write down a thorough list of uncertainty. New uncertainty could emerge, and stable factors in the past could become uncertain in the future. The card players also knew how the uncertain factors affected the possibility of making a contract successfully, but the economists did not always have clear ideas about how the uncertain factors were related to a particular economic index. For such an open system, the repetition of uncertain situations cannot be as strict as it is in the play of the game of bridge. From time to time, greater variances in economic situations can happen and an economist did not have as many opportunities to experience similar situations as did the card players. Given such a big difference in economic measures, it is reasonable to expect the economist to be aware of the very peculiar nature of that quarter, and therefore to display a greater sense of uncertainty. However, in fact, they were much more overconfident than the card players. What are the reasons? I considered that the lack of the uncertainty from observable rivals perhaps is one. It might let the economists feel the situations less uncertain, or controllable to some extent, although the situations which they faced were much more uncertain. Indeed, since a long time ago, the Chinese have given much more concern to the uncertainty and risk involved in competition situations with clear rivals, such as a war. If one traces the Chinese history of decision making, one can find that most of the influential works about decision making are on wars.

Another important reason which might lead to the judgmental extremeness in forecasting economic indices, perhaps, is that the economists somehow mixed their expectations with actual possibilities. Even after the actual results have demonstrated the biases of their forecasts, they still argued, "such high speed of increase is abnormal," "We could not expect such high rates," and even, "We have recommended only 6% to 7% increase in industrial production." Such feelings might have seriously discouraged them to think extensively of unlikely possibilities. They made the low forecasts of some indices, because they disliked seeing the high happen. In this aspect, sometimes they also had overconfidence in the impact of their recommendations on the government. It was also found that the general scenarios of the prospect of the national economy in the minds of the economists had heavily affected their judgments about particular economic indices. With a flamboyant scenario in mind, optimistic forecasts were more likely. Whereas with a conservative scenario, pessimistic forecasts were more possible. In September, 1990, most of the economists attending this experiment favoured moderate increase. It may suggest that the forecasts of the economists perhaps were also biased by their involvement of the processes of decision making regarding the economic policy.

The tasks which both the economists and the card players faced are also different in that the probability judgments would become well known to their colleagues and peers. So, it may be possible that the economists were pushed by some sort of social motivation to make "reasonable" forecasts, that is, a group-process factor may be involved here.

The economists made probability judgments quite similar to the students when they were asked to forecast the uncertain quantities. I suppose that it may be explained by one significant similarity between the two tasks, that is, both the students and the economists made probability judgments about continuous uncertain quantities. The dislike of imagining the "small" possibilities of the values which were far from their best estimates had led to their forecast range being too narrow. Expertise could have helped the economists to make better judgments than the students. Unfortunately it seemed to promote only their confidence in their best estimates. The similarity between the two Chinese groups in probability judgments may suggest an important characteristic of Chinese probabilistic thinking, acknowledging only what they think are most possible and overlooking what they think are almost impossible, especially when the outcomes are imagined by themselves.

After all, the first conclusion which can be derived from the results of the two experiments is that previous findings of cultural differences cannot be generalized into other uncertain situations. People have no constant way of dealing with uncertainty, and they may consciously or unconsciously modify their way in dealing with different uncertainties. The present study has clearly manifested the close association between the ways by which people deal with uncertainty and the features of uncertain events. This finding is not isolated, and corresponds to the finding in the study of risk. For example, MacCrimmon and Wehrung (1986) have illustrated that the risk propensity of executives depended on the situations they confronted. For example, one manager could be found to be a risk taker in a law-suit and a joint venture, but a risk averter in personal gambles. MacCrimmon and Wehrung believe that behaviour in risky situations cannot be generalized across different tasks. It suggests that with varying characteristics of uncertain situations, cross-cultural studies can induce many possible patterns of cultural differences and similarities. Therefore, searching for a general pattern of cultural differences in probabilistic thinking will be unsuccessful, and the division of people from an individual culture into probabilistic thinker or non-probabilistic thinker is overly simplistic.

An important message which future cross-cultural studies in probabilistic thinking can get from this present study is that the investigation of cultural influence on uncertainty judgment should go deep into human cognitive processes in dealing with a variety of uncertain events. Prior generator knowledge, stored historical data, heuristics, and systematic biases may be stressed differently by people in different uncertain situations. This may also explain why early studies were not successful in inquiring into the cultural interpretation of the previous findings of cultural differences. Cultural interpretations can be meaningful and convincing only when they are related to particular uncertain situations. Cultural differences in probabilistic thinking must be traced to the cognitive processes which people go through in making probability judgments. Individual cultural factors may have influence on specific cognitive processes within a particular uncertain situation. It seems to be more persuasive to attribute the overconfidence of Chinese students in answering the general knowledge questions to their self-confidence in their memory, which obviously reflects Chinese cultural tradition in education. Similarly, the more probabilistic attitude that the Chinese amateur card players expressed in playing the game of bridge may be interpreted to their sensitivity to external uncertainty, especially when it comes from rivals, which is related to the cautious tradition in competition promoted by Sun Tzu. Intensive study is demanded in future to investigate human cognitive processes in dealing with different uncertain situations and to probe cultural differences at a more basic level.

Chapter 5. Conclusions

This study started from questioning the validity and applicability of Western decision approaches in a non-Western, in particular the Chinese, culture. It criticized the attitude of simply copying Western decision approaches into China and emphasized the significance of examining the principle assumptions and limitations, and the adaptation of Western decision methods in a quite different cultural environment of decision making. It was recognized that the unique characteristics of Chinese decision makers and thus the clashes and agreements between the Western decision techniques and the Chinese decision culture could not be revealed and understood without studying the behaviour of Chinese decision makers. I considered that such a behavioral study had been neglected in China in the past decades for a number of reasons, and it now should be put at the top of the research agenda of decision making. The present study concerned one of the basic demands of modern decision theory for a decision maker: making adequate probability judgments. Its investigation was mainly concentrated on the adequacy of subjective probability judgments and the human cognitive processes of making the judgments. A series of experiments were designed and carried out for such a purpose. The first one followed earlier studies and employed a general knowledge questionnaire to stir up feelings of uncertainty in the minds of college students. Previous findings of cultural difference in probabilistic thinking were further confirmed and moreover, some relationships between probabilistic thinking and general information processing strategy were also revealed. The subsequent experiments extended the investigation to some other uncertain situations which people might get into in typical decision environments. Players of the game of bridge were asked to make probability judgments about the outcome of a contract in playing the game, and economists were asked to predict the indices which they were most familiar with in the form of probability distribution. I also made efforts to apply proper elicitation techniques in order to reduce avoidable distortion. With careful design of the experiment, I attempted to examine the actual capability of Chinese decision makers in making probability judgments when they were faced with less artificial or abstract tasks. It was my contention that such experiments might provide more meaningful data and thereby highlight more serious implications.

Although I have made an effort to choose typical decision environments to examine Chinese decision makers' behaviour in dealing with uncertainty, this study is certainly far from thorough. Even so, fresh evidence from such empirical investigation may still allow me to make further discussions and induce several preliminary conclusions. First, I will try to describe the cognitive processes which people may go through in making probability judgments in more general terms based on the findings of the present study. Two subprocesses, the structuring of problem and the discriminating of feelings of uncertainty, will be particularly emphasized. With this description of cognitive processes, I hope we can explain better why people sometimes can complete probabilistic tasks as expected, but sometimes cannot. Following this description of cognitive processes, it will also become possible to explain the variation of cultural differences in making probability judgments under different uncertain situations, which were found in this study. In the second section, I will particularly discuss its implications and propose several suggestions for a future cross-cultural study in probabilistic thinking along the progression of cognitive process in making probability judgments. It is hoped that the cultural differences in probabilistic thinking will be further revealed and the specific conditions which are required by individual cultural groups for making good probability judgments will be identified. In the third section, my discussion will move beyond the issue of uncertainty judgment to explore the rationality embedded in Western decision theory. From the discords found between Western rationality in dealing with uncertainty and the observed behaviour of Chinese decision makers, I suggest that the introduction of Western decision approaches into China should be carried out carefully and needs serious preparatory works. Chinese decision makers should be informed about the implication of the Western rational way of decision making, its assumptions and limitations. The requirements for the proper use of Western decision techniques, such as the adequacy of probability judgments of Chinese decision makers, should be investigated before it is actually put into practical use. Also, the discussion about the Chinese way of making decisions and dealing with uncertainty will suggest that keeping an open mind to more alternative ways and synthesizing them efficiently may have some advantage over sticking only to a single way. I believe that this is especially true for Chinese decision makers.

5.1. Cognitive processes in making probability judgment

Previous studies

Numerous experimental data about human uncertainty judgments are available, but are not consistent. Christensen-Szalanski and Beach (1984), for example, found that 44 per cent of the total 87 empirical studies which they reviewed observed good performance, whereas 56 per cent observed poor performance. More recent empirical studies of calibration have also reported both calibrated and overconfident probability judgments (see some examples in chapter 2). The present study has further demonstrated such inconsistency in several Chinese subject groups. The student group and the economist group were found to be very overconfident, but the players of the game of bridge were much more realistic. Contradictory results often lead to opposite points of view. The pessimists claim that too often the cognitive short-cuts or heuristics that people use can lead to biased judgments in dealing with uncertainty (e.g. Kahneman, Slovic, & Tversky, 1982). I have previously mentioned availability, representativeness, anchoring and adjustment. In contrast, the optimists emphasize what Wallsten and Budescu (1983) call an "existence demonstration -- there do exist conditions under which experts can provide subjective probabilities which are relatively free of bias, are well calibrated, and score well". They encourage researchers to study how good uncertainty judgment is made, and to develop proper procedures to help people overcome possible cognitive biases. They also question the appropriateness of the normative models that are used as criteria in the evaluation of uncertainty judgment and argue that the pessimists' evidence of bias may have no firm foundations, as in many studies the subjects and the experimenters may not have shared the same understanding of the experimental tasks at all (Beach, Christensen-Szalanski, & Barnes, 1987). This dispute between the optimists and the pessimists still continues.

I consider that the fundamental difficulty in calming this dispute, is that there are still many unknowns about how people make judgments under uncertain situations. Indeed, it is far more difficult to probe the cognitive processes underneath good or poor uncertainty judgment than simply to demonstrate good or poor judgment. Understandably, most of the studies of calibration mainly focus on the latter issue and leave the subjects' insight unknown. However, a few researchers have made initial efforts to trace the cognition paths in making probability judgments and have proposed several cognitive models, some of which we have seen in the earlier review. Memory searching, inference and discrimination of feelings of uncertainty are commonly described as three subprocesses, although their foci may not be the same. The model proposed by Koriat, Lichtenstein and Fischhoff (1980) emphasizes the processes of evidence searching and assessing, while the model of Phillips and Wright (1977) seems to stress more the tendency of discriminating uncertainty. More recently, based on his experiment using geographical north-south items, May (1986) has proposed a "global process model," describing the cognitive processes of making probability judgment as three phases: problem-solving, emergence of subjective certainty and quantification. With this model, the author illustrates how subjective confidence and the probability of a correct answer (accuracy) are related, and how background knowledge, and the inferences subjects have made from it, influence the two factors. The experimental items are assumed to be solved by inferences from cognitive maps, and miscalibration is explained as the result of a mismatch between subjective confidence and the probability of a correct answer.

However, to date most of the cognitive models of making uncertainty judgment are derived from the experiments using general knowledge questionnaires, and inevitably have their limitations. Perhaps it is not at all the original intention of those model constructors to describe human cognitive processes of making uncertainty judgments in general. Not surprisingly, they may not exactly describe how weather forecasters make probability judgments about precipitation or tornados, how underwriters estimate probability about a car crash, how lawyers assess the probability of whether a suspect is innocent or not, and so on. More important, as most of the models were developed under the shadow of the findings of overconfidence, is that they have less power in describing how some other groups or individual subjects can avoid overconfidence and obtain calibrated probability judgment in dealing with different probabilistic tasks. In particular, these models tell us little about how people discriminate between their internal feelings of uncertainty and then transform them into numbers. I have suffered from such insufficiency myself in searching for the reasons behind the quite different performance between the Chinese students, the economists and the players of the game of bridge. The theoretical study of human cognitive processes of making probability judgment should go beyond the limitation of general knowledge questionnaires and develop cognitive models based on the evidence collected in more general uncertain situations.

The lack of a theoretical study in cognitive processes does not restrict researchers from finding ways of improving the quality of subjective probability judgment. Several necessary conditions have been identified and formal rules or procedures have also been proposed. Phillips (1987) has listed eight conditions which he believes to be essential for assessors to generate precise, reliable and accurate probability judgments. Mainly, the assessors are required to be experts or a group of experts in the concerned field. And, a training in probabilistic thinking should be given as necessary. Simplifying complex events or reconstructing problems are indispensable in some situations to ease the difficulties of making probability judgment.

Similarly, Von Winterfeldt and Edwards (1986) have also proposed several rules for getting probability judgments properly. They believe that assessing uncertainties that may control significant decisions is a serious business and should be done in the right atmosphere, and say that classroom settings are inappropriate. Good procedure is suggested too. The quantity to be assessed should be clearly defined. The same or related questions should be asked in various ways to look for inconsistencies, as this may promote people to think hard about the entire problem behind the uncertain quantity. And finally feeding back the scores obtained from proper scoring rules or calibration data to respondents, to a certain extent, can be helpful, although it is not informative about how one should think differently, only about how one should behave differently.

Stael von Holstein and Matheson (1979) have even written a manual that provides decision analysts with detailed guidance to elicit subjective probability distribution about an uncertain quantity. They divide the procedure of eliciting probability into five phases: motivating, structuring, conditioning, encoding and verifying. In order to achieve reliable results, a subject is first motivated to realize the importance of his responses to the decision making and to become willing to take part in the encoding process. The uncertain quantity is defined and structured in the second phase. For this, it needs to inquire and understand how the subject considers the quantity, the variables he thinks relevant, the information he uses, and so on. In the third phase, the subject is promoted to evoke his knowledge relating to the quantity, which will provide the subject with a conscious basis for making probability judgments and can help him overcome possible encoding biases. The subject's judgment is quantified in terms of a probability distribution in the fourth phase. All values or probabilities elicited in this phase are plotted on a probability graph paper away from the subject's view. Finally, the judgments are tested to see if the subject really believes them. If the subject is not comfortable with the final distribution, it may be necessary to repeat some of the earlier steps of the interview process.

Although these studies did not directly discuss the cognitive processes of making probability judgments, we still can perceive some of their understanding about the processes from what they recommended or discredited. The formal rules or procedures of encoding accumulate the authors' long-time observations and experiences as decision analysts, reflecting their perception of the conditions under which adequate probability judgment are more likely to be made in many real decision situations. Generally, good judgments are frequently found among experts. Feedback can help overcome inconsistency and encourage further thinking. Adequate elicitation techniques may ease the difficulty of discrimination of internal feelings. However, why can expertise be helpful and how can it guide the making of a calibrated judgment? How does feedback make adjusting of probability judgments happen, and what kind of feedback can lead the adjustment in the right direction? It is not enough to answer such questions depending only on external perception of the possible relationships between the performances and conditions. Even so, these studies, in non-experimental situations, are an inspiration and do lead to deeper thinking of how good uncertainty judgments are made and where poor ones go astray.

Some scholars have also concentrated on developing particular techniques to improve subjective probability judgments, which also motivate deep thinking about the cognitive processes of making probability judgments. Fischhoff (1982), for example, has reviewed most of the well received studies and he reported two experimental findings: overconfidence and hindsight biases. He summarizes a series of debiasing strategies which are categorized according to their implicit allegation of culpability, that is, whether responsibility for biases is laid at the doorstep of the judge, the task, or some mismatch between the two. Lichtenstein and Fischhoff (1980) have conducted 11 training sessions, each of which involved 200 two-alternative general knowledge items, to observe whether training can ameliorate probability judgment. The subjects were given feedback immediately after every training session, which included the distributions of probability judgments used by the subjects and the quality of judgment measured by overconfidence, calibration, knowledge, resolution and the total Brier score. Most of the improvement happened after the first training session and cannot be generalized to other different tasks. Although the results are encouraging, such studies still leave us with uncomfortable feelings. Why was there no further improvement in the later training sessions, and more basically, how did the training reduce overconfidence? For example, it is a fact that Sweden is about thirteen thousand square kilometres smaller than Kenya, but a subject may be quite confident in his belief of the reverse and argues that Sweden does cover a larger area than Kenya in his Penguin Map of the World. How can the debiasing procedure described above considerably reduce subject's confidence, without informing the subject that a same area is drawn larger in high latitudes than in low latitudes in the map? The corrective procedures described above seems to be "treating only symptoms but not the causes of a disease."

Satisfactory answers to the questions which I have raised above cannot be found from the results of early psychological studies of human cognitive processes of making probability judgments. Much more effort in theoretical study is required to examine human cognitive processes of making probability judgment in uncertain situations other than using general knowledge questionnaires. The task characteristics, which a general knowledge questionnaire may not have, should be given particular attention in the study. For without this, we will continue to argue about whether or not we should trust the subjective probability judgments of decision makers. And without this we cannot lay down a reliable foundation for further development of adequate encoding and correcting procedures. In the rest of this section I seek to develop a model based on present study, which may describe, in more general terms, how probability judgment is made. Before that, we need a further analysis in order to understand the connotation of the conception of calibration.

Calibration standard

Lichtenstein, Fischhoff and Phillips (1982) opened their review of the study of calibration of probabilities with the following statement:

"From the subjectivist point of view (de Finetti, 1937/1964), a probability is a degree of belief in a proposition. It expresses a purely internal state; there is no 'right','correct', or 'objective' probability residing somewhere 'in reality' against which one's degree of belief can be compared. In many circumstances, however, it may become possible to verify the truth or falsity of the proposition to which a probability was attached. Today, one assesses the probability of the proposition 'it will rain tomorrow.' Tomorrow, one looks at the rain gauge to see whether or not it has rained. When possible, such verification can be used to determine the adequacy of probability assessments."

Here, Lichtenstein et al. reject the objective explanation of probability from the subjectivist stand, but apparently also recognize that useful subjective probability should not be far away from objective frequency of occurrences in a long term. Do the authors mean that calibration is an objective standard of subjective probability, at least in some cases? I would not like to speculate further and it may be better to follow them and thereby keep away from the long-lasting theoretic controversy. However, I should emphasize here, that no matter how theoretical the disputes are, the hard fact is that subjective uncertainty judgment has to face objective verification in many situations. And no matter how subjective uncertainty judgments are, if they guide decisions, the realistic ones may probably be rewarded more and unrealistic ones may probably be punished more in the real world. The argument here is very much concerned with the quality of subjective probability which the decision analysis technique demands, rather than the internal or external attributions of probability. Not surprisingly, even though such "goodness" of uncertainty judgment has been argued not to be required inherently in subjective decision theory, most decision analysts take this problem seriously and many decision makers hesitate to use decision analysis before they are convinced about the adequacy of subjective judgment. Indeed, according to a respondent of Von Winterfeldt and Edwards (1986), "Many serious decision makers are concerned about cognitive illusions and refuse to use decision analysis. I do not wish to justify this attitude but it is very common." Actually, in real life, people seem to be more pragmatic and are ready to get feedback and adjust their subjective opinions against external occurrences from time to time, even if they may not follow the Bayes' theorem spontaneously in the theorists' eyes. They know they cannot afford to ignore the objective boundary of subjective judgment. From their experience, they know that to survive and to make a success they must adapt themselves to the changing environment.

Probability may be thought of as expressing decision makers' internal feelings, but its freedom is certainly restricted by the external environment. Such restrictions can be sensed in the active adjustment of decision makers and in the pressure from reality. In fact, the emergence of the measurement of calibration is a response to the requirement of describing the restriction in a quantitative way. Making a probability judgment is a discrimination process of internal feelings about uncertain events which develop and happen following some unknown or partly unknown ways. Calibration requires decision makers to discriminate appropriately their feelings of uncertainty into categories of number and more importantly to map accurately such a numerical categories with the frequencies of uncertain events. Cognitive processes are needed to tune the mapping against the feedback from time to time.

Discrimination

In order to make adequate probability judgments, people first must be able to discriminate their feelings of uncertainty finely. It means that people are required to express their feelings to a resolution of 0.01, or at least 0.1. The difficulty for people in fulfilling such a task can vary greatly in different uncertain situations. People may find even a rough discrimination almost impossible in one situation, but may be able to present their probability judgments with a high precision in another. Answering the general knowledge questions seems to be a very difficult task in the sense of discrimination of feelings of uncertainty. Lichtenstein and Fischhoff's (1980) subjects, for example, even after attending 11 training sessions of 200 general knowledge items, were still rarely able to describe how they made their mental discrimination in great detail, and especially felt it difficult in the use of intermediate responses of 0.6, 0.7, and 0.8. Such predicaments can be better understood from the vivid descriptions in the following students' self reports, "I think I'm still kind of unsure on how to use 0.7 and how to use 0.8 because I either feel I don't know it or I know it, and it's sort of hard to say how much I don't know something," or "I think I'm judging a little bit better between my 0.5's and 0.6's --just what is a 0.6--but I don't think I really know what a 0.7 is yet." Similar observations were obtained in the present experimental studies too. The students were found to be very hesitant to discriminate their feelings of uncertainty in answering some of the general knowledge questions.

The experiment of using the game of bridge as a task, however, provides us with a quite different picture. The Chinese players of the game of bridge seemed to be much more comfortable than the students in making probability predictions about the success or failure of a contract. It was a total surprise when the experimenter found that the card players made their probability judgments so decisively and swiftly that he was actually worried that they had not given the numbers wholeheartedly, they being captivated by the competition itself. However, as we have seen, their performance turned out to be much better than the students', in terms both of discrimination and of calibration.

It is clear that the students endured much more difficulty than the players of the game of bridge in making mental discriminations of their feelings of uncertainty. But what makes such a difference? There is no available answer. Most of the previous studies have concentrated on exploring the cognitive processes of how people solve a problem and the factors which may increase or decrease confidence, but the process itself, in which people discriminate their feelings of uncertainty into several categories, has more or less been neglected. Although most of the cognitive models of making probability judgments contain a phase of translating the feelings of uncertainty into numbers, few of them have described the process of mental discrimination in detail. The differences between uncertain situations in the need of mental efforts or the difficulty in discriminating between the feelings of uncertainty thus has also been ignored. From the study of Fischhoff, Slovic, and Lichtenstein (1977), it may be understood that overconfidence in making probability judgments results partly from subjects' ignorance of the inappropriateness of their inferences and the biases in the views reconstructed from their memory. However, is the subjects' inability to discriminate their feelings of uncertainty in a fine way also a reason behind the overconfidence phenomenon? Phillips and Wright's (1977) model stresses the distinction between the thinking situation as black and white and the thinking situation probabilistically, so a detailed description of mental discrimination of uncertainty was not their major concern. However, the sharp contrast between the performances of the Chinese students and the card players suggests that serious mental difficulties in discriminating their feelings of uncertainty might have pushed the students to make more unrealistic probability judgments. These speculations led me to inquire how people translate their feelings of uncertainty into numbers.

First, let us consider how a player of the game of bridge estimates a probability of the success or failure of a contract. In playing the game, card players feel uncertain about whether a contract can be made or not, because they cannot get to know the actual distribution of cards in the hands of their partners and opponents, and because they cannot predict how their opponents are going to play. When the card players are asked to predict the outcome of a contract in terms of probability, the most natural way that they may follow to approach a probability judgment is the so-called "ergodic" way. That is, being card players of several years' experience, they can estimate the probability of success of the contract in question by retrieving the frequency of success of a class of similar cases accumulated in their memory. This way can be further balanced by a singular way, with which the card players also take the propensities of the particular case at hand into account as they still observe the differences between the immediate case and previous similar cases.

However, my greater concern at this stage is how the card players translate their feelings of uncertainty about the success of a contract into probabilities. I suppose that the process is fulfilled through a kind of tangible comparison of evidence. The situation of playing the game of bridge allows the card players to make fine discriminations between their feelings of uncertainty about the success of contracts. It is clear in the card player's mind that the distribution of cards, the opponents' strategy and the content of the contract are main factors which decide whether a contract can be made or not. It is also clear how these factors affect the results. A contract of high claim has less possibility of completion than a contract of low claim. Facing strong opponents, the card players in the offensive position will have less chance of successfully making a contract than when facing weak ones, and with advantageous cards they are more likely to achieve good results than with disadvantageous cards. Most importantly, these factors can be measured to the extent that fine mental discrimination becomes possible for the card players. The card distributions can be carefully measured depending on whether they are in favour of making a contract. Ace is counted as 4 points, King 3 points, etc. The difficulties of making a contract may be measured by its required number of successful rounds (tricks). Even the strength or weakness of a card player can be measured according to the "level" which he has reached. Based on empirical evidence, a card player having played thousands of games may have stored a series of patterns of game in their memory, which are finely categorized according to their propensities of leading a contract to success or failure. Therefore, mental discrimination of feelings of uncertainty does not become difficult and can be fulfilled by recognizing the present patterns and comparing them with previous ones. Although no counts have been made yet about the number of patterns that an experienced card player of the bridge game can recognize, the numbers of different configurations of pieces on the chessboard which expert chess players can recognize have been estimated at around fifty thousand (Simon, 1983). Even assuming the numbers of patterns which the card players attending our experiment recognized are not so high, an accumulation of around several thousands or even several hundreds can make their mental discrimination much easier. It may partly explain why the card players could be so decisive and swift in making probability judgments and showed good performance. And a key difference between expert card players and amateurs, among others, is that the experts accumulate more patterns and are able to recognize and discriminate them more finely.

In contrast to the task of playing the game of bridge, a general knowledge questionnaire is a set of heterogenous items which covers a variety of domains of knowledge. For every question, subjects are required to make a choice from, say, two alternative answers and present a probability to express how sure they are about their choices. A choice made by a subject may be a result of memory searching, a consequence from reasoning, or a mixture of these two. It may even simply come from his intuition, "This answer sounds right." If a subject has no idea about a question, he just needs to pick up one and present a probability of 50%. If he finds evidence which can definitely reject or confirm one of the two alternatives, he will also have no difficulty to present a probability of 100%. However, it is more common that he cannot be absolutely sure that he has chosen the correct answer. The recollection in his mind may be blurred, the inferences may not be convincing enough. Past experiences may also tell him that intuition is not always reliable. In such situations, subjects have to find a number between 50% and 100% to express their feelings of uncertainty.

The subjects responding to a general knowledge questionnaire approach a probability in quite different ways from the card players. They make judgments based on the arguments of weighing and shifting evidence or on unanalyzed experience (Kahneman & Tversky, 1982). However, I consider that to make fine discrimination of feelings of uncertainty with such ways is very difficult. Suppose that a subject is asked, "Which legs do cows use first when getting up from the ground, hind legs or front legs?" If he is like many other people, he may have never carefully observed how cows get up, although he has seen cows numerous times in his life. He decides to choose the answer, "front legs", simply because he feels an image of a cow getting up with hind legs is somewhat funny. How should the subject work out a number to express his feelings of uncertainty about the choice? It is very difficult based only on such unanalyzed experience. In such a situation, people fall into a situation which demands discrimination of pure feelings. With "pure", I mean that people have no way to transform such discrimination of feelings of uncertainty into some kind of tangible comparison between uncertain events. Maybe there are no difficulties in using 50% or 100% to express the feelings of total uncertainty or certainty. However, how strong should the feelings of 55%, 60%, ..., and 95% be? Any attempt to ask subjects to enumerate their feelings of uncertainty will make us realize the difficulty of carrying out such discrimination of pure feelings, as the subjects of Lichtenstein and Fischhoff experienced. There is no demand in day-to-day life for making fine discrimination of pure feelings, and so there is very little practice. Similarly, people perhaps should present high probabilities when their recollections are sharp, or low probabilities when they are blurred. However, our experience can tell us that it is also a rather hard task to make fine mental discrimination depending only on memory clarity. Suppose in a subject's memory the scene that acids turn litmus paper to red is brighter than the scene acids turn litmus to blue, so that the subject selects the answer "Red". But how sure should he be in terms of probability? Could you expect that he can sort this kind of feelings of uncertainty into eleven meaningful categories depending on the clarity of vague recollections? Although there is evidence that people are more confident when their memory is correct, I have less confidence in their ability of making fine discrimination depending on the clarity of their recollections. Until now, few calibrated probability judgments have been found in the responses to any general knowledge questionnaire. In contrast, very often the middle parts of the calibration curves were found horizontal or fluctuating randomly.

Can people make fine discrimination of feelings of uncertainty based on internal arguments? In many situations it may be very difficult. For example, the question, "Which city is further north, London or Beijing?" can be dealt with in a fashion of reasoning. A subject may first think that Beijing should be on a latitude further north than London, because Beijing is much colder than London in winter. However, the fact that Great Britain is an island country warmed by the Gulf stream may also remind him that the maritime climate may still make London warmer than Beijing, even if it is farther north.

The two pieces of evidence lead to different choices, and both of them are obviously not sufficient to lead to a certain answer. The subject has to balance between the evidence with incomplete reasoning. Suppose that the subject finally somehow selects London. How high should his confidence be? It depends on the subject's beliefs about the vague relationships between evidence and conclusions. Fine measurement of feelings of uncertainty seems to be less possible based on such vague reasons. The subject may hardly explain why he presents a probability of 70% but not 60%. People may recognize their own uncertainty and lower their overconfidence, if they can find other different ways to arrive at an answer (Pitz, 1974), or if they can find more negative reasons (Koriat, Lichtenstein, & Fischhoff, 1980). However, people still have to face difficulties of measuring their feelings of uncertainty. Perhaps it is one of the reasons why some elicitation techniques use instruments, such as the probability wheel, to ease such difficulty in making mental discrimination. The comparisons between two areas of sector in a wheel or two heights of counters in troughs may make mental discrimination visible. However, it is conceivable that even with such help, the mental discrimination described above is still rather difficult, due to its abstractness.

The characteristics that the contents of most of the questions are unrelated make such mental discrimination of feelings of uncertainty more difficult. Even when a subject notices that he ought to make consistent judgments among the general knowledge questions, he may still have difficulties if he tries to discriminate the feelings of uncertainty about unrelated questions. Suppose that a subject makes both of the judgments, based on unanalyzed experience, about the birth place of singer Frank Sinatra and the name of the Apollo lunar module that landed the first man on the moon. Can he explain why he gives a high probability to one of them and a low probability to the other. The fact that Japanese like eating rice may lead to a judgment that Japan produces more rice than wheat, and the fact that Finland was occupied by Sweden during late twelfth century may lead to selecting Swedish rather Norwegian as the second official language of Finland. How can a subject compare the power of conviction between the two pieces of unrelated evidence? Of course, it is quite possible that subjects may have different feelings of uncertainty about these two choices, but what I argue here is that people may have less difficulty with homogenous items and their probability judgment may also be more reliable. May (1986) supposed that the subjects had constructed a geographic image in their minds in judging which city was further north or south between many pairs of cities. If the two cities are quite close in a subject's image, his confidence about the judgment may be low. Similarly, if two cities are distant in his image, he has more confidence about his judgment. From this, May has distinguished two kinds of task difficulty and has further argued that calibration is theoretically possible, when the difficulty is noticeable for the subjects (e.g. in pure psychophysical problems where difficulty only results from variations in the objective differences which are the basis for a comparison). However, the subject is necessarily overconfident, if the difficulty is a property of an item that strengthens the tendency towards a wrong answer (misleadingness), but cannot be detected, because it is based on the individual's own wrong knowledge.

To make an adequate probability judgment people require to express their feelings of uncertainty in a fine differentiated way. Previous discussion suggests that this is sometimes easy, but sometimes it is a really hard task. Fine measurement is unlikely to be achieved when people wrestle with discrimination of pure feelings. It has been shown that the students had much more trouble than the card players in making probability judgments. With unanalyzed experience, they were not likely to make meaningful and fine mental discriminations of feelings of uncertainty aroused by unrelated general knowledge questions. I conjecture that fine measurement of feelings of uncertainty is more attainable when people can relate mental discrimination to a tangible comparison between uncertain events based on measurable evidence. If such comparisons can be carried out easily, mental discrimination can become less difficult, and the more meticulous such comparison can be, the finer the mental discrimination can be achieved. The card players obviously have an advantage in this aspect. Fine comparison between patterns has led to fine measurement of feelings of uncertainty about the success of contracts. The image in the card players' mind may be an accumulation of different game patterns which are related to possible results in some way. The examples that I discussed here may represent two extreme situations. More often people may not face such extreme situations and the mental difficulty in measuring the feelings of uncertainty can thus vary between the two extremes. Unanalyzed experience, incomplete inference, and fragmentary comparison between patterns may all make their contributions to an uncertainty judgment. It is also possible that people may not have the same mental difficulty in measuring their feelings of uncertainty even if they are in the same situation. Experts in an area may feel less difficulty in making fine discrimination between feelings of uncertainty than do novices, as they may know more and different patterns and can make a finer comparison between them. In this sense, mental discrimination depends on experience. However, the possibility of carrying out tangible comparisons is more essential.

Mental problem structure

Sound mental discrimination of uncertainty is a necessary condition for making adequate probability judgments, but it is certainly not a sufficient one. A group of subjective probabilities may be consistent and finely discriminated, but its curve can still be far from perfectly calibrated. Calibration requires decision makers not only to discriminate their feelings of uncertainty into fine categories and to express them consistently, but also to make precise mapping between subjective probability judgments and objective occurrences. This is the second, but more fundamental, hurdle that people have to overcome. I consider that such precision of mapping depends on whether people can develop a sound structure of the problem. Mental discrimination is carried out within structure, and if people construct an inappropriate problem structure, their judgment may have already been steered in the wrong direction, no matter how fine the discrimination. Calibrated probability judgment can be made only when the mental problem structure appropriately, or at least approximately, matches the real problem structure.

The issue of problem structure is certainly not new. In dealing with reality, people have to, and can, condense a huge outside world into a small world in their mind. Such words, "size up the situation accurately" or "get to the heart of the problem" express people's desire to catch the core problem structure efficiently within the limitations of their capacity of information processing. However, this issue does not draw sufficient attention in the study of cognitive processes of making probability judgments. Recently, the lack of understanding of subjects' problem structure has been noticed by several researchers, although they do discuss uncertainty judgment in general terms.

Phillips (1983), for example, has expounded the importance of knowing the subjects' internal structural representation of the task for adequately interpreting their data. In proposing his generation paradigm, he further emphasized the role of problem structuring and argued that process was embedded in structure and people could not talk about information processing without reference to the internal representation of the task. He also distinguished general structure from problem structure which represented the task at hand. From the inspiration of the early research on cultural and individual differences in probabilistic thinking, Phillips supposed that people might impose a general structural framework on a problem. It was suggested that in dealing with uncertainty, British people tended to use causal structure, while the Chinese tended to take fatalistic structures. He regarded that general structuring, problem structuring, and information processing were carried out in any order and they were done iteratively.

In a similar vein, Beach, Barnes and Christensen-Szalanski (1986), and Beach, Christensen-Szalanski and Barnes (1987), have also argued that experimenters often neglect how the subjects frame the problems in their minds and they wrongly assume that subjects share the same understanding of the experimental task with them. They suspected that many of the reports of poor performance and findings of biases might not stand scrutiny, if the subjects had misframed the problems from the beginning. In their contingency model of judgmental forecasting, they proposed two ways which people might follow to frame problems: aleatory and epistemic reasoning.

The basic distinction between the two ways of framing problems is their focusing on the characteristics of the element in question. Aleatory reasoning treats all elements in a particular set as mutually intersubstitutable and ignores their unique properties. In contrast, epistemic reasoning explicitly involves knowledge about the unique characteristics of specific elements and the framework of knowledge, including the causal network and set memberships, in which they are embedded. It is suggested that some of the observed poor performance in judgmental and reasoning tasks results from subjects using epistemic logic on what "properly" are aleatory problems. More importantly, while in most discussions it is assumed that aleatory rather than epistemic logic is appropriate, this assumption is not necessarily justified from the subject's point of view. These two ways of framing problem seem to be viewed as the general structures which Phillips have discussed. Beach, Barnes and Christensen-Szalanski also argued that whether a subject tended to use aleatory or epistemic reasoning to frame a problem was not arbitrary, and the characteristics of the task itself appeared to dictate the choice.

To develop a generative problem structuring calculus, Humphreys and Berkeley (1983; 1985) have proposed a multi-level scheme to conceptualize decision problems. This scheme formalizes over five progressive levels of abstraction along with the process of cognitive development within decision makers. At each level, the operations performed by the decision maker in developing a problem representation are modeled. The content manipulated at each level is qualitatively different, and what is represented as form at one level can be manipulated as content at its next level.

The operations at the first level are concrete and limited to providing "best assessments" of quantities to be represented as content at a defined node in a problem structure that has been fixed a priori. Making probability judgments and assessing preferences are typical operations at this level. At the second level, formal operations are performed to explore the decision problem representation through varying the value assessed at any chosen node within the structure and to investigate the impact of doing this at other points of interest within the current representation. Sensitivity analysis is such a type of operation. More fundamental operations in structuring and restructuring a decision problem are manipulated at Level 3 and above. At the third level, a decision problem is structured to handle a particular uncertainty of high level, such as the uncertainty about how to conceptualize the worth of consequences when more than one criterion is involved, the procedural uncertainty that concerns means to process a decision, and so on (Berkeley & Humphreys, 1982). Decision problem-structuring activity at Level 4 is to articulate the principles that enable the manipulation of complete Level 3 problem-structuring systems as content. A decision maker working at this level has either to articulate these principles within his or her own natural language or to learn a new language for generating systems linking Level 3 (sub)problem representations into a structure comprising the whole range of aspects of the problem under consideration. The activities at Level 5 are moved forward to explore the small worlds that encompass the decision maker's problem-structuring activities and the knowledge representations that the decision maker believes to be relevant to these activities. More high levels of abstraction can be developed.

However, in calibration study, the relationships between the development of problem structure and probability judgment do not draw enough attention. Subjects are often presented with a given uncertain event and are asked to make probability judgments. Perhaps it is because, in decision theory, people are often assumed to face a problem which has already been structured and only need to assess numbers to the given uncertain events. Humphreys and Berkeley have put the operation of making probability judgment on the lowest level of abstraction in representing decision problems. However, I must argue that whether people can provide adequate probability judgment is related to the exploration of the whole problem structure and that making probability judgment is a complicated process starting long before the moment of giving a number.

When uncertainty is one of the decision makers' major concerns, the uncertainty of the problem of structure may become a main part of the whole decision problem structure. Uncertainty is perceived, identified, or disregarded with the development of decision problem structure. In many situations, the structuring of the problem of uncertainty cannot be separated from the whole decision problem structuring, which is embedded into the entire process of the development of decision problem structure. First, uncertainty is tied with the development of options. Specific uncertainty only draws the attention of a decision maker when it can be related to an option. Suppose that John works in a company and has not been promoted for many years. Now he considers whether he should take some actions to change such a situation. There may be no obvious uncertainty relating to the option of doing nothing. However, if he thinks of the option of moving to other companies, various uncertainties will emerge, the opportunity of promotion in the new position, the working environment, the prospects of these companies, and others. Very different uncertainties may also appear, if making a complaint to his boss has also been considered as an option. His boss may accept or reject his demand immediately, or may promise to consider it in the future. So, people consider different uncertainties when they think of taking different actions. Second, with the identification of uncertainty, further options will be created. For example, the possibilities of being rejected or getting no clear promise may lead John to consider further options, to threaten his boss that he may move to other companies, to wait for three months, and so on. New uncertainties then will come out in his mind with the creation of new options. In such a way, uncertainty is structured in the mind of decision maker with the unfolding of the whole problem structure, or in other words, the structuring of decision problem moves forward with the structuring of uncertainty.

In a calibration study, people are often asked to make a probability judgment about a given uncertain event, and there is no clear requirement for them to develop the whole uncertainty problem structure. However, I consider that making a probability judgment should be viewed as a process starting from the structuring of problem. Previous analysis suggests that it is not always appropriate to label uncertain events with a number, and very serious effort is needed to structure uncertainty problems, including the identification of all the possible outcomes (individual events) and the investigation of the relationships between the related events. Although in this phase, the quantification process of uncertain events may not have started, such activities can vitally affect later probability judgment about a particular uncertain event. In a calibration study, subjects usually are not asked to construct an exhaustive set of events themselves and experimenters often present them with a given event. In some situations, the exhaustive set to which the given event belongs is explicit. For example, success and failure clearly consist of an exhaustive set of events in a game of bridge. However, in some situations, it is not easy to imagine all the possibilities. For example, John may overlook the possibility that his boss does not take a simple action of rejecting or accepting his demand. Even for the game of bridge, if card players are not asked to judge the success of a contract, but the score of a game, they may meet much more difficulties to construct an exhaustive set of events. Humphreys (1983) has presented a real case which describes how Neer, a motor company failed to predict all the possible outcomes of an action that had been taken. After Neer took the decision from four options to investigate a private branding of tyres, to its surprise it found that no tyre manufacturer was willing to bid for its contract. Failing to construct an exhaustive set must bias the probability judgment towards the clearly identified uncertain events. Even failing to represent such a set properly may also lead to biased judgment. Fischhoff, Slovic, and Lichtenstein (1978) have found that subjects underestimated the possibility of "other reasons" causing the failure of starting a car. However, it is not uncommon in a calibration study to present subjects with an uncertain event and simply ask them to estimate the probability of whether one outcome will happen or not, without explicitly presenting many other possible outcomes. For example, the physicians in the Christensen-Szalanski and Bushyhend's (1981) study perhaps would have given less overconfident probability judgments if they had been presented with or had been asked to imagine all of the main diseases, not only pneumonia, which can be associated with the symptom of a cough, rather than being simply asked to estimate the possibility of pneumonia. The second impact of early structuring of the problem of uncertainty on later probability judgment is that, with the development of problem structure, the relationships between the events have also been assumed. Such assumptions as independency, interdependency and conditional dependency, can also affect later thinking about uncertainty of individual events. Especially, in order to simplify a complicated problem, people tend to ignore "trivial" dependency, which sometimes can breed serious mistakes in making a probability judgment.

To make probability judgments about individual outcomes, people need further effort to explore the problem of related uncertainty. With the discovery of the relevant factors affecting the development of an uncertain event, and the understanding of how the movement of these factors leads to individual outcomes, a structure can gradually be built up. People grasp the real problem by developing such a problem structure before they make a probability judgment. This structure is a representation of a real problem in their mind, it dictates the information that they demand in judging outcomes, it determines the rules that they follow in weighing and integrating evidence, and it influences the ways that they apply in discriminating the feelings of uncertainty. Obviously, it may not always be possible to find a perfect structure under uncertain situations. In some situations, people are unable to find a causal system at all, and may have to retreat to a reliance on their observations of occurrences of past events. Making probability judgment about the side of a coin tossed in the air, the sex of a newborn baby, and the outcome of thrown dice are all such cases. However, there are few uncertain situations which in reality have so neat a form, and subjective probabilities about such uncertain events are rarely needed. More often, people are able to go beyond the accumulation of frequencies and probe a problem more deeply, although they may only be able to develop an unsound or fragmentary structure. The factors involved may not all be identified and the associations between the known factors and possible outcomes may not be clearly clarified. Such a structure cannot serve people as a good guidance in searching for information or in utilizing it to predict the possible outcomes. So, feelings of uncertainty will emerge. This kind of uncertainty expresses solely people's beliefs or confidence in the appropriateness of their mental problem structure.

People make probability judgments with the problem structure they have developed and the accuracy of the judgments, thus, depends heavily on the appropriateness of the problem structure. Although any problem structure can be argued as a biased representation of a reality, some structure may still be more appropriate than the others. It should not be doubted that people are more likely to make calibrated probability judgments with an appropriate structure than with a distorted one. Therefore, the verification of probability judgment is primarily the verification of subjective problem structure. In this sense, developing a sound problem structure has prime importance in making probability judgments.

A subjective probability is a degree of belief in an uncertain event, but such belief is strengthened or weakened by the belief in the soundness of the structure on which the probability judgment is based. Before estimating probabilities, people have already assessed the soundness of the structure that they developed. Just how uncertain people may feel about an event is closely related to their beliefs in the soundness of structure of the problem which has the event as one of its outcomes. Obviously, confident judgment is more likely to be made with a satisfactory structure, while less confident judgment is more likely to be made with an unsatisfactory structure. The feelings that people have about the soundness of the structure may vary with the change of situation.

A complete structure can become incomplete when the information about a key factor is not available. A structure may only be valid under specific conditions and can be very sensitive to the change of some relevant factors. In dealing with uncertainty, people may develop a series of variations on a basic structure. In order to make calibrated probability judgment, people must be able to assess the soundness of the variations of structure in a proper way. Overestimating or underestimating the soundness of a structure can bias probability judgments.

Once people have a problem structure in their mind, no matter if it is complete or incomplete, they will search for information and process information within this framework. Various compositions of information representing different situations then can be compared and the discrimination is fulfilled. A sound structure can make it easier to realize tangible comparisons and fine discrimination is more hopeful than a fragmentary structure.

Uncertainty can be increased by an assessor's inability to develop a sound problem structure. However, even with a sound problem structure, people can still feel uncertain, if they cannot get sufficient and reliable information. Of course, people more often face worse situations, under which both of the problem structure and information environment are not ideal. Their beliefs about the quality of information can also increase or decrease their confidence about the probability judgments which are made based on such information. The final number, a probability, is a result of integrating all the feelings about the structure and information and comparing the present case with past similar cases, or with other parallel uncertain events. Therefore, I suppose that in making probability judgments, people may go through the processes of problem structuring, information searching, and uncertainty quantifying. In this supposition, I have particularly stressed the effect of uncertainty problem structuring on probability judgment and the possible ways with which people discriminate their feelings of uncertainty.

Applications of the general model

With the model proposed here, several problems which I raised earlier perhaps can be better explained. The key point I argue here is that a proper matching between subjective and real problem structures is a fundamental condition for making calibrated probability judgment. Many early studies gave little regard to the effect of feedback on adjusting the uncertainty problem structure and only noticed its effect on discouraging overconfidence. In this study, only an insignificant effect of feedback was found in the probability judgments of the card players of the game of bridge. Perhaps, it is because the card players have formed rather stable problem structures from their long time at playing the game and that cannot be significantly modified with only short-term feedback. The previous lack of success in experiments on training may have been the result of the failure of the feedback provided to have any impact on the adjustment of problem structure. So, training people to develop a sound problem structure may be more helpful than just letting them scratch the surface of overconfidence. Probability judgments about homogenous and repeated events are often found to be better calibrated. The main reason, I suppose, is that with such events people are allowed to develop a consistent problem structure. There should be no surprise when we find experts often presenting good performance in making probability judgment about events in their area, as they have almost all the advantages mentioned above and so they are able to develop a sound problem structure which leads their probability judgment in the right direction. Previous analysis has clearly shown that the players of the game of bridge is such a case. Similarly, calibrated probability judgments are also found among the players of field hockey games (Vertinsky, Kanetkar, Vertinsky, & Wilson, 1986), the meteorologists in weather forecasting (Murphy & Winkler, 1974), the physicians attending an emergency room (Lusted et al., 1980), banking experts in predicting future interest rates (Kabus, 1976), and so on. I suppose that such good performances are grounded on the sound problem structures they have developed.

However, if developing a sound problem structure becomes difficult or almost impossible, poor performances will probably result. The physicians (Christensen-Szalanski & Bushyhend, 1981), even as experts, did present very uncalibrated probabilities of pneumonia for 1,531 patients who were examined because of a cough. The reason behind the poor performance perhaps is that the physicians had never faced such a task in their routine diagnosis and failed to adjust the problem structure developed in the past to deal with the new problem which was specifically designed for the purpose of the experiment. Not surprisingly, very poor performances were shown when people had difficulty in developing a sound problem structure, that is, catching the core of the problem. Asking the college students to judge the nationality of the children by their drawings, to predict stock price depending only on the data published in the newspapers (Lichtenstein & Fischhoff, 1977) are exactly such cases. If they did not know how to deal with the problems, we would not expect that they could build up a sound problem structure, and thereby present calibrated probability judgments. Calibration could be even worse if the experimenters presented a subtle task which can easily lead subjects to develop a wrong problem structure or ignore the difficulty in developing a sound problem structure.

5.2. Implications for future cross-cultural studies

The development of this cognitive model also has important implications for any future cross-cultural study in probability judgment. Early findings of cultural differences between the British and several Asian groups in probabilistic thinking have led to the supposition that people from different cultures deal with uncertainty differently because they may not cast the same general problem structure in dealing with uncertainties (Phillips, 1983). In the first experiment of this study I examined whether people's probability judgment was related to their ways of perceiving information and of making decisions, and the results suggested some different characteristics between the general problem structures of the Chinese and the British students. Although the first experiment provided some positive evidence to the supposition, the possible general problem structures that Chinese and British people may hold have not been clearly identified and how they lead to different performances in making probability judgments is also far from clear. The inconsistent performances which were later found among several groups of Chinese subjects implies that the relationship is much more complicated than it first seemed to be and may not allow a simple explanation. In future studies, more extensive experimental works are required to investigate the variations of performance under a wider range of uncertain situations, especially for the Chinese case. Moreover, such investigations should go more deeply into human cognitive processes of making probability judgments. On this point, the cognitive model proposed here may be helpful as it can lead the investigation of cultural differences in probabilistic thinking into individual cognitive levels. In future experimental studies, the tasks which can lead to identify the general problem structure, both Western and Chinese, and to contrast the ability of discriminating their feelings of uncertainty between Western and Chinese people, should be carefully chosen. It may also be particularly useful, if we can find some way of comparing people's performances before and after they have built up a structured way of thinking about a problem. It may be able to tell us more about the effect of problem structuring in making probability judgments.

This study has shown that the cultural differences are task specific. It demonstrated that the Chinese card players judged the outcome of a contract in a probabilistic way, but the Chinese students and economists performed their tasks in a non-probabilistic way. Subsequently, the cultural differences found between the Chinese and Western people do not form a constant pattern. Indeed, people may start from different points and follow different routes to achieve their objectives (equifinality). According to the model proposed above, future cross-cultural study needs to investigate how Chinese and Western people form their problem structure in dealing with various uncertainties and whether their problem structures have different characteristics. We may not expect that Chinese and British always form the same problem structure, even for the same problem. Obviously, Western and Chinese traditional physicians definitely do not follow the same way of examining patients and interpreting the origin of diseases. And Chinese businessmen and their Western counterparts may perceive uncertain situations quite differently. Therefore, if Chinese are found to perform probabilistic tasks differently from their Western counterparts, it is quite possibly because they may not structure the same problem in the same way in the first place. Correspondingly, when Chinese and Western people make alike probability judgments, perhaps that is first because they hold similar problem structures. The experiment of the game of bridge is probably is one such case. Western and Chinese card players quite possibly held the same problem structure. So, how people from different cultural backgrounds structure problems of uncertainty should be the first issue to be investigated in any future cross-cultural study. Before searching direct associations between general problem structure and probability judgment, it is very worthwhile to look at how people in different cultures develop their own problem structures. Only after sufficient investigations of problem structuring in a variety of uncertain situations, can we identify some general problem structures which Western and Chinese people may have in their minds in dealing with uncertainty and understand how the identified general problem structures influence the formation of the structure of a specific problem and the whole process of making probability judgment.

In problem structuring, there are two issues which I suggest future investigation should look closely at. The first one is the imagination of alternative outcomes of an uncertain event. Until now this issue has not been carefully explored in calibration study. In fact, many previous studies either simply presented the subjects with all the outcomes of the uncertain events and thus eliminated the possibility to observe how people themselves would have thought about the outcomes or assumed the subjects would know all alternative outcomes, but made no inquiry to the process of imagining of outcomes. However, I consider that the imagination of alternative outcomes should not be separated from the investigation of calibration, since it may influence probability judgment. The Chinese economists made extreme probability judgments, probably because they could not imagine a wider range of possible values of the economic indices for the future. And even the Chinese card players were asked to judge only the success of a contract, but it was still possible that they had more alternative outcomes in their minds, e.g. a contract failed with 4 tricks or 5 tricks, a contract made with 7, 8, 9 tricks. In future cross-cultural studies, the ways people in different cultures imagine outcomes, and the number of the outcomes that they can imagine, should be compared, and possible reasons should also be analyzed.

Another issue I consider as important is the focusing that people have on probabilistic tasks. A calibration study usually requires subjects to make probability judgments about a series of uncertain events, which may be tightly or loosely related in some way. People may focus their attention on these uncertain events differently. Some of them may give more attention to the common characteristics of the whole task and easily build up a common problem structure to deal with individual items. Good probability judgments, or at least consistent judgments, more likely occur based on a sound problem structure. However, some people may tend to focus their attention more on the particular characteristics of individual items or their differences and so ignore their common characteristics. A common problem structure thereby is less likely to be developed, and the experimental items are dealt with separately. With such a way, consistent and good probability judgments probably cannot be expected. In the discussion about Chinese culture, focusing on particularity has long been argued as an evident characteristic of Chinese thought. It may be one of the reasons why Chinese people tend to make extreme probability judgments in some situations. In future cross-cultural study, comparison between different cultural groups in this aspect will give us more insights about the cultural differences in probabilistic thinking.

Future cross-cultural studies should also consider how people in different cultures search out information to support their making of uncertainty judgment. Although this study has compared the ways of information perception and evaluation between Chinese and British students, I have discussed little about the characteristics of the content of information itself. Is there any cultural difference in the preferences of information between Chinese and Western decision makers? In calibration study, subjects are often asked to make probability judgments about a series of repeatable uncertain events. However, in reality, few uncertain events can exactly repeat themselves as tossing a coin in the air, and one specific case is always different from others in this or that aspect. I suppose that Chinese tend to catch particular and concrete information in some situations, as they view the cases as individuals and Western people may be more interested in general information about all the cases and tolerate the "trivial" differences.

In previous studies of probabilistic thinking, mental discrimination of feelings of uncertainty has remained almost untouched. However, this present study suggests that there may be a cultural difference between Chinese and Western people in discriminating their feelings of uncertainty, especially when such discrimination cannot be transformed into some kind of tangible comparison of evidence. It requires further investigation to see if Chinese people have more difficulty in discriminating internal uncertainty than their Western counterparts, as suggested in the comparison between the Chinese and the British students.

The investigation of these issues may be closely related in many situations. For example, we may still not be able to understand why people in one culture feel more difficulties than those from another culture in discriminating their feelings of uncertainty without comparing the structures they developed for a particular problem.

5.3. Rationality in dealing with uncertainty

Until now the inquiry of the present study to the applicability of Western decision approaches in China has mainly concentrated on the adequacy of probability judgments of Chinese decision makers. Although the inconsistency between the three groups of Chinese people in making probability judgments still does not allow me to make a conclusion easily, a series of analyses of the results do demonstrate that culture has significant impact on the way of probabilistic thinking, and such impact may vary from situation to situation. These findings imply the conditionality of the use of decision analysis techniques on culture, and promote a more serious and cautious attitude to the introduction of such "soft" Western techniques into China, which is definitely not as simple as the import of some forms of "hard" Western techniques. In this final section, however, my discussion will go beyond the adequacy of probability judgments to a more general issue, the rationality behind the way of making decisions and dealing with uncertainty advocated in the Western decision theory. I will examine the strengths and weaknesses of the Western rationality in Chinese culture.

Western Rationality

Rationality is used to describe human behaviour. In the West, the conception of rationality is closely related to reason. When J. H. Newman said "We call rationality the distinction of man, when compared with other animals", he meant that human beings had the power of being able to exercise reason. Rationality has been extensively discussed in the literature of philosophy and economics. For example, some economists have described a human being as "economic man" who behaves in a rational way of pursuing the maximization of subjectively expected value. A broad definition of rationality is given by Simon in "A Dictionary of the Social Science" (Gould & Kolb, 1964), which denotes rational behaviour as being appropriate to the achievement of given goals within the limits imposed by given conditions and constraints. Later Simon (1976) further defines such rationality as substantive and distinguishes it from procedural rationality which is used when behaviour is the outcome of appropriate deliberation. This definition is quite understandable from people's daily experience of using the word(s). Most people here or in the United States might think that Saddam Hussein was irrational in deciding to fight with the allied army in the Gulf war. Henry Kissinger, the former American Secretary of State, must be one of them, for only nine days before the Gulf war broke out, he had made the confident prediction on BBC television Newsnight programme that no such conflict would take place by saying "Saddam is not mad. He knows that a war will destroy the one thing that keeps him in power - his military machine."(The Times, January 17, 1991). So, from Doctor Henry Kissinger's point of view, Saddam was certainly irrational, or substantively irrational, because his behaviour was not in line with his own goal. Rationality may also be used in another way, to evaluate the processes of making judgments or decisions. For example, one person is appreciated by his colleagues as rational, often because his judgments or decisions are made based on proper reason, not dominated by his feelings or emotions. Of course, with rationality people may mean both the action and the way of deciding to take the action are rational in many situations.

Von Winterfeldt and Edwards (1986) have also clearly distinguished two kinds of rationality, the rationality in the build-up of goals or the selection of ends or moral imperatives and the rationality in selecting ways of thinking and acting to serve the ends or goals or moral imperatives. They called the latter "instrumental rationality". In the literature of decision making, a definition which Jungermann (1983) thought was common, specifies rational action as being in line with the values and beliefs of the individual concerned, or more precisely, is "logical" or "consistent" as stated in a set of axioms. Watson and Buede (1987) have more directly defined that a person's behaviour is considered as rational when his action is consistent with the rules which he has adopted. In modern decision theory, the principle rule of making a choice is maximizing subjectively expected utility, and the rule of judging uncertainty is to follow several axioms of probability.

It is obvious that Western and Chinese cultures do not cultivate consistent ideas of value, beliefs, social consensus, and so on. Therefore, very possibly, some behaviour which is considered as rational in Chinese culture may be evaluated as irrational in the West and vice versa. For example, borrowing money and paying high interest in order to buy a car or some other expensive goods is quite normal here, but most Chinese may think it is irrational. It is not unusual to find Chinese families in Britain placing saving as a priority, even if it may disqualify the families on low incomes from claiming social benefits. This kind of difference is more concerned with the ideas of value and social traditions between the two cultures, but not the ways by which they reach their judgments or decisions. This study does not discuss such conflict of rationality, which is closely related to the values or beliefs rooted in different cultures. It is interested in the rationality of the way by which people achieve the goal, that is, the rationality in the way of making decisions, the way of dealing with uncertainty in particular, and the cultural differences between Chinese and Westerners in such rationality.

The essence of Western decision theory and the analytic procedure developed from it is that they provide formal guidance of strict logic to decision makers. Western decision theory is the fruit of Western philosophy, which is keen to develop a theoretic system from assuming a set of simple axioms about utility and probability. The rationality that it advocates is to adopt these axioms and make judgments and decisions only when they conform to them. Whether a decision maker behaves rationally or not is judged by whether his thought and action comply with the rules, which are either defined by the assumed axioms or derived from them. For example, if one's probability judgments can satisfy $P(A)P(B/A) = P(B)P(A/B)$, one's probabilistic thinking is rational, otherwise it is irrational, because one's judgments are contradictory to the rules of probability. If one takes the course of action leading to maximal expected utility, one behaves in a rational way, otherwise one doesn't, because one gives up the choice which can be proved as the best on the basis of rules of utility.

Exercising rationality needs great effort. Following the analysis procedure developed in Bayesian decision theory, a complex and uncertain decision problem should first be decomposed into several alternative actions and the expected consequences, when each action is taken, listed. The preferences of a decision maker to certain outcomes are measured in terms of utility, and the possibility of the occurrence of the outcomes are estimated as a probability value. Following particular rules, numerical judgments about values and possibilities are recomposed, and the best candidate for the course of action emerges as the one which has maximal expected utility. In the past decades, many techniques have been researched and developed to help people properly carry out such analysis.

However, this rationality, even in the West, is still far from being widely acknowledged. Its basic assumptions and feasibility of operation are both under fire. Many scholars have criticized Bayesian decision theory on the basis of the findings concerning the conflicts between human behaviour and the fundamental assumptions of the theory. One piece of evidence often referred to is that many people do not respond to Allais' (1953) paradox in a rational way, as assumed by Savage's "sure-thing" principle. For example, consider the following table which describes Allais' paradox. The task is to choose between gamble 1 and gamble 2 in both situation A and situation B. The table shows the probabilities of winning and the amounts of money for the various gambles.

	Probability of winning		
Situation A	0.01	0.10	0.89
Gamble 1	£1,000	£1,000	£1,000
Gamble 2	£0	£5,000	£1,000
Situation B			
Gamble 1	£1,000	£1,000	£0
Gamble 2	£0	£5,000	£0

For this problem, the "sure-thing" principle supposes that a subject would choose either gamble 1 or gamble 2 in both situations, that is the change in the amounts of money with 0.89 chance of winning should not influence the subject's choice, as for both gambles they are still same. However, in responding to such a test, most subjects who had chosen gamble 1 in situation A, were found to turn to gamble 2 in situation B. So, varying the values of outcomes of a state do affect people's choice between two alternatives, even if the values are still kept as the same for the two alternatives.

Similarly, Ellsberg's (1961) paradox also showed that many people's behaviour violated the "sure-thing" principle. In the Ellsberg's test, a subject is first asked to imagine an urn known to contain 90 balls, 30 red, and 60 black or yellow with unknown proportions. Then he is asked to consider a decision problem under two situations which can be described below.

	Red	Black	Yellow
	(30)	(60)	
Situation A			
Bet on red	£100	£0	£0
Bet on black	£0	£100	£0
Situation B			
Bet on red or yellow	£100	£0	£100
Bet on black or yellow	£0	£100	£100

It was found that most subjects responding to such a test preferred betting on red than on black in situation A, but preferred betting on black or yellow than on red or yellow in situation B. Obviously, it conflicts with the "sure-thing" principle, as it is easy to see that in both situations, the two alternatives have the same outcomes if a yellow ball is picked up. In situation A, the subjects who decided to choose betting on red, probably had presumed that there were less than 30 black, or more than 30 yellow balls in the urn. However, in situation B, they turned to betting on black or yellow, probably because they supposed that there were less than 30 yellow balls! This phenomenon also leads to doubting the assumption that a decision maker's beliefs can be represented by a unique probability measure, as it is shown that most people prefer the alternative of exact probability to the alternative of "ambiguous" probability.

There are not many scholars who still argue that rationality is a sound description of the natural mind. That is, in reality people may often violate the rules which are set according to the axioms of utility and probability. However, many scholars accept the adequacy of this version of rationality and emphasize more and more its normative characteristics.

Howard (1980) speaks bluntly of normative rationality embraced in Bayesian decision theory. In his opinion, it is not important whether the rationality is descriptive or not. The power of decision analysis is just that it can improve natural decision making as people's natural decision processes are often deficient when they meet complex decision problems. Howard has also strongly defended the rationality implicated in the axioms of probability. More moderate attitudes to the imposition of such rationality are found among other scholars. Watson and Buede (1987), for example, explicitly point out the conditionality of rationality on fundamental assumptions and its usefulness in enhancing consistency in decision making. Rationality is judged by the rules it adopts, and different rules can lead to different judgments about rationality. Choosing one rule is to decide how to behave in a complex decision making situation. Watson and Buede emphasize that although decision theory constitutes a sensible set of rules to follow, it does not necessarily mean that people who do not comply with the precepts of decision theory are irrational and they may well have perfectly sensible rules of their own which they are following most rationally.

If we accept normative rationality, can it be achieved in dealing with real decision problems? The answer of Von Winterfeldt and Edwards (1986) to this question is that rationality is attainable. They believe that rationality in decision making can be reached if decision makers can be provided with sufficient and efficient decision aids. They have argued that the SEU model is an appropriate tool for finding a rational choice and introduced many decision techniques which they thought can help a decision maker assess probability and evaluate utility properly. However, they also clearly recognize the reliance of realizing instrumental rationality on structuring decision problems. The SEU model can lead a decision maker to a rational act, only after he knows the problem, the alternatives, the uncertainty, and the values of outcomes, that is, after he has clearly structured the problem. Rationality is meaningful only when it is related to a specific problem structure.

In contrast, Simon (1983) believes that rationality is unattainable from the point of the impossibility of satisfying the requirements of using the SEU model. He described the SEU model as "a beautiful object deserving a prominent place in Plato's heaven of ideas," but could not be employed in any literal way in making actual human decisions. He argues that when facing a complex, dynamic and uncertain decision problem, a decision maker, with limited information processing ability, just cannot find all the alternative choices, cannot predict the consequences of each of the available choices, cannot assign a joint probability distribution to future states of the world, and cannot balance all his conflicting partial values and synthesize them into a single utility function, as the SEU theory assumes he can do. Simon considers that people cannot realize global rationality, but only "bounded rationality". In reality, people rarely pursue the object of maximization, but behave like "administrative men" and search only for satisfying solutions. From his argument about the limits of reason, Simon also emphasizes that the SEU model at best tells us how to reason about fact and value premises, but says nothing about where they come from. In fact, Winterfeldt and Edwards have also recognized the weakness of the SEU model, but they attempt to remedy it by developing adequate techniques of structuring decision problems.

Simon rejects global rationality and admits only bounded rationality, from the impossibility of satisfying the premises of the SEU model. However, there are other scholars who do not reject the use of the SEU model, although they also accept that people have limited information processing ability. They promote the rational way of making decisions, but at the same time, are very cautious in imposing the analytic result into the real world as a rational act. Phillips (1983), in discussing his theory of requisite decision models, seems to express such a point of view. The key point of his arguments, of concern here, is that the primary use of building models in decision analysis is to develop a social reality of shared understanding of the problem by the problem owners. The goal of creating a requisite model is to help construct a new reality, to create a future. The final result should be seen as a guidance and at best it is conditionally prescriptive, because the model is only an approximation of reality and the understanding of decision makers to the problem may be deficient when the model is built up. Although in the case study that they introduced, Phillips and his colleagues employed the multi-attribute value model as a tool, his arguments, to my understanding, certainly do not exclude the SEU model.

Rationality has been widely disputed for decades and the above discussion is far too limited to do it justice. However, with this discussion I wish to highlight several points which are of real concern here. First, decision analysis with the SEU model as a major instrument is powerful in enhancing logic and consistent thinking in judging uncertainty and making decisions. Second, the rationality contained in Western decision theory is derived from a series of fundamental assumptions and so it is not unique and must have some limitations. Third, the SEU model does not contain a vital decision activity, structuring the decision problem. This still remains as art.

"Irrational" Chinese way

The Chinese way of making decisions and dealing with uncertainty in many aspects has been suggested as irrational by today's Western decision theorists and analysts. Some of their viewpoints have been mentioned in the first chapter. Recently, Lieberthal and Oksenberg (1988) have discussed the limitation of imposing a rational model to interpret the processes of current Chinese policy making and argue that the reality does not allow the Chinese leaders to attain the rationality which the Western scholars assume. Instead, Chinese leaders actually pursue the building of consensus among participants in decision making. Perhaps, from the Western standpoint of rationality, the Chinese way of making decisions can be judged as irrational in many aspects. However, in a broad sense of rationality, such judgments may not stand. It is hard to imagine that the ancient Chinese developed only very irrational ways of making decisions over several thousand years, and that it could survive. Many decisions in Chinese history are appreciated not only in China, but also in other countries. Fukuda (1988), for example, regards Qin Shi Huang (The First Emperor), who unified the country in 221 BC, as a great manager by any standards. After the dynasty was founded, The Emperor decided to standardize weights and measures, currency, roads, written language, and so on, which accelerated subsequent development of China as a unified nation, and which even today are considered as crucial and should be admired. Probably, the fact is that Chinese decision culture had developed in a very long period of isolation from the West and thus cultivated a very different way of decision making and different ideas of rationality.

Perhaps, the main characteristic of Chinese decision making which astonishes Westerners and leads them to make judgments of its irrationality is its lack of a strictly logical analysis and its heavy dependence on intuition. However, this point may not be fully supported by the results of the first experiment which used the MBTI. This is possibly because the concept of intuition discussed by many philosophers is much more general than the MBTI can test with several simple questions. This phenomenon is closely related to the development of the whole Chinese culture. Indeed, recent rethinking about Chinese culture has attributed the sluggish development of science and technology in modern China to the lack of boldness in creating a strict theoretic system from several assumptions made in ancient China (Lin, 1985; Jin, 1988). Ancient Chinese had no less scientific findings than their Western contemporaries. For example, the description about the Gou Gu theorem (Pythagorean theorem) can be found in an ancient Chinese mathematical book, Zhou Bi Suan Jing (The Arithmetical Classic of the Gnomon and the Circular Paths of Heaven) written during Warring States period over two thousand years ago. However this finding and many others had never led to a development of a theoretical system of geometry and they were often proposed along with the solving of practical problems. Again, the Mohists even designed very elegant experiments in physics, especially in optics. However, this research method was soon given up in later scientific research. The ancient Chinese scientists left their descendants many masterpieces, such as, "Qi Min Yao Shu", "Meng Xi Bi Tan", "Ben Cao Gang Mu", and "Tian Gong Kai Wu", which collected, sorted, and compiled ancient Chinese knowledge, experiences, and methods in agriculture, handicraft industry, and medicine. However, no integrated theory has been further developed from these works. The deficiency in the development of a theoretical system in ancient China is closely related to less interest by ancient Chinese in logical reason and modelling.

So, not surprisingly, in ancient Chinese decision books, one may hardly find any strict development of concepts as in the West, but simply principles. For example, Sun Tzu (Griffith, 1963), in the opening chapter, spoke directly of the five fundamental factors and seven elements in the estimation of a war situation without making any logical arguments. Ancient Chinese sages developed principles from experiences and their intuition. These principles were then explained and taught by vivid analogy and actual cases. For example, to let people understand the proposition that soft can beat firm and weak can overcome strong, Lao Tzu explained, "Nothing is softer than water in the world, but in attacking strongholds water is second to nothing." When Sun Tzu emphasized to the readers the importance of adapting to the situation, he compared an army with water and said, "as water shapes its flow in accordance with the ground, so an army manages its victory in accordance with the situation of the enemy." The readers were not convinced by logical arguments, but by such analogy, context, and actual cases. The readers understood the profound meanings behind principles with their own experience and intuition, and the resonance stuck in their mind. So, teaching and learning were not completed through strict definitions, concepts, and logical arguments, but intuitive comprehension. And in the development of the Chinese way of decision making, the decomposition of problem, logical reason and synthesis which prevailed in the West were apparently bypassed.

Of course, it is naive to say that the ancient Chinese made decisions without analysis. In fact, one can find very rational analysis in many ancient decision works. However, the rationality mostly reflected in their penetrating comprehension of a problem, but not the rationality in the way of making decisions that stresses strict logical analysis as advised in the West. The lack of logical analysis presumably results from Chinese decision makers' extreme faith in their intuition. Indeed, even now when the Chinese managers attending the training course given by Western scholars in Da Lian, China were asked to estimate their own managerial type, most of them still thought they were intuitive in decision making (Pegels, 1987). However, the intuition admired by Chinese is not intuition in a simple sense, but intuition inspired from the experience of their own and more importantly, of their ancestors which they inherited from the immense historical records of decision making. Since Confucius compiled "Spring and Autumn", over two thousand years of ancient Chinese history has been chronologically recorded by ancient historians throughout the dynasties. Si Maqian wrote "Shi Ji", 130 chapters in 13 years (104 B.C. to 91 B.C.), which recorded the rise and fall of nations and historical figures over several hundred years. "Zi Zhi Tong Jian" of 294 chapters written by Si Maguang in 19 years recorded the experiences of success and the lessons of failure in country management for over 1,300 years, which served as reference for governors. Ancient Chinese history is also rich in works on decision making, especially about war. Chinese decision making is heavily affected by this historical heritage.

In ancient China, some decision problems, such as in war, were well explored and had relatively stable structures. From the experience accumulated and recorded over a long period of time, an uncertain situation has gradually been substituted by a group of possible states which happened in the past. At the same time, for every state, various alternative ways had been tried, selected and compiled to cope with the problem. Therefore, for successive decision makers, the solution to the problem seems to be straightforward. The present situation may be compared with similar situations in the past, and the best option is suggested from previous experience of success and failure. What some ancient decision theorists actually did was to categorize situations and advise corresponding strategies. For example, in an ancient Chinese work on war, "Thirty-six Strategies", a series of alternative strategies were assembled and recommended, which could be chosen in fights according to different situations. Wu Tzu, another well-known ancient Chinese military strategist, especially wrote one chapter in his own "the Art of War" to explain how to respond to changing situations, one solution to one particular situation. In "Bai Zhan Qi Lue" ("One Hundred Ingenious Strategies"), Liu Qi expounded 100 different military strategies based on historical battle cases.

Therefore, over a long period of time, a series of relatively stable problem structures have been developed in Chinese decision culture. Of course, new experience may add more alternative options and different possible states from time to time. Therefore, decision making might consist of two main activities, correctly identifying a situation and choosing an option from the alternatives suggested to the identified situation. Knowing that reality is always more complicated and varying, many ancient Chinese decision theorists also emphasized the art in the application of strategy and repudiated any rigid manner. "Fighting only on paper" has been used to satirize the person who applies theory idly. Of course, the developed strategies and tactics may also be extended to deal with other quite different decision problems, but with similar problem structure. For example, some strategies and tactics developed for fighting can be used for running a business.

In dealing with uncertainty, ancient Chinese decision theorists have emphasized prudence and adaptability to change. The famous argument of Sun Tzu, "Know the enemy and know yourself; in a hundred battles you will never be in peril" has suggested the attitude. Zhu Geliang, a famous military strategist in Chinese history, was well known for his extreme discretion in making decisions. To estimate uncertain situations many relationships between evidence and possibility have been suggested based on past experience. Chinese decision makers may prefer waiting until the situation becomes almost certain rather than taking a decision under uncertainty, especially, when they believe that they have been able to predict all the possibilities and have been well prepared to deal with whatever happens. This tendency is obviously related to their beliefs in experience and intuition. Of course, it probably also reflects the cultural differences in the attitude towards risk between Chinese and Western people. For example, Chinese people tend to wait to see when facing uncertainty, as they may be more prone to risk avoidance. However, such discussion will make us include another important topic in the cross-cultural study, but unfortunately, I am not able to discuss it further here. Nevertheless, it is evident that the Chinese way is unlikely to lead to a trade-off between value and uncertainty, or to lead to a balance between gains and losses in terms of a series of quite different decisions. Following the Chinese way, uncertainty is overcome step by step with the development of a situation, and a decision is often made in an incremental fashion.

The traditional Chinese decision culture has significantly impacted modern Chinese decision makers. One can easily find how similar Mao Tzetong's military thought is to Sun Tzu's. One can also find the way of dealing with uncertainty described above in today's Chinese officials or managers engaging in the corporation that is developing oil resources with Western companies. When the prospect of oil or gas in an area is not clear, they avoid any participation of finance and leave it to foreign oil companies, but keep the door of later participation in development open as wide as possible. The decision about the project of Three Gorges has been prolonged for several decades, as huge uncertain factors are involved.

Assimilation of Western decision approaches

Therefore, the Chinese way of decision making is concrete, experience-oriented, and intuitive, which consists of particular rules and strategies to deal with different kinds of problems. Chinese decision makers are guided by the strategies which have been used and enriched from generation to generation. They are decision tools for Chinese, but the application of them remains as art and needs intuition and creativity. Considering the lack of logical analysis, it is clear that the quality of Chinese decision making should and can be improved through use of Western decision approaches, in the sense that they are powerful in stressing formal procedure and enhancing logical and consistent thinking. The Chinese processes of decision making, in which experience and intuition dominate, can be compensated from and reinforced by powerful analysis aids. This becomes more important, if we notice that in modern China an overappreciation of experience and intuition is still popular. In early 80's, the Baoshan project, building a steel factory which was the biggest in Chinese history, started even without a careful feasibility study. It is not unusual that decisions are made in such a way. Formal and analytic procedures can promote careful investigation and consistent thinking. Especially, when the analysis is supported by advanced information technology, such as decision support systems, it becomes more powerful. Complicated computerized models of decision problems are built and run, which can demonstrate a possible future. Sensitive factors can be tested and warnings given in vital situations. With the help of Western decision techniques, better decisions will become more possible.

However, in the Chinese reactions to the Western decision approaches, one attitude should be immediately rejected, which is held by some people, and that is the fascination with only the beauty of modelling and the quantifying of a decision problem in Western decision approaches. They ignore the fact that no matter how exquisite a model is, "garbage in, garbage out". I fully agree with Howard's points of view that the overall aim of decision analysis is not numbers, but insight. Particularly, I argue here that quantifying decision makers' feelings of uncertainty cannot reduce the substantial uncertainty they face. In calibration study, it has been long argued whether or not people can make calibrated or adequate probability judgments. However, there are no researchers, to my knowledge, who have discussed the limitation of calibration of probability judgments. In particular, some optimists seem to deliver an illusion that people can make calibrated probability judgments, if they are well trained, aided, and so on. However, it must be said here that in some uncertain situations there is no way which can lead people to make calibrated probability judgments. From the previous discussion about problem structuring, it is believed that people feel uncertain first about the structure of a problem. Facing an open system, they are not able to identify a complete set of events. They may not even know what they need know. In this sense, probability judgment is only a kind of numerical expression of uncertain feelings and calibration is simply an aim which cannot be reached under some uncertain situations.

In the introduction of Western decision techniques, one should clearly notice its limitation. As mentioned previously, the Western way of decision making has provided very limited help as yet for these vital activities of decision making, structuring problems and creating alternatives. Also, modern decision theory only permits long-term benefits for a decision maker. However, long-term benefits are irrelevant, when a decision maker is unable to continue his decision activity because of an immediate loss. The Chinese way should not be disregarded as it has some merits. First, Chinese culture has a rich vein of alternative options, or strategies, which were developed for dealing with particular decision problems. They are the great resource of the Chinese people and should be better tapped and used. With these, new alternatives can be further inspired and imagined for the problems confronted. Second, as intuition has played a very important role, Chinese decision culture may have some advantage in developing intuition in decision making. For example, Sun Tzu proposed the alternative of defeating the enemy without fighting, which even today is well appreciated in the West. In many aspects, the Chinese and Western way of decision making can reinforce each other. Following the Chinese way of decision making people examine change through deep investigation into particular problems and attempt to find the most likely outcome, while the Western way may promote people to consider a variety of possibilities properly but may also lead them to being satisfied with simple uncertainty estimates. It is a great challenge to find a proper way to synthesize the Chinese way with Western decision approaches.

5.4. Concluding remarks

In this final chapter, I have made my own contributions to the progress of cross-cultural studies of calibration and of decision making. I hope that I have made clear several points, which I consider to be very important. In comparison with previous studies, this present study has made a much greater effort in probing how people develop a problem structure and how they discriminate their feelings of uncertainty within that structure. It has been demonstrated that Chinese people may feel more difficulty in discriminating their feelings of uncertainty if they are unable to transfer it into some sort of tangible comparison. In some situations, cultural differences found between Western and Chinese people may be explained simply in that they do not develop similar problem structures for a same problem in the first place. The Dutch and Chinese amateur card players did not present very different performances, probably because they generated and held similar problem structures in making their probability judgments for the outcomes of the game of bridge. The tendency of extremeness found in the probability judgments of the Chinese students may show that they were less capable in making fine discrimination of feelings of uncertainty. The difficulties in developing a precise mental problem structure might have forced the Chinese economists to take some heuristic ways of making their forecasts and this led to their failure.

Although the experimental work of this study has provided some positive evidence, one may easily find that such support is still limited in some aspects. When I started this study, I had the ambition of presenting a more general description of the Chinese way of dealing with uncertainty and making decisions. Unfortunately, such an ambition is still far from being realized, due to my inexperience and the particular difficulties for a student in organizing the experiments in a foreign land. I managed to carry out three experiments, but two parallel experiments for British card players and economists had to be abandoned. Otherwise, the cross-cultural comparisons would have been better. Some regrets are also unavoidable. My speculations about the subprocesses of problem structure and discrimination of feelings of uncertainty emerged only after the experiments were completed, so with hindsight, I thought I should have done them better. Future studies certainly can advance this study in many ways. The subprocesses of discrimination of feelings of uncertainty and problem structure can be more effectively investigated with more soundly designed experiments. Future cross-cultural comparisons in probabilistic thinking may also be more productive through turning their investigations to the differences between Western and Chinese people in developing problem structures and discriminating feelings of uncertainty. It may not be too far away that a better explanation for the cultural differences in dealing with uncertainty and decision making in general will appear.

I hope that I have been successful in arguing the serious implications of the findings of cultural differences in dealing with uncertainty for the introduction of Western decision approaches. I believe that Chinese decision makers need to assimilate Western information technology and decision analysis techniques to improve their decision making. However, it should be a process of selection and renovation according to Chinese decision culture. Chinese decision makers must avoid counterproductive learning. They should listen to the old Chinese saying:"A young man heard that the people in Han Dan, the capital of Zhao, walked in a very graceful manner and went to learn from them. He returned home, crawling. Not only was he unable to learn the Han Dan's way, but he also forgot his own".

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