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Masao Ogaki
Saori C. Tanaka

Behavioral Economics

Toward a New Economics by Integration with Traditional Economics

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To Rieko, Rem, and Renee

—Masao Ogaki

To my family

— Saori C. Tanaka

Preface

This book is intended as a textbook for a course in behavioral economics for advanced undergraduate and graduate students who have already learned basic economics. The book will also be useful for introducing behavioral economics to researchers. Unlike some general audience books that discuss behavioral economics, this book does not take a position of completely negating traditional economics. Its position is that both behavioral and traditional economics are tools that have their own uses and limitations. Moreover, this work makes clear that knowledge of traditional economics is a necessary basis to fully understand behavioral economics. Some of the special features compared with other textbooks on behavioral economics are that this volume has full chapters on neuroeconomics, cultural and identity economics, and economics of happiness. These are distinctive subfields of economics that are different from, but closely related to, behavioral economics with many important overlaps with behavioral economics. Neuroeconomics, which is developing fast partly because of technological progress, seeks to understand how the workings of our minds affect our economic decision making. In addition to a full chapter on neuroeconomics, the book provides explanations of findings in neuroeconomics in chapters on prospect theory (a major decision theory of behavioral economics under uncertainty), intertemporal economic behavior, and social preferences (preferences that exhibit concerns for others). Cultural and identity economics seek to explain how cultures and people's identities affect economic behaviors, and economics of happiness utilizes measures of subjective well-being. There is also a full chapter on behavioral normative economics, which evaluates economic policies based on findings and theories of behavioral economics.

Tokyo, Japan — Masao Ogaki
Kyoto, Japan — Saori C. Tanaka

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Part II Prospect Theory and Bounded Rationality

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Part I
Behavioral Economics and Neuroeconomics

Chapter 1
What Is Behavioral Economics?

Abstract This chapter defines behavioral economics as "the study of economics which does not rely on the assumption of the rational, selfish economic man." It also gives some examples of experimental studies in behavioral economics.

Keywords Behavioral economics · Economic man · Endowment effect
Ultimatum game · Dictator game

This chapter explains what behavioral economics is. Since many studies can be categorized both in behavioral economics and traditional economics,[1] defining behavioral economics is not an easy task. While presenting the definition of behavioral economics that will be used in this book, this chapter will also discuss several concrete examples of experimental economic studies[2] in behavioral economics. These will give the reader a practical understanding of what behavioral economics really is. In the following chapters we will go into depth on the theory behind these examples.

1.1 What Is Economics?

Economics is often thought of as the study of how to earn money or avoid loss. As a part of economics, behavioral economics can certainly speak to this point. Among the general audience books that discuss behavioral economics, many will focus narrowly on this subject alone. To avoid a misunderstanding, we would like to be clear that satisfying this particular curiosity is not the purpose of this book. Before defining behavioral economics, we will begin this chapter with a clear definition of the field of economics itself and then proceed.

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[1] In this book traditional economics includes neoclassical economics, new Keynesian economics, and traditional game theory. An example of studies that can be categorized both in behavioral and tradtional economics are those for outcome-based social preferences as explained in Chap. 8.

[2] For the principles and methodology behind both behavioral and traditional economic experiments, see Davis and Holt (1993).

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Economics is the study of how scarce resources are or should be allocated among people. Here, scarce resources mean land, oil, plants and animals, the environment, and human time and labor, among others. Allocation addresses the method of producing goods and services, as well as to whom the goods are allocated and how much each person consumes. A central theme of economics is to understand people's individual behavior and interactions. These factors form the basis for the entire allocation process. If we can understand this process, then we can also understand the effects of government economic policies on the final allocation of resources. One of the purposes of economics is to study potential economic policies, evaluate them, and understand which policies are desirable. Even if in actuality the best policy cannot be specified, we still claim that having the ability to evaluate economic policies to a certain degree is obligatory for any voter in a democratic nation who has completed a college-level education.

1.2 What Is Behavioral Economics?

1.2.1 Behavioral Economics and the Economic Man

In traditional economics the main actor is an imaginary character called "economic man" or "*Homo economicus*."[3] He is a selfish and rational maximizer of his own personal utility. Actual humans, *Homo sapiens*, are not completely selfish the way an economic man is, nor are they perfectly rational and often allow their emotions to affect their economic decisions. However, in traditional economics the divergence between actual humans and the economic man has not been considered an important factor in the advancement of the study of economics.

It is possible to define behavioral economics as "the study of economics that does not rely on the assumption of the rational, selfish economic man," and this is the definition we will use throughout this textbook. Behavioral economics employs theories and results from psychology, sociology, anthropology, neurology, and other disciplines, and makes use of empirical studies including experimental ones to demonstrate the inconsistency between the assumption of an economic man and actual economic decision making. Because there are important questions that cannot be addressed within a framework of traditional economics which relies on the supposition of a rational selfish economic man, this new approach attempts to leave this assumption behind.

As a subfield of economics, one of the purposes of behavioral economics is to evaluate policies. However, the greater purpose of behavioral economics is to gain a deeper understanding of human behavior and interactions, and therefore to understand how they will behave both individually and in groups (such as in organizations). By observing how a particular person chooses to use his or her precious

[3]"Economic man" is a traditional technical term even though it is not politically correct.

time, income, or assets, we can infer much about the individual making the choices. Behavioral economics applies the expertise of psychology, anthropology, neuroscience and related fields to construct a theory with which to better interpret these observations. If by reading this book the reader gains a deeper understanding of the people or firms around them, we the authors will be very pleased. That is because in order to better love our fellow humans, it is necessary to first understand them.

Here we would like to discuss three important points related to the assumption of a rational selfish maximizer, the economic man. The first point is that the economic man's preferences over goods and services are both exogenous and stable. To say that preferences are exogenous means they are determined by factors outside the economic system, for example by heredity.[4] Second, economic man is selfish, but even in traditional economics there are cases of a parent having altruistic feelings toward a child. In this situation we consider the decision maker as maximizing with respect to themselves and their descendants as a single unit, preserving the postulation of selfish man. Third, the definition of rationality of the economic man differs markedly from the commonly used definition of rationality. On that note, in this text we will use the term "economic man's rationality" to emphasize this distinction. We will look further at these three points in Sects. 2.2 and 2.3 of this chapter.

Finally, on a subtle note, the preferences of economic man are assumed to be over the final consumption of goods and services which includes the assumption that only the final allocation is relevant. A small modification further specifying preferences over combinations of goods (for example not only preferences over a salad or a hamburger, but also over a menu containing only salad versus a menu containing both a salad and a hamburger) will enable us to model temptation and self-control as well. Self-control in the presence of temptation will be discussed in Chap. 3.

1.2.2 Are Preferences Exogenous and Stable?

In traditional economics, the preference ordering of an individual is represented by a utility function, and it is assumed that economic man maximizes the utility subject to some conditions such as the behaviors of other economic agents and a budget constraint. Moreover, for the question as to how resources *should* be allocated, traditional economics uses the concept of *Pareto efficiency*. In order to define the concept, we first consider the process of improving an inefficient resource allocation. Given a resource allocation in an economy, if the utility of one economic agent gets higher without making utility of any other agent lower by changing allocation of resources, then this change is called a *Pareto improvement*. If one resource allocation is inefficient, then a Pareto improvement is possible. After promoting economic efficiency

[4]Stable preferences mean either preferences that do not change, or preferences whose preference shocks are stationary in the case that they do fluctuate. Stationarity means that their joint probability distributions do not change over time.

and accumulating Pareto improvements, the economy will finally attain an allocation that is no longer possible to improve further. We define this allocation as Pareto efficient: a Pareto efficient allocation is an allocation that cannot be Pareto improved. In other words, the Pareto efficient allocation does not have any waste on resources.

For instance, suppose that a highway that nobody will ever use was constructed as a result of a resource allocation of an economy. If the economy uses the labor time to build this highway to build another highway which at least one person will use, it must be possible to have a Pareto improvement which heightens the utility of the highway users without lowering anyone's utility. Therefore, we can see that a resource allocation resulting from a public policy to construct the useless highway is not Pareto efficient.

The concept of Pareto efficiency is philosophically based on *welfarism* that all the ethical judgment should be done according to people's welfare as a result of various behaviors including public policy decisions. A branch of welfarism is utilitarianism, which pursues "the greatest happiness for the greatest number." Both in utilitarianism and in the concept of Pareto efficiency, the concept of happiness is utility, and increasing utility is considered to be desirable.[5] In utilitarianism, utilities of different individuals are compared and added up; on the other hand, such interpersonal comparisons of utilities are avoided in the evaluation based on Pareto efficiency. Traditional economics has been greatly developed by the use of the concept of Pareto efficiency.

If preferences are endogenous and unstable, however, the use of the concept of Pareto efficiency faces a critical limitation. For instance, suppose that a man's preferences toward a mug changes because he develops an attachment to it just by watching it placed before him for a while. Then should preferences of which point in time be considered in order to make an analysis about Pareto efficiency? In addition, if his preferences fluctuate considerably, is it meaningful to pursue how resource allocation should accomplish Pareto efficient based on such preferences? Indeed, the result of many experiments has indicated that researchers can manipulate preferences of experiment participants as explained later in this chaper.

Thus, showing that preferences are endogenous and unstable includes a big challenge to the usefulness of traditional economics. Because the knowledge of economics provides tools for a better life, however, its users are required to utilize it with an understanding of its limitations and uses. Every tool has its limitation and it is not wise to deny all the usefulness of the tool when users have found its limitations. For instance, even when preferences for a mug drastically change, preferences for durable goods as a bigger category including the mug may not change. If it is true, then the analysis based on Pareto efficiency in traditional economics will be meaningful. However, in reality, if preferences are endogenous and unstable, unless we learn to what extent the results of analyses in traditional economics are indeed affected by these factors, it is difficult to make any policy recommendations.

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[5]see Chap. 10 for various concepts of subjective well-being and happiness.

Thus, showing the limitation of traditional economics is one of the critical roles of behavioral economics.

In the following, we will summarize a few experimental studies about changes in preferences. Through this summary, we would like to show the limitations of behavioral economics as well as the uses and the possibility of further development as a discipline that has been developing recently.

Kahneman et al. (1990) conducted an important series of experiments in this field. In their typical experiment reported in this paper, they are using a mug with a university logo. In traditional economics, to analyze their decision making if an individual does not have any mug, the maximum amount the individual is willing to pay to purchase a mug is called *willingness to pay* (WTP). If this mug is on sale in the market and one's WTP is higher than the price of the mug, then this individual will purchase the mug at that price. Thus, the number of prospective buyers whose WTP is higher than a certain price is the market demand as long as one buyer purchases one mug. If two buyers have the same amount of income, one buyer who really likes the mug has higher WTP, but the other who does not like it so much has lower WTP. If buyers have the same preferences, those who have higher income have higher WTP, and those who have lower income have lower WTP as long as the mug is a normal good.[6] This is an income effect.

Let us consider a person who owns a mug, and her decision making about whether or not she sells her mug. The minimum sales price that she is willing to accept to sell the mug is called *willingness to accept* (WTA). In the market, an owner will sell the mug if the owner's WTA is lower than the market price of the mug. Accordingly, if one individual owner is to make a sale of one mug, then the market supply at a price is the number of the owners whose WTA is lower than the price.

The standard theory of traditional economics predicts that the only reason for WTP and WTA to be different is income effect from obtaining a mug if two people have the same preferences and initial income. In order to understand this prediction, we have to know that in economics income used for the budget constraint is not necessarily the income only from labor work. We call goods and time that individuals own before participating in the market as "endowment." When an individual is endowed with various goods, one way to analyze how he makes decisions about buying and selling goods is to hypothetically think that he initially sells all endowment goods and then he redeems the goods he wishes to consume at the market prices. His final action for a good whose one unit is endowed to him is to sell it to the market if he does not wish to redeem it, while his final action is to keep the good if he wishes to redeem it. Accordingly, income in this analysis should include the revenue when endowed goods are sold. Therefore, if someone gives a mug as a gift to another and if the mug's market price is three dollars, then the income of the recipient increases three dollars for the purpose of computing the budget constraint in this analysis. Because of this income increase, his WTA after

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[6]We call the goods "normal goods" when people's income increases and so does consumption. Most of goods are normal goods.

receiving the gift should be higher than his WTP before receiving the gift. This effect is called *income effect.* The income increase, however, can be spent not only on the mug but also on the other goods. Hence his WTA cannot be that much higher than his WTP. To consider the meaning of "much" here from the example of the three-dollar increase of income, it can be presumed that WTA could never be higher than WTP by three dollars. It is because when many other purchases are possible, nobody would want to spend all the increased amount of income on a mug. Using WTP and WTA of an individual, we can measure the valuation of goods by the individual.

If preferences are indeed exogenous and stable as the assumption in traditional economics, the preferences should not be affected by whether or not an individual owns a mug. Suppose that there are two people who have exactly the same preferences and income. If one of them receives a gift of a mug and owns it, and the other does not, then the only reason for WTP of the non-mug-owner toward a mug and WTA of the mug-owner should be different is the income effect from receiving the mug. Here, we can logically predict that WTA is not exactly the same as WTP, but WTA should be somewhat higher than WTA.

Kahneman et al. did not think that preferences are exogenous and stable. They predicted that, based on the prospect theory introduced in Chap. 4, people would tend to dislike losing goods once they own them. If this is true, then we can predict that WTA of the mug recipient would be far higher than WTP of the recipient right before receiving it. Kahneman et al. call this effect on individual valuation toward endowed goods *endowment effect*.

In order to examine the presence of the endowment effect, Kahneman et al. conducted several experiments with university students in the United States and Canada as participants. Here we review Experiments 6 and 7 in their paper. First of all, the research participants were randomly divided into three groups with roles of seller, buyer, and chooser. Each member of the seller group received a mug from researchers, and each was asked whether or not she was willing to sell the mug at each price on the list of prices in the range of 0–9.25 dollars. This was a questionnaire survey on WTA. Each member of the buyer group was also asked whether or not he was willing to buy the mug at each price on the same list of the prices. This was a questionnaire survey on WTP. Each member of the chooser group was asked whether they wanted to have the mug or have cash equal to the amount at each price on the list. In a sense, a chooser was "buying" a mug when they receive it instead of receiving money. Thus, this was a kind of questionnaire survey on WTP.

Because both sellers and choosers were able to sell the mugs, their income was higher than buyers'. The income of each member of the two groups increased by the same amount. Both sellers and choosers were asked about the choice between mug and cash, and their conditions of income were the same. The only difference was that a seller already owned a mug as an endowment, but a chooser did not.

In Experiment 6, 77 university students from Simon Fraser University were research participants, and in Experiment 7, 117 university students from British Columbia University were. The only difference in the experimental procedures between Experiment 6 and Experiment 7 was that in Experiment 7 the price tag of the mug was left attached, and in Experiment 6 there was no price tag. As a result of the questionnaire surveys during the experiment survey, the data from WTA of sellers and WTP of buyers and choosers were obtained. The data were to be analyzed statistically.

Creating a histogram is often useful for this type of analysis. The entire range of data for WTA values of the sellers will be divided into a series of intervals such as "below 1.0, 1.25–2.0, …, 8.25–9.00, above 9.25," and the number of the values that fall into each interval is called density. In a histogram, the horizontal axis shows the intervals, and the vertical axis shows the density of each interval. In this way, a histogram roughly indicates the probability distribution of the WTA values in the data. One effective way to summarize properties of the distribution is to calculate a single number from the data. For example, mean, median, and mode are measures of central tendency. Median is the number located in the center when data values line up in order from the smallest to the largest (if the number of the data is an even number, the median is the average of the central two values). If the distribution of the data is symmetric, mean and median should be exactly the same. If the distribution of data have extremely large values, then its mean tends to be bigger than its median. Thus, when the data contain many extreme values, the median is a preferred measure. Mode is the value that most frequently appears. Unlike mean and median, mode is meaningful even for qualitative data such as the gender of the survey participants.

According to the result of Experiment 6 by Kahneman et al., the median of the sellers' WTA was 7.12 dollars, that of the choosers' WTP is 3.12 dollars, and that of the buyers' WTP was 2.87 dollars. In the result of Experiment 7, the median of the sellers' WTA was 7.00 dollars, that of the choosers' WTP was 3.50 dollars, and that of the buyers' WTP was 2.00 dollars. In these two experiments, the difference of WTP between choosers and buyers can be explained as income effect: the income effect in Experiment 6 is estimated to be 0.25 dollars; and in Experiment 7, 1.50 dollars. Since three groupings were random, if the assumption that the preferences are exogenous and stable is really true, then the two medians of seller WTA and chooser WTP should be the same. However, as can be seen in the experiment data, the median of seller WTA is more than twice as big as that of chooser WTP. This difference cannot be explained by income effect. Accordingly, Kahneman et al. interpret this to have been caused by the endowment effect.

This experiment result has been interpreted as clearly showing the existence of the endowment effect among most behavioral economists. However, Plott and Zeiler's (2005) experiment results strongly indicate that this interpretation is wrong. Plott and Zeiller showed that the experiment result that had been supposed to show the endowment effect could be greatly affected by slightly changing the experimental procedure. In Chap. 4, we will explain the procedure of their experiment in detail. For example, one of their procedures is that participants practice in experiments that actually pay money for the purpose that all participants understand the experimental procedure and consequences of their decisions. According to the experiment of Plott and Zeiler, participants' valuation of the mug does not become higher after owning the mug, unlike the result of Kahneman et al. Based on the result of Plott and Zeiler, Knetsch and Wong (2009) and others have been making progress in new experimental research. At this moment, among the behavioral economists, there is still no conclusive interpretation of these past experiments. However, the study of Isoni et al. (2011) found astatistically significant difference between WTA and WTP by using a lottery that pays money as a prize instead of using a mug with the same experimental procedure of Plott and Zeiller. Moreover, the ratio of the difference between WTA and WTP can be even nearly two on average.[7]

Thus, even if a clear result is shown as in the experiment of Kahneman et al. (1990), if the experimental result can be interpreted into a persuasive theory like the endowment effect, and if many scholars have agreed upon it for more than 10 years, the theory is not necessarily valid in real human behaviors. Through a series of innovative experiments conducted by researchers, our understanding toward economic human behaviors deepens. From these experiments of Kahneman et al (1990), Plott and Zeiler (2005), and specifically Isoni et al. (2011), what we can conclude is that the hypothesis that preferences are always exogenous and stable is not really true. Moreover, even for a very important aspect in economics such as the valuation of goods and assets (as a lottery is considered one of the assets), the deviation from the hypothesis is indeed quantitatively important. By shifting the preferences by the manipulation of researchers, the valuation of an asset can be affected to even twice as big as the original valuation of the asset. It is great progress to know that the hypothesis that preferences are exogenous and stable is not true, and that the deviation from the hypothesis is critical to understand economic phenomena. However, behavioral economics is under development because we are uncertain about how preferences change. There are some well-known theories like the endowment effect theory, but we need to explore why there is a difference in endowment effect between goods and lotteries that pay money. At this point in time, it is necessary to pursue further research beyond existing theories rather than sticking to them, by exploring the limitations of the theories.

1.2.3 Economic Man's Rationality

Being rational is usually understood as to stand to reason and to make sense, and it is naturally better to act rationally than to act irrationally. Here, we have to be careful about various different meanings in the expression of "rational." Two broad categories of the meanings are (1) one acts according to reason in order to attain the purpose, and (2) the purpose stands to reason. We would like to emphasize that rationality of these original meanings is different from rationality assumed for economic man in traditional economics. For this reason, we call the latter *economic*

[7] Chapter 4 will explain Plott and Zeiler's experiments and experiments that were motivated by them, as well as a theoretical hypothesis that potentially explains these results.

man's rationality in this book. In behavioral economics, real human behavior does not meet this economic man's rationality. This does not mean that we should immediately judge that real human behavior is irrational. Deciding whether behaving in economic man's rationality is good or bad depends on cases and requires careful judgment.

First, as an example in which economic man's rationality and the rationality in the original meaning coincide, we can think of business negotiations. In most such negotiations, it is rational for negotiators to pursue profits rather than being controlled by their emotions. It is more reasonable to continue business conversations for mutual profits than quitting a business conversation due to temporal and personal emotions when a negotiator does not personally like the other party.

Next, as an example to see the difference between economic man's rationality and rationality in the original meaning, let us think about a psychopath test.

A Psychopath Test: While attending her mother's funeral, a woman meets a man she's never seen before. She quickly believes him to be her soulmate and falls head over heels. But she forgets to ask for his number, and when the wake is over, try as she might, she can't track him down. A few days later she murders her sister. Why?[8]

How will you answer this question? A typical answer of an ordinary person is "I felt anxious that my sister would go out with the man," but a typical answer of a psychopath could be "If I kill my sister, then that man will show up at her funeral, and I will be able to see him again."

In this example, a psychopath logically tries to take advantage of everything including a family member's funeral in order to achieve her purpose to increase her utility with her economic man's rationality. The logic of ordinary people, however, unconsciously ignores such selfish use of a family funeral. The economic man's rationality only cares about logical actions and does not care about morality or ethics. In this example, it must be obvious that economic man's rationality is not necessarily the same as rationality in the original meaning.

In order to deepen understanding about economic man's rationality, let us introduce a game theory. This game theory is the one that studies the interactions and the decision-making processes among plural economic agents each of whom pursues his own benefits while considering how the others behave. The theory was proposed by von Neuman and Morgenstern (1944). This theory has been developed further by contributions of many researchers such as Nash (1951), and is now the mainstream in micro-theory economics. In this book, if game theory assumes that the agents are selfish and have economic man's rationality, then we call it traditional game theory. On the other hand, another mainstream traditional economic theory is "market equilibrium theory." It analyzes the equilibrium of supply and demand in each market. In the basic market equilibrium theory, the markets are assumed to be perfectly competitive: an individual agent cannot affect market prices. In this case, each economic agent can decide about demand for each good by

[8]This test question is from Adams (2012).

Table 1.1 Prisoners' dilemma game

	Prisoner B keeps silent (cooperates)	Prisoner B confesses (deflects)
Prisoner A keeps silent (cooperates)	−2, −2	−15, −1
Prisoner A confesses (deflects)	−1, −15	−10, −10

comparing his own WTP and its market price, and decide about supply for each of his endowed goods by comparing his own WTA and its market price. Here none of the agents needs to know how the others behave. On the contrary, in traditional game theory, each agent needs to know how the other agents behave.

To clarify the meaning of economic man's rationality in game theory, we explain the Prisoners' Dilemma as a classical example. In this game, two members of a criminal gang are arrested and imprisoned. Each prisoner is in solitary confinement with no mean of speaking to or exchanging messages with the other. The prosecutors offer a bargain to each prisonner as follows. If the two remain silent, both serve 2 years in prison. If one keeps silent and the other confesses, the prisoner who kept silent serves 15 years in prison; and the confessed prisoner only serve 1 year. If two confess, both of them serve 10 years. Each prisoner has to make a decision on whether to remain silent or to confess. The rule of the game of Prisoner A and Prisoner B can be illustrated in a payoff matrix as in Table 1.1. The table shows how each player obtains a payoff from his action or strategy, given the other player's action. When Prisoner B chooses a strategy to cooperate (keep silent) and Prisoner A chooses to deflect (confess), the payoff of Prisoner A is 1-year imprisonment and the pay-off of Prisoner B is 15-year imprisonment. Each pay-off is described as (−1, −15). Other combinations are illustrated in the table.

Nash equilibrium is "a strategy combination that each player is making a best reaction to the strategies chosen by the other players" (see its mathematical definition in the Appendix). Nash equilibrium in the Prisoners' Dilemma is that each prisoner confesses. In order to confirm the Nash equilibrium, we first study the best reaction by Prisoner A. Suppose that Prisoner B chooses to confess. Then if Prisoner A keeps silent, his payoff is −15, and if he also confesses, then his payoff is −10. The best reaction of Prisoner A in this case is to confess. Suppose that Prisoner A chooses to confess, then the best reaction of Prisoner B is also to confess. Hence, the strategy combination of both choosing to confess is a Nash equilibrium. There is no other Nash equilibrium. For instance, if Prisoner B chooses to keep silent and Prisoner A chooses to keep silent, the payoff of Prisoner A is −2. If A confesses, then his payoff is increased to −1. The best reaction for A is to confess in order to maximize the payoff given B's strategy.

In this way, if both of them cooperate with each other, their imprisonment will finish in 2 years, but if both betray each other, their imprisonment will be 10 years. As a team, they will make a foolish choice because each one tries to maximize his payoff with economic man's rationality.

In the game of Prisoners' Dilemma, each prisoner has a purpose of shortening his imprisonment. In the Nash equilibrium, even though both can get a 2-year imprisonment, both end up with 10-year imprisonments. In this sense, we cannot say that the purpose is accomplished in the Nash equilibrium. In experiments of this Prisoners' Dilemma game, it is often observed that many research participants choose to cooperate. Although this action does not satisfy the economic man's rationality, it can be indeed rational in its original meaning of "rationality," because it accomplishes the purpose. Behind the economic man's rationality, there is an assumption that each decision maker has his economic man's rationality. If the other participant is an economic man, he will never choose cooperation so that the betrayal should be rational. In reality, choosing to cooperate can be irrational even for selfish participants if the other player is not an economic man. This point is further discussed in Chap. 5.

Next, let us consider whether it stands to reason to have the selfish purpose in the Prisoners' Dilemma game. For this purpose, it should be easier to understand when we can apply this game to environmental issues. Think about the world consisting of Country A and Country B. Suppose if the Gross Domestic Product (GDP) of Country A and B can be affected by the policy toward environmental issues. If both countries cooperate and cope with the environmental issues, each of them can obtain a GDP of 5 billion dollars. If both ignore the environmental issues, each of them gains 2 billion dollars as GDP. When one country chooses to betray while the one country copes with environmental issues, the former country can obtain a GDP of 7 billion dollars, but that of the other country drops to 1 billion dollars. This situation can be described as the payoff matrix in Table 1.2. Assuming each country wants to maximize its own GDP, this environment game has a structure of the Prisoners' Dilemma game. Thus, the only Nash equilibrium is for each country to betray. One aspect of the difficulty of international cooperation on environmental issues is illustrated in this game and its Nash equilibrium.

In this situation, is it really rational to have the purpose of maximizing the GDP of one's own country? In fact, whether it is "rational" or not depends on the social norms and people's worldviews, discussed in Chap. 9. There is a worldview under which it is rational for people to maximize their own country's GDP. On the other hand, there are different worldviews under which betraying other countries is shameful, and it is not rational to maximize their own country's GDP. Or there can be another worldview under which it is rational to consider the GDP of other countries as part of the purpose.

Table 1.2 Environmental issues and the Prisoners' Dilemma

	Country B Cooperates	Country B Deflects
Country A Cooperates	5, 5	1, 7
Country A Deflects	7, 1	2, 2

Environmental issues are one of the biggest tasks that human beings are facing today. Choosing the best public policy depends on how we view (1) economic man's rationality and (2) rationality in the original meaning discussed above. In reality, many countries do tackle environmental issues, and they may or may not be rational depending on this view. This book does not intend to provide the definitive answer to these issues but does intend to show how we can think based on the vast literature.

1.2.4 Are Humans Selfish?

Related to the issue that the selfish purpose of utility maximization of economic man in traditional economics is as described in the last subsection, another critical issue is whether humans are selfish or not. Before we go to further discussions, we have to admit that defining "selfishness" is not an easy task for the purpose of defining behavioral economics. We will discuss this issue in Chap. 8, but in this chapter we will explain how the ideas in behavioral economics have been developed through series of experiments.

There are many variations in the experiment of the ultimatum game. In the standard game, the participants are randomly grouped as pairs of two participants. In each pair, one is randomly chosen as the proposer, and the other, the responder. The proposer receives a certain amount of money such as 10 dollars (1000 cents) as an endowment and is requested to make an offer to the responder in such a way so that he keeps some money to himself and gives the rest to the responder. If the amount to the responder is x cents, the rest is $1000 - x$ cents: these payoffs are written as $(1000 - x, x)$. The responder has to decide whether or not to accept this offer. If the offer is accepted by the responder, the proposer receives $(1000 - x)$ cents; and the responder, x cents. In case the responder does not accept the offer, two people end up receiving 0 cent.

In contrast to a *simultaneous game* such as Prisoners' Dilemma in which all the players decide their strategies at the same time, this ultimatum game is a *sequential game* in which players make their decisions in turn. In general, a sequential game has many Nash equlibria, and among these equilibria, a *subgame perfect equilibrium* is considered valid to analyze the interactions of real humans.

In the standard ultimatum game, the proposer can choose any amount to offer to the responder as long as it does not exceed the endowed amount. To simplify our explanation, however, we will first focus on a mini-ultimatum game in which the proposer can choose to offer only designated amounts. Let us consider a game in which the endowment is 10 dollars and the proposer is to decide to offer either 1 cent or 5 dollars. Here there are three subgames. The first is the subgame after the proposer has offered 1 cent, and the second is the subgame after the proposer has offered 500 cents (5 dollars). The third subgame is the entire game. The third subgame includes the first two subgames. If the combination of strategies is such that a Nash equilibrium is attained in each of all the subgames, then we call it a *subgame perfect equilibrium*.

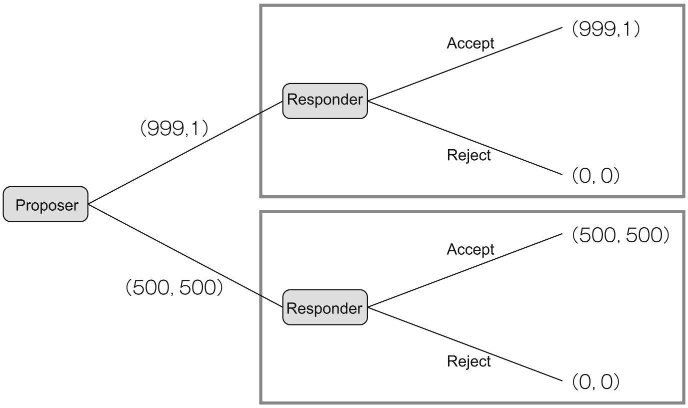

Fig. 1.1 A game tree of a mini-ultimatum game

This game can be described as in Fig. 1.1. We call a figure like this a *game tree*. A node of a game tree shows where the players are in the game and is labeled by the player whose turn it is to move. A branch shows how an action of a player results in another node and is labeled by the action. When a game is described by a game tree, this way of description is called the *extensive form*. The way of describing a game by a payoff matrix as in Tables 1.1 and 1.2 is called the *normal form*. We can use the normal form for a sequential game but can use the extensive form to offer more information about the game, especially its turns.

To explore the subgame perfect equilibrium, we start with a subgame of the responder. In the subgame in the upper rectangle of Fig. 1.1, the proposer has offered 1 cent. In this subgame, the responder receives a higher payoff of 1 cent by choosing to accept the offer rather than receiving 0 cent by choosing to decline it. Hence an economic man must accept the offer. Because the proposer does not choose any strategy in this subgame, this is the Nash equilibrium. In the subgame in the lower rectangle of Fig. 1.1, the proposer has offered 5 dollars (500 cents). In this subgame, the responder receives a higher payoff of 500 cents by choosing to accept the offer rather than receiving 0 cent by choosing to decline it. Hence an economic man must accept the offer. This is the Nash equilibrium in this subgame. Lastly, let us consider the entire game. Suppose that the two subgames in the responder's turn are in Nash equilibrium. Then if the proposer offers 1 cent for the responder, the proposer receives 999 cents and the responder receives 1 cent. The payoff pair of (999, 1) is written just above the upper branch for the proposer for this reason. If the proposer offers 5 dollars, then the payoff pair is (500, 500) written for the lower branch. Because 999 is greater than 500, if the proposer offers 1 cent for the responder, and if the responder accepts the offer, then it is a subgame perfect equilibrium.

In this mini-ultimatum game, then the result of the responder to accept the proposer's 5-dollar offer can also be a Nash equilibrium, but we can prove that the only subgame perfect equilibrium is when the proposer offers one cent, and the responder accepts the offer (see Exercise E.2.1). For the proposer, it is more beneficial to be accepted with 1 cent than to be accepted with 5 dollars because the payoff of the proposer is larger. Here, if the responder is an economic man who is only interested in obtaining a larger payoff, then even receiving 1 cent by accepting a 1-cent offer is more attractive than receiving 0 cent by declining the offer.

Similarly, the same logic is applicable to other variations of the ultimatum game. If the amount of an offer is restricted to the natural numbers, such as zero, one, and two, then a subgame perfect equilibrium is obtained when the proposer makes a 1-cent offer and the responder accepts the offer. When the responder is an economic man, he must be indifferent between accepting or declining a 0-cent offer because he is getting 0-cent in either choice. Hence there is another subgame perfect equilibrium in which the proposer makes a 0-cent offer and the responder accepts the offer. These are the only two subgame perfect equilibria; because there is no need for the proposer to offer 2 cents or more in order for the responder to accept the offer, there is no subgame perfect equilibrium in which 2 cents or more are offered.

The result of real experiments, however, does not support this theoretical prediction of the subgame perfect equilibrium at all. According to 75 experiments in 37 papers reported by Oosterbeek et al. (2004), on average the proposer offers about 40% of the endowment to the responder, and on average 16% of the offers are rejected. Many of these experiments are conducted with university students in Western countries with the initial endowment of about 10 dollars even though some of them are conducted in developing countries. The result that the theoretical prediction does not hold at all is also endorsed by the experiment in Indonesia when the amount of the endowment was about three times larger than the average monthly expenditure in the experiment by Cameron (1999): the average amount of the proposer's offer was about 42% the endowment.

We can consider a hypothesis that proposers have altruistic motivation. Many responders, however, tend to decline low offers even if they lose money. Many people seem to feel they are treated unfairly and get angry when they receive low offers such as less than 10% of the endowment. Hence the proposer may also have a selfish motivation to avoid receiving no money when their offers are declined.

There is another experiment that excludes this selfish motivation of proposers, in which the decision making of the responder is eliminated in the ultimatum game. The proposer decides the amount to offer from the endowment such as 10 dollars (1000 cents). The proposer decides the outcome of the payoff pair as $(1000 - x, x)$ by offering x cents. This game is called a *dictator game*. If the proposer is selfish like an economic man, he will distribute 0 cent as (1000, 0). According to the result reported in 261 papers included in Engel's (2011) survey that include experiments in developing countries, about 30% of the pie is offered by the proposers on average.

What we can say from the results of these experiments is that the prediction of traditional game theory, assuming selfish economic man who ignores the norm of fairness and only pursues his own benefit, is not supported by the data. If so, what type of economic theory should be constructed? According to the result of the dictator game, a hypothesis can be drawn naturally that real humans are not completely selfish unlike the traditional hypothesis of economic man. In addition, when we review the actions of the responder in the ultimatum game, it is now clear that humans not only have altruistic aspects, but also have a sense of fairness: They often decline unfair offers even if their monetary payoff decreases, so that they can avoid an unfair outcome. These experimental results provide us a useful starting point to think the role of altruism, norms, and worldviews. These topics are further discussed in Chaps. 8 and 9.

1.3 Summary and Further Reading

In this textbook, we define behavioral economics as "the study of economics which does not rely on the assumption of the rational, selfish economic man." Here, the word "rational" needs to be carefully understood because economic man's rationality is not rationality in its true meaning of the word. Two broad categories of the meanings are (1) one acts according to reason in order to attain the purpose, and (2) the purpose stands to reason. We have seen that economic man's rationality does not attain the purpose of selfishly making money as a proposer in a typical ultimatum game experiment in which low offers are rejected. Regarding the purpose of selfishly maximizing utility from material satisfaction, it may not stand to reason when we think about a situation of coordinating countries for environmental protection. Another important element in the assumption of economic man is exogenous and stable preferences. Experimental evidence shows otherwise: preferences are endogenous and unstable.

One good way to understand a field of study is to learn about its history. For behavioral economics, there can be many ways to interpret its history. Thayler (2016) presents a succinct description of the history strating from the historical roots of Adam Smith. Heukelom (2014) gives a detailed explanation of an important academic interpretation of the history of behavioral economics. Another good way to understand a field is to see how it can be used to analyze what we experience in everyday life. For this purpose, we recommend Ariely (2010) and his subsequent books for general readers even though his use of the word "irrational" needs to be carefully interpreted.

1.4 Questions and Problems

1.4.1 Multiple-Choice Problems

1. Choose the most appropriate answer about the seller's WTA and the buyer's WTP in the mug experiment of Kahneman et al. (1990),

   (A) Suppose that the experiment participants behave like economic men. Since the income of a recipient of a mug increases, the seller's WTA must be higher than the buyer's WTP as much as the amount of his income increased.

(B) Suppose that experiment participants behave like economic men. Though the income of a recipient of a mug increases, the seller's WTA and the buyer's WTP must be exactly the same.
(C) Suppose that the experiment participants behave like economic men. Though the income of the recipient of mug increases, the income can be used for other goods. Thus, the seller's WTA must be higher than the buyer's WTP, but the difference should be much smaller than the income increased.

2. Choose the most appropriate answer about the seller's WTA and chooser's WTP in the mug experiment of Kahneman et al. (1990).

(A) Suppose that the experiment participants behave like economic men. Since the income of a recipient of a mug increases, the seller's WTA must be higher than the chooser's WTP.
(B) Suppose that experiment participants behave like economic men. Though the income of a recipient of a mug increases, the seller's WTA and the chooser's WTP must be exactly the same.
(C) Suppose that the experiment participants behave like economic men. Since the income of a recipient of a mug increases, the seller's WTA must be higher than the chooser's WTP as much as the amount of his income increased.
(D) Suppose that the experiment participants behave like economic men. Though the income of the recipient of the mug increases, the income can be used for other goods. Thus, the seller's WTA must be higher than the chooser's WTP, but the difference should be much smaller than the income increased.
(E) A and C
(F) A and D

3. Suppose that the result of Experiments 6 and 7 in the mug experiment of Kahneman et al. (1990) were robust and unchanged by any experimental procedure. Choose the most appropriate answer about the result of the experiment.

(A) The median WTA of the sellers was far higher than the median WTP of the choosers, and the median WTP of the choosers was a bit higher than the median WTP of the buyers.
(B) The median WTA of the sellers is almost the same as the median WTA of the choosers, and the median WTP of the choosers is a bit higher than the median WTP of buyers.
(C) The median WTA of the sellers, the median WTP of the choosers, and the median WTP of the buyers were almost the same.
(D) There was an endowment effect to the preferences of experiment participants in that their WTA became higher at the moment when they came to own mugs.

(E) The preferences of experiment participants were always stable like those of economic men.
(F) A and D
(G) A and E
(H) B and D
(I) B and E
(J) C and D
(K) C and E

4. About the theoretical prediction and result in the experiments of the ultimatum game, choose the most appropriate answer.

(A) If the experiment participants behave like economic men, it can be predicted that because of subgame perfect equilibrium, the proposer gives 40% of the endowed amount to the responder, and the responder accepts it.
(B) If the experiment participants behave like economic men, it can be predicted that because of subgame equilibrium, the proposer gives the least amount of money to the responder, and the responder accepts it.
(C) In the real experiment, the proposer typically gives about 40% of the endowed amount to the responder.
(D) In the real experiment, the proposer typically gives about 20% of the endowed amount to the responder.
(E) In the real experiment, the responder declines 16% of the offers on average.
(F) In the real experiment, the responder declines 8% of the offers on average.
(G) A, C, and E
(H) A, C, and F
(I) A, D, and E
(J) A, D, and F
(K) B, C, and E
(L) B, C, and F
(M) B, D, and E
(N) B, D, and F

5. Choose the most appropriate answer about the results and interpretation of the ultimatum game experiment.

(A) Both the proposer and the responder behave like economic men.
(B) The proposer behaves like economic man, but the responder does not.
(C) The responder behaves like economic man, but the proposer does not.
(D) By the result of experiment, it is clear that the proposer is not completely selfish.
(E) It is clear that proposers are selfish but are giving higher offers solely from the motive to avoid receiving no money when their low offers are declined.
(F) There are two possibilities; one that the typical proposer is not completely selfish, and the other that the typical proposer has a motive to avoid receiving no money when his low offers are rejected. We are not certain which, either of these or both, is true, from this result.

(G) A and E
(H) B and E
(I) C and E

6. About the theoretical prediction and result of the dictator game experiment, choose the best answer.

(A) If the dictator behaves like selfish economic man, it can be predicted that the dictator will give about 30% of his own endowed amount to the recipient.
(B) If the dictator behaves like selfish economic man, it can be predicted that dictator will give nothing to the recipient.
(C) In the real experiment, the dictator typically gives about 5% of the endowed amount to the recipient.
(D) In the real experiment, the dictator typically gives about 30% of the endowed amount to the recipient.
(E) A and C
(F) A and D
(G) B and C
(H) B and D

7. In the framework of understanding actions of the experiment participants by their own selfish or altruistic preferences (not including the influence of norms of an outside group), choose the best answer.

(A) The typical dictator behaves like selfish economic man.
(B) It is clear that the typical dictator is not completely selfish but is altruistic or pursues fairness from the result of the experiment.
(C) It is clear that the typical dictator is selfish but is giving higher offers solely from the motive to avoid receiving no money when his low offers are declined.
(D) There are two possibilities; one that the typical dictator is not completely selfish, and the other that the typical dictator has a motive to avoid receiving no money when their low offers are declined. We are not certain which, either of these or both of these, is true, from this result.

1.4.2 Short Answer/Essay Problems

The following three problems are about the ultimatum game in which the proposer receives 5 dollars as an endowment. Answer the problems, assuming that each player is a selfish economic man for the analysis based on game theory (Do not consider mixed strategies as this textbook only treats pure strategies).

1. Consider a mini-ultimatum game in which the proposer can offer either 1 cent or 2.5 dollars to the responder. It may not be realistic, but assume that each player shows his own strategy at the beginning of the game, and the responder makes a

Table 1.3 A payoff matrix of a mini-ultimatum game

Responder					
Proposer		Accept if 1 cent and accept if 2.50 dollars	Reject if 1 cent and accept if 2.50 dollars	Accept if 1 cent and reject if 2.50 dollars	Reject if 1 cent and reject if 2.50 dollars
	Offer 1 cent				
	Offer 2.50 dollars				

commitment to his own strategy even if the mood changes as in Table 1.3. Fill in the empty entries for the payoffs for each of the eight strategy pairs. Among the strategy pairs, find all the Nash equilibria. Explain why each of these strategy pairs is a Nash equilibrium, while the others are not.

2. Suppose that the mini-ultimatum game in the previous problem is played as a sequential game. Draw a game tree, illustrating that offering 1 cent is a subgame perfect equilibrium and that offering 2.50 dollars is not a subgame perfect equilibrium.
3. Consider another mini-ultimatum game in which the proposer can offer can either 0 cents, 1 cent, or 2.5 dollars to the responder. Draw two game trees, illustrating that there are two subgame perfect equilibria, and that there is no other subgame perfect equilibrium. Draw one tree for a subgame perfect equilibrium and show the best response in each node by making the appropriate branch a colored line.

Appendix: Nash Equilibrium

This Appendix gives a definition of Nash equilibrium for pure strategies (see, e.g., Tadelis 2013 for more details).[9] Consider a game in which there are n players, and let the set of players be $N = \{1, 2, \ldots, n\}$. Let S_i denote the set of all possible strategies s_i of player i and $u_i(s_i, s_{-i})$ denote the utility function when player i chooses strategy s_i, when the other players choose strategies $s_{-i} = (s_1, \ldots, s_i - 1, s_i + 1, \ldots, s_i)$ (here, $j = 1, \ldots, n$ and $s_j \in S_j$ For a pair of pure strategies, (s_i, s_{-i}), if for other players' strategies s_{-i},

$$u_i(s_i, s_{-i}) \geq u_i(t, s_{-i}) \tag{1.A1}$$

hold for all $t \in S_i$, we call this strategy s_{i} a best response to s_{-i}.

[9]In this book, we do not consider mixed strategies.

Here, when the pair of strategies (s_i, s_{-i}) satisfy (1.A1) for all $t \in S_i$ and $i \in N$, we call it a Nash equilibrium. In other words, Nash equilibrium is the strategy pair in which each player is choosing a best response to the strategies of all other players.

References

Adams, T. (2012). The wisdom of psychopaths by Kevin Dutton-review. The Guardian. http://www.theguardian.com/books/2012/oct/07/wisdom-of-psychopaths-kevin-dutton-review. Accessed 8 May 2016.

Ariely, D. (2010). *Predictably irrational, revised and expanded edition: the hidden forces that shape our decisions*. New York: Harper Perennial.

Cameron, L. A. (1999). Raising the stakes in the ultimatum game: Experimental evidence from Indonesia. *Economic Inquiry, 37*(1), 47–59.

Davis, D. D., & Holt, C. A. (1993). *Experimental economics*. Princeton University Press.

Engel, C. (2011). Dictator games: A meta study. *Experimental Economics, 14,* 583–610.

Heukelom, F. (2014). *Behavioral economics: A history*. Cambridge, UK: Cambridge University Press.

Isoni, A., Loomes, G., & Sugden, R. (2011). The willingness to pay-willingness to accept gap, the "endowment effect." subject misconceptions, and experimental procedures for eliciting valuations: comment. *American Economic Review, 101*(2), 991–1011.

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1990). Experimental tests of the endowment effect and the Coase Theorem. *Journal of Political Economy, 98*(6), 1325–1348.

Knetsch, D., & Wong, W.-K. (2009). The endowment effect and the reference state: Evidence and manipulations. *Journal of Economic Behavior & Organization, 71*(2), 407–413.

Nash, J. F., Jr. (1951). Non-cooperative games. *Annals of Mathematics, 54,* 286–295.

Oosterbeek, H., Sloof, R., & van de Kuilen, G. (2004). Cultural differences in ultimatum game experiments: Evidence from meta-analysis. *Experimental Economics, 7,* 171–188.

Plott, C., & Zeiler, K. (2005). The willingness to pay-willingness to accept gap, the "endowment effect." subject misconceptions, and experimental procedures for eliciting valuations. *American Economic Review*, *95*(3), 530–545.

Tadelis, S. (2013). *Game theory: An introduction*. Princeton University Press.

Thayler, R. H. (2016). Behavioral economics: Past, present, and future. *American Economic Review*, *106*(7), 1577–1600.

von Neumann, J., & Morgenstern, O. (1944). *Theory of games and economic behavior*. Princeton University Press.

Chapter 2
What Is Neuroeconomics?

Abstract This chapter briefly reviews the historical background of neuroeconomics and introduces its main research topics. Neuroeconomics focuses on the brain's work when humans make decisions. One of the aims of neuroeconomics is to develop an economic theory that can explain real human behavior including individual preference in economic behavior based on the brain mechanism.

Keywords Neuroeconomics · Neuroimaging · Functional magnetic resonance imaging (fMRI)

We daily encounter and solve multiple-choice questions on "reward," ranging from financial returns and food choices. How do our brains work in the process of the decision making? Neuroeconomics is a science to answer this question.

In the field of neuroscience, many researchers have studied the mechanism of the reward system and decision making in animals and humans. Recently, a computational-theory approach examining the assumption of a mathematical model of the brain in experimental methods is more commonly used to reveal the mechanism. Today, by the development of measuring methods, such as *functional magnetic resonance imaging* (fMRI), which does not require any surgical operation for the brain, it turns out to be fairly easy to access the function of the human brain engaged in solving complex assignments like financial decision making.

As we stated in Chap. 1, in traditional economics we assume that decision making is performed under the rationality of an economic man. Thus, since traditional economists have put the biological mechanism of decision making into a black box, and they have not paid attention to the neuroscience of decision making. However, it is clear that neuroscientists try to build up a "literally humanistic" economic theory because without the assumption of an economic man they directly reveal the mechanism of brain functions on real economic behavior. In other words, the researchers in this field have been exploring the purpose of behavioral economics discussed in Chap. 1, through pursuing the mechanism of the brain function.

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Therefore, the interdisciplinary study of economics and neuroscience started between the late 1990s and the early 2000s, and the new academic field neuroeconomics was created. In short, neuroeconomics is to reveal the brain functions which cause individual economic behavior by utilizing neuroscientific methods, and to create new economic theory that provides better explanation for real economic behavior. In the field of behavioral economics, researchers used to explore economic behavior by psychological experiments in the early days, but today they are focusing on the experiments of neuroeconomics. This chapter briefly reviews the historical background of neuroeconomics and introduces its main areas of studies.

2.1 Decision Making Based on Reward

When you see a row of migratory birds flying for more food or people waiting for a bargain sale in the supermarket, you understand that behavior of animals is greatly affected by the reward. There has been a series of experiments in conditioning using animals beginning in the early twentieth century to examine the effect of reward. Pavlov (Ivan Petrovich Pavlov 1849–1936), a Russian physiologist, found that the dogs produced saliva immediately after hearing the sound of a bell, when the researcher repeatedly trained them to receive food after the bell sound (so-called Pavolov’s dog). The phenonomenon is termed “classical conditioning.” Thorndike (1911) at Columbia University found that cats learn by trial and error that pushing a lever allowed them to leave the cage, and the time of their response got shortened as they repeat this experiment. This was called “instrumental conditioning.” Skinner at Harvard University formularized a series of experiments in conditioning, defining a reward as something to reinforce the cooperation of a stimulus and response, and something to increase the probability of causing the response. Psychologists call it a “reinforcer.” Thus, the meaning of reward is almost the same as the meaning of “incentive” in economic terms.

2.2 The Structure and Function of the Brain

In experimental psychology, researchers have targeted mainly animals to examine the relationship between reward and response. Recently, there are many studies to identify the brain mechanisms regarding a reward by using the noninvasive measuring methods of the brain on quasi-economic behavior with financial reward. Before discussing the contribution of neuroeconomic experiments, we will share with you some basic knowledge of neuroscience in order to understand neuroeconomics.

2.2.1 The Basic Mechanism of the Brain

The brain is an organ that consists of a central nervous system with the spinal cord in vertebrate animals. It is divided into cerebrum, cerebellum, and brainstem (Figs. 2.1 and 2.2). The cerebrum and cerebellum are mainly divided into gray matter that consists of neural cell bodies and white matter that consists of neural fibers extending from cell bodies (Fig. 2.3). Gray matter is located outside of the white matter in the cerebrum and cerebellum, and it is called the cortex. Neurons connect to other neurons in complex networks. Electrical signals are transmitted along the neural networks and cause various functions, such as senses, movements, and memories. In other words, information processing across neural networks generates almost all the functions of the brain.

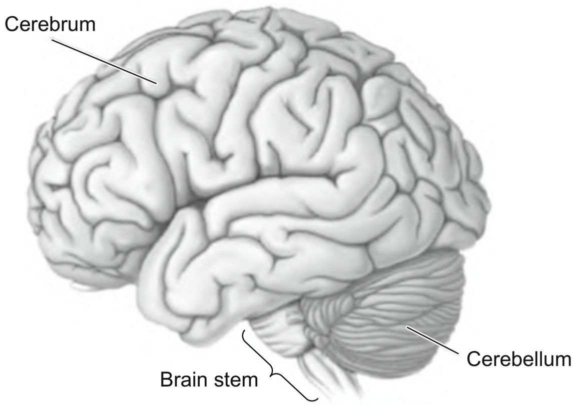


Fig. 2.1 Lateral view of the brain

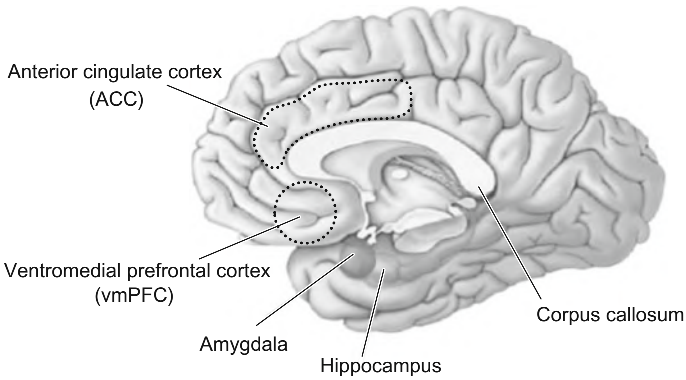
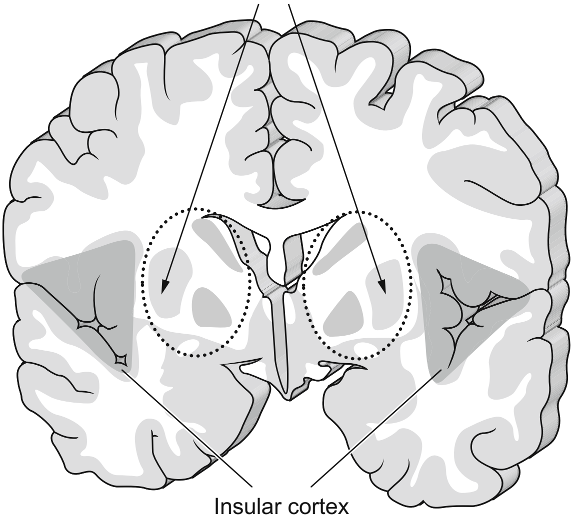


Fig. 2.2 Medial view of the brain (cerebrum cortex only)

Fig. 2.3 Coronal slice of the brain



Therefore, to reveal the mechanisms of the brain we must explore the neural system of information transmission and data processing. The electrical activity to transmit information is called "firing" of the neuron. The neural firing is caused by the dynamic change of membrane potential generated by the electrical gradient of ionic density between the inside and the outside of the neuron. When the membrane potential reaches the threshold, an action potential is generated and transmitted to the end of the neural axon. This is the process of firing. The information that a neuron conveys is only a signal, either zero (no firing) or one (firing). Just when a neural firing occurs, the neuron can convey the information to the next neuron. Synapses are located at the ends of axons and have the role of communication between neurons. When the electric signals on axons reach the synapse, the information is conveyed as chemical substances. The electric signals induce the movement of follicles from inside the synapse to the surface of the cell membrane, and they emit chemical *transmitting substances*. Neurons do not physically connect with each other, and there are very narrow chasms between synapses, whose size is about one thousandth of a millimeter. The postsynaptic cell has a *receptor on the membrane*. When the emitted chemical substance reaches the receptor, electric signals occur and the information is transmitted. The data processing in the brain is caused by the repeated electrical activities on the neural circuits. There are many kinds of chemical substances to convey information on behalf of the electrical signals, for example, glutamine acid, γ-amino butyric acid (GABA), dopamine, acetylcholine, and others.

2.2.2 Methods to Measure the Function of the Brain

As we discussed above, transmitting information and data processing of neurons requires electric and chemical reactions. In order to explore the function of the brain, it is necessary to measure the electric and chemical phenomena in the brain. For this purpose, the *electrophysiological* method is widely used to record the electrical activities of neurons. Specifically, to record the electrical activities of awake animals, extracellular recording method is mainly used. This procedure is to record electrical activities of the target brain area from outside with adjacent neurons through inserting micro electrodes into the target brain area. It is indeed a useful method to reveal the mechanism of information transmission and data processing because this enables us to measure the electrical activities of the neurons directly with higher time resolution. However, it is necessary to injure the brain of animal subjects for the insertion of electrodes. Thus, a non-invasive method is mainly adopted for the experiments for human subjects.

Typical non-invasive measuring methods are electro encephalography (EEG), which measures electrical activity on the scalp, and *magneto encephalography* (MEG), which measures the magnetic field caused by electrical activities of neurons. These methods have higher time resolution as well as the electrophysiological method, but do not have a *spatial resolution*. This is because there is a distance from the neuron to the sensor, and because there are just a few sensors to measure signals fired from multiple neurons (an ill-posed problem).

Recently, the most widespread non-invasive method is *functional magnetic resonance imaging* (fMRI). With this method it is possible to visualize the change of the blood flow associated with the neural activities in measuring the changes of local magnetic fields. At the time of neural firing, the amount of the blood flow increases 20–40% compared to the resting state. This is because neural activities require oxygen and glucose so that a larger amount of hemoglobin attached to oxygen, oxyhemoglobin, is provided through the blood flow in capillaries. In the series of neural activity, some oxyhemoglobin becomes deoxyhemoglobin because of oxygen consumption, but the increase of the consumption is only about 5%. It is rather less than the increase of local blood flow, so oxyhemoglobin increases relatively in a local area. Oxyhemoglobin tends not to be smoothly magnetized compared to deoxyhemoglobin, so that neural activity decreases magnetization and increases magnetic resonance signals in the local area. Thus, by measuring the change of these magnetic resonance signals, fMRI can indirectly capture and visualize neural activity. We can identify the significantly activated brain areas through statistical analyses of the magnetic resonance signals.

2.2.3 Several Approaches to Study the Function of the Brain

We have introduced measuring methods to study brain function. This section introduces another measuring method to explore brain functions in animals. To test a hypothesis about the function of the particular parts of the brain, one is a promising way to manipulate the neural activity in the brain. As one of the typical approaches in animal experiments, researchers observe the alteration of behavior under the manipulation of activity of the specific brain area by injecting pharmacological agents. In another method, they investigate the relationship between a certain gene and a function by suppressing the gene expression in a specific brain part. For humans, there are some cases in which the deficit in a particular function is observed by damage to a particular part of the brain due to a stroke or an external injury, e.g., in a traffic accident. Indeed, the function of the specific brain parts has been assumed from clinical cases. Penfield (Wilder Graves Penfield 1891–1976) found a method to moderate epilepsy by removing a damaged part of the brain and conducted many surgical operations, insisting that a specific brain part had a specific function. In the course of his operations, he discovered that when he touched a certain part of the brain with an electrode carrying a microcurrent, a specific part of the body moved and memories from the past were evoked. Penfield found the map of each part of the area behind the central sulcus corresponding to each part of the body (Penfield's brain map).

This localization of brain function is the key concept for "brain functional specialization," which suggests the relationship between a specific area and its function. Brain functional specialization is used in neuroeconomics in order to realize that "utility function and probability are implicated in what part of the brain." Moreover, it is very important to compare new outcomes of research and well-known facts, focusing on similarities and differences. The brain area processing inputs in an early phase of information processing, like the primary visual cortex, has been well studied in its structure and mechanism of data processing. However, the area that process inputs from the various areas in the later phase of information processing is considered to have many complex functions, so that it is indeed difficult to allocate a certain function. For example, the frontal lobe, which is specifically developed in mammals, is related to various "higher" cognitive functions, such as working memory, language, and reasoning. The complex functions are likely related to multiple areas of the brain. If this is true, it is important to know how the neural communication occurs between brain areas. It is now necessary to make a holistic mapping that covers the flow of information in the whole brain.

Korbinian Brodmann (1868–1918), a German neurologist, established a localization map of brain function. He visualized neurons on the cerebrum by the Nissl method of cell staining, divided a brain into parts that have similar structures, and gave Arabic numbers 1–52 to each part. This map is called the "Brodmann map," which has been used for later brain research. Interestingly, in spite of the fact that this Brodmann map divided the brain according to only the characteristics of cell construction without functional information, the allocation fitted well to the localization of brain functions. In other words, this denotes that the characteristics of cell construction closely relate to the brain functions. For instance, the primary somatosensory cortex (S1) in the brain map of Penfield is 1, 2, 3 in the Brodmann area (BA), and the primary visual cortex (V1) is BA 17. This categorization in the Brodmann map is commonly used to label an activity in a specific area.

The brain functions, including those involved in decision making based on reward, have now been explored. We discuss concrete findings later in Chaps. 4, 6–8.

2.3 Summary and Further Reading

This chapter briefly reviews the historical background of neuroeconomics and introduces its main research topics. Neuroeconomics focuses on the brain's work when humans make decisions. One of the aims of neuroeconomics is to develop an economic theory that can explain real human behavior including individual preference. based on the brain mechanism, on economic behavior.

To understand a field of study from the point of view of economics, we recommend Glimcher (2011) as an introductory textbook. Glimcher et al. (2013), the textbook of neuroeconomics, gives detailed approaches and findings of neuroeconomic studies. For more general interests in the brain, Aamodt (2008) is a good introduction to broad research topics in neuroscience and psychology.

2.4 Questions and Problems

2.4.1 Multiple-Choice Problems

1. Choose the most appropriate answer.

(A) Neuroeconomics is a study for economic activities of people with a neurotic disorder.

(B) Neuroeconomics is a study to reveal the brain functions which cause economic activities by utilizing neuroscientific methods, and to create a new economic theory that provides a better explanation for real economic activities.

2. Choose the most appropriate answer.

(A) Many methods used in neuroeconomics, such as *functional magnetic resonance imaging* (fMRI), do not require any surgical operation for the brain.

(B) All methods used in neuroeconomics, such as *functional magnetic resonance imaging* (fMRI), require surgical operations for the brain.

2.4.2 Discussion Question

Why do you think that it is easier to use results from neuroeconomics for research in behavioral economics than in traditional economics?

References

Aamodt, S., & Wang, S. (2008). *Welcome to your brain: Why you lose your car keys but never forget how to drive and other puzzles of everyday life* (1st U.S. eds.). New York: Bloomsbury.

Glimcher, P. W. (2011). *Foundations of neuroeconomic analysis*. Oxford University Press.

Glimcher, P. W., Fehr, E., & ebrary Inc. (2013). *Neuroeconomics: decision making and the brain* (2nd ed.). Academic Press.

Thorndike, E. L. (1911). *Animal intelligence; experimental studies*. New York: The Macmillan Company.

Part II
Prospect Theory and Bounded Rationality

Chapter 3
Economic Behavior Under Uncertainty

Abstract The chapter explains the expected utility hypothesis as a useful theory of decisions under uncertainty in traditional economics. There have been paradoxes, found in experiments and hypothetical surveys that cannot possibly be explained by the expected utility hypothesis.

Keywords Expected utility theory · Risk aversion · Allais paradox · Ellsberg paradox · Temptation · Self-control

In Chaps. 4 and 5, we will study prospect theory and bounded rationality, which are the foundations of how we understand economic behavior under uncertainty in behavioral economics. This chapter prepares the reader for these two chapters by explaining expected utility theory, which is the basic theory for economic behavior under uncertainty in traditional economics. Expected utility theory was formalized by von Neumann and Morgenstern, who were founders of modern game theory. Expected utility theory is now broadly used in macroeconomics, general equilibrium theory, and finance as well as in game theory.[1] Prospect theory generalizes expected utility theory in order to explain economic behavior that cannot be explained by expected utility theory. For this reason, in order to deeply understand prospect theory, we need to have knowledge about expected utility theory. Some theories of bounded rationality are based on prospect theory. For these reasons, this chapter starts by explaining expected utility theory. One important aspect of expected utility theory is the degree of risk aversion of preferences of each person. This chapter explains how the degrees of risk aversion have been estimated by methods in traditional economics and the method of hypothetical questions used in behavioral economics.

[1]An example of detailed explanation of expected utility is in Gilboa (2009).

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3.1 Lotteries and Expected Utility

It is important to consider an individual's forecasts when we try to understand their economic behavior under uncertainty. In many cases, we use the concept of the expected value in order to consider forecasts. For example, imagine that there is a lottery for which you win 3 dollars if a 6-sided die is thrown and 1 or 2 comes up, and you win 12 dollars if 3, 4, 5, or 6 comes up. An elementary event is a possible outcome. In this example, an elementary event is the number that comes up when the die is rolled. The set of all elementary events is called the probability space, and any subset of it is called an event. Suppose that there are m elementary events. Then the probability space is $\{1, 2, \ldots, m\}$. In the above example, we have 6 elementary events, and the probability space is {1, 2, 3, 4, 5, 6}. Here, {1, 2} and {3, 4, 5, 6} are examples of events. An elementary event does not have to be a number: it can be a vector of numbers or can be abstract such as people's optimistic sentiment and pessimistic sentiment.

A real valued function[2] with the domain of a probability space is a random variable. The realized values of X are denoted by $X_1, X_2, \ldots, X_m$. Imagine that probabilities $P_1, P_2, \ldots P_m$, are attached to each elementary event. Then each P_1 is nonnegative, and the sum of m probabilities add up to 1. The expected value of a random variable X is

$$E(X) = P_1 X_1 + \cdots + P_m X_m = \sum_{i=1}^{m} P_i X_i$$

where the notation of $\sum_{i=1}^{m} Y_i$ denotes $Y_1 + Y_2 + \cdots + Y_m$.

A lottery that pays the prize money amount of a random variable X is denoted by $(X_1, P_1; X_2, P_2; \ldots; X_m, P_m)$. A lottery is often called a prospect. In the above example, a random variable X takes the prize money amount as its realized value. For $i = 1, 2$, $X_i = 3$, and for $i = 3, 4, 5, 6$, $X_i = 12$. If an individual owns this lottery, then she can get 3 dollars with probability $1/3$ and 12 with probability $2/3$. This lottery can be denoted by $(300, 1/3; 1200, 2/3)$. The expected value of this lottery is

$$(1/3) \times 3 + (2/3) \times 12 = 9.$$

Thus the lottery's expected value is 9 dollars. If you could choose between getting this lottery and getting 9 dollars for sure, then which one would you choose? In economic experiments with such a choice, most people choose 9 dollars for sure rather than a lottery with risk. Such experimental results are consistent with the fact that many people try to avoid risk in economic choices in real lives. In order to consider such choice, we will express getting 9 dollars for sure as a lottery with

[2] A real valued function X with the domain A assigns a unique real number $X(a)$ to each member a of A. For a random variable, we often use a notation with a subscript X_a for $X(a)$.

probability 1, and denote it by (9.1). We will consider assets such as common stock whose holders lose money when their prices fall. For example, if a holder of one share of common stock gains 15 dollars with probability 0.8 and loses 12 dollars with probability 0.2, then the share is denoted by (15, 0.8: −12, 0.2).

Expected utility theory explains a person's risk aversion by predicting that she will choose a lottery that gives her the highest expected value of utility rather than choosing a lottery that gives her the highest expected value of money prizes.[3] Now, consider how an individual evaluates a lottery that pays the realized value of a random variable X as its prize money with expected utility theory. Let the utility value when the individual has z dollars for sure be $u(z)$. Imagine that the individual holds e dollars as her initial endowment holding of her asset. Then the individual's expected value of utility (expected utility) is

$$\begin{aligned} E(u(e+X)) &= P_1 u(e+X_1) + \cdots + P_m u(e+X_m) \\ &= \sum_{i=1}^{m} P_i u(e+X_i). \end{aligned}$$

For example, let us consider $u(z) = \log(z)$ as a utility function. Here, we take $\log(z)$ as a natural logarithm (ln(z) in Microsoft Excel and many other software programs). In expected utility, we use the individual's entire asset holding as her initial endowment. However, let us imagine that the individual has 10 dollars in her wallet, and let 10 dollars be her initial endowment. If we consider the above example of the lottery of (3, 1/3; 12, 2/3), then because $\log(13) \simeq 2.565$, $\log(10+12) \simeq 3.091$, the expected utility from the lottery is

$$(1/3) \times \log(13) + (2/3) \times \log(22) \simeq 2.91.$$

In order to compare, consider the expected utility from getting 9 dollars for sure. Then

$$\log(19) \simeq 2.94 > (1/3) \times log(13) + (2/3) \times log(22)$$

In expected utility theory, it is supposed that the individual prefers the lottery which gives a higher value of expected utility. Therefore, if the individual has the utility function of log(z), then she will prefer getting 9 dollars for sure to the lottery in the above example.

We considered $u(z) = \log(z)$ as the individual's utility function as an example. We can consider many other forms of utility functions. How can we express an individual's preferences toward risk by a utility function? In order to answer this question, we will see the relationship between utility functions and preferences. Suppose that probabilities $P_1, P_2, \ldots, P_m$ are attached to elementary events in a probability space {1, 2,…, m}. Lotteries are all random variables on this probability

[3]See Appendix 1 for the relationship between preferences for lotteries and their expected utility.

space. We consider preferences of an individual for these lotteries. If X is at least as good as Y, then we write $X \succsim Y$. Here $\succsim$ gives a preference ordering for the lotteries.

Suppose that a utility function $u(z)$ is such that for any two lotteries X, Y, $X \succsim Y$ if and only if $E(u(X)) \geq E(u(Y)$. Then we say that $u(z)$ represents this preference ordering. Are there other utility functions than $u(z)$ that represent the same preference ordering? For real numbers α and β, if $\alpha > 0$, and if

$$v(z) = \alpha u(z) + \beta$$

then $v(z)$ is said to be a positive linear transformation of $u(z)$. Here, $E(u(X)) \geq E(u(Y))$, if and only if $E(v(X)) \geq E(v(Y))$. Therefore, u(z) and v(z) represent the same preference ordering. Namely, if $u(z)$ is a utility function that represents a preference ordering, then all its positive linear transformations represent the same preference ordering. Because a utility function weighted by probabilities represent a preference ordering in expected utility, it can be proved that only the positive linear transformations of $u(z)$ represent that preference ordering.

3.2 Attitudes Toward Risk

3.2.1 Preferences for Risk

Imagine an individual with 10 dollars initial endowment who is thinking about either receiving a dollar amount for sure or receiving the last section's example of the lottery, (3, 1/3; 12, 2/3). She will be indifferent between receiving the lottery and receiving a certain amount of money for sure. This level is about 8.45 dollars because

$$\log(10 + 8.45) \simeq 2.92 \simeq (1/3) \times \log(13) + (2/3) \times \log(22).$$

The *certainty equivalent* of a lottery is the sure amount of money that an individual views as equally desirable as the lottery. A *risk premium* is the difference between the expected value of the lottery and its certainty equivalent. Namely, if an individual has a utility function $u(z)$ and an initial endowment e, then the certainty equivalent of a lottery that pays a random variable X as its prize is a real number y such that $u(e + y) = E(u(e + X))$. The difference between the lottery's expected value $E(X)$ and is certainty equivalent, $E(X) - y$ is the risk premium. In the above example, the risk premium is 0.55 dollars because 9–8.45 = 0.55.

There are three possible kinds of attitudes toward risk for an individual. If the risk premium is positive, then she is *risk averse*. If the risk premium is negative, then she is *risk loving*. If the risk premium is zero, then she is *risk neutral*. It is presumed that most people are risk averse and their risk premium for a lottery is positive.

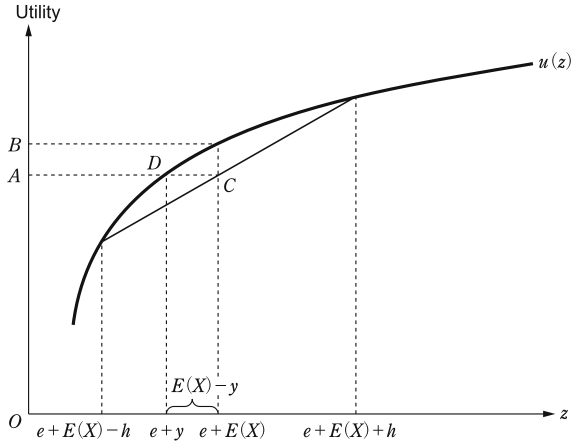


Fig. 3.1 Risk aversion

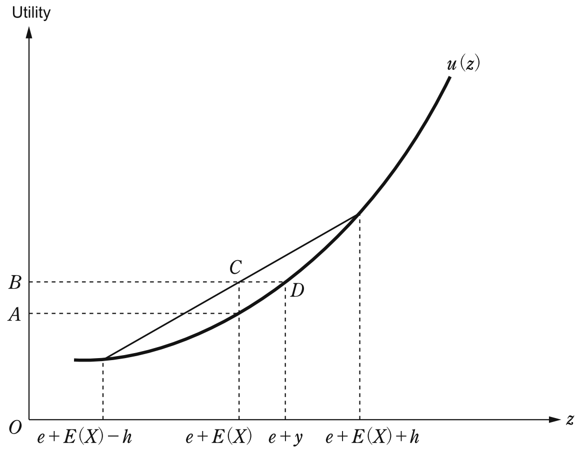
3.2.2 Preferences for Risk and the Shape of the Utility Function

This section explains the relationship between an individual's preferences for risk and the shape of a utility function that represents the preference ordering. Here, we use an example of a lottery X that pays $E(X)+h$ with a probability 0.5 and pays $E(X)-h$ with a probability 0.5, which is denoted by $(E(X)+h, 0.5; E(X)-h, 0.5)$. The expected value of this lottery is $E(X)$ dollars. Whether or not this individual is risk averse or risk loving depends on the shape of the utility function that represents her preferences.

In Fig. 3.1, the shape of $u(z)$ is concave downward. A function with such a shape is a concave function.[4] An example of a concave function is $\log(z)$. In the figure, the length of the line segment OA is equal to $0.5u(e+E(X)+h)+0.5u(e+E(X)-h)$ and expresses the expected utility when the individual receives the lottery, $E(u(e+X))$. The length of the line segment OB expresses the utility when receiving the sure amount of $E(X), u(e+E(X))$. The certainty equivalent, y, is obtained by dropping a perpendicular line from the intersection point D between the line segment AC and $u(z)$ on the horizontal axis, The certainty equivalent is the difference between the length of the intersection of this perpendicular line and the horizontal axis and e. We can see that the individual prefers receiving a sure amount of its expected value to receiving the lottery because the length of the line segment OA is shorter than that of the line segment OB if the utility function is concave. In addition, because $e+E(X)$ is greater than $e+y$, the risk premium $E(X)-y$

[4]Mathematically, a real-valued function $u(z)$ is a concave function if $tu(x)+(1-t)u(y) \leq (u(tx+(1-t)y)$ for any two points x and y in the domain and for any real number t such that $0 \leq t \leq 1$.

Fig. 3.2 Risk lovingness



denoted by $\{\cdot\}$ in the figure is positive. Thus, an individual is risk averse if her utility function is a concave function.

In Fig. 3.2, the shape of $u(z)$ is convex downward. Such a function is a convex function.[5] In the figure, the length of the line segment OB is equal to $u(e+E(X)+h)+0.5u(e+E(X)-h)$ and expresses the expected utility when the individual receives the lottery, $E(u(e+X))$. The length of the line segment OA expresses the utility when receiving the sure amount of $E(X), u(e+E(X)$. The certainty equivalent, y, is obtained by dropping a perpendicular line from the intersection point D between the extension of line segment BC and $u(z)$ on the horizontal axis, The certainty equivalent is the difference between the length of the intersection of this perpendicular line and the horizontal axis and e. We can see that the individual prefers receiving the lottery to receiving the sure amount of its expected value because the length of the line segment OA is shorter than that of the line segment OB if the utility function is convex. In addition, because $\mathrm{e}+E(X)$ is smaller than $e+y$, the risk premium $E(X)-y$ in the figure is negative. Thus, an individual is risk loving if her utility function is a convex function. In the figure, the length of the line segment OA expresses the expected utility $E(u(e+X))$, and the length of the line segment OB expresses the utility when $E(u(E(X))$.

If the shape of the graph of the utility function is a straight line, then the risk premium must be zero if we think from Figs. 3.1 and 3.2. In this case, the individual is risk neutral. If the graph is a straight line, then the utility function is a linear function, $\mathrm{u(z)} = \alpha\mathrm{z}+\beta$, where α, β are constants.

Next, we will see the relationship between attitudes toward risk and *marginal utility*. For this purpose, we first consider the relationship between the shape of a utility function and marginal utility. When $u(z)$ is an individual's utility function, its derivative $u'(z)$ is marginal utility. In a graph, the slope of the utility function is

[5]Mathematically, if $-u(z)$ is a concave function, then $u(z)$ is a convex function.

marginal utility. The shape of the utility function depends on what happens to the marginal utility as z increases; (1) the marginal utility decreases (*diminishing marginal utility*), (2) the marginal utility increases (*increasing marginal utility*), and (3) the marginal utility remains the same (*constant marginal utility*).

As in Fig. 3.1, the marginal utility decreases as z increase if the utility function $u(z)$ is a (differentiable) concave function. If $u(z) = \log(z)$, for example, $u'(z) = 1/z$, and the marginal utility decreases as z increases. In the case of diminishing marginal utility like this, $u''(z) < 0$. Conversely, a utility function with diminishing marginal utility is a concave function. As in Fig. 3.2, if a utility function is a convex function, then the marginal utility is increasing. Conversely, a utility function with increasing marginal utility is a convex function. If the graph of a utility function is a straight line, then the utility function is a linear function, $u(x) = \alpha x + \beta$, and the marginal utility is constant at α. Conversely, if the marginal utility is constant, then the utility function is a linear function. Therefore, an individual with diminishing marginal utility is risk averse, an individual with increasing marginal utility is risk loving, and an individual with constant marginal utility is risk neutral.

3.3 Measures of Risk Aversion

In this section, we consider measures of risk aversion of a person when his preferences can be represented by $u(z)$.

3.3.1 *Two Measures of Risk Aversion*

Pratt (1964) and Arrow (1965) defined the measure of absolute risk aversion $R(z)$ and the measure of relative risk aversion $R^*(z)$ as follows:

$$R(z) = -\frac{u''(z)}{u'(z)}$$

$$R^*(z) = -\frac{zu''(z)}{u'(z)}$$

When we define these measures of risk aversion, we assume that all utility functions have positive marginal utility $(u'(z) > 0)$. We will explain the meaning of “absolute” and “relative” later.

There can be other measures of risk aversion, but both of these measures satisfy the following three desirable properties of such a measure.

1. If $u''(z) < 0$ for a value of z, then the measure is positive. If $u''(z) = 0$, then the measure is zero.
2. For two utility functions $u(z)$ and $v(z)$, if $u'(z) = v'(z)$ and $|u''(z)| > |v''(z)|$ for a value of z, then the measure of risk aversion for $u(z)$ is greater than that for $v(z)$.
3. If $v(z)$ is a linear transformation of $u(z)$, then they have the same measure of risk aversion.

According to Property 1, if a preference ordering shows risk aversion $(u''(z) < 0)$, then the measure is positive. If a preference ordering shows risk neutrality $(u''(z) = 0)$, then the measure is zero. According to Property 2, if preference orderings represented by two utility functions $u(z)$ and $v(z)$ are both risk averse, then $u''(z) < 0$ and $v''(z) < 0$ because $u(z)$ and $v(z)$ are concave functions with diminishing marginal utility. For a value of z, suppose that $u'(z) = v'(z)$ and $|u''(z)| > |v''(z)|$. This means that the degree of concavity of $u(z)$ is greater than that of $v(z)$. According to Property 2, the measure of risk aversion is greater for $u(z)$ than that for $v(z)$. For example in Fig. 3.3, $u(z)$ and $v(z)$ have the same slope and $u(z)$ has a greater degree of concavity than $v(z)$ at $z = e + E(X)$. Here, if we consider risk premium for each of the utility functions as in Fig. 3.1, then we see that risk premium for $u(z)$ is greater than that for $v(z)$ at $z = e + E(X)$ where the marginal utility is the same. Therefore, this property is desirable for a measure of risk aversion. According to Property 3, a linear transformation of a utility function represents the same preference ordering. Hence, the measure of risk aversion should not change for two utility functions. Both the measures of absolute and relative risk aversion satisfy these three properties. However, in order to understand the difference between these two measures, we need to see other properties.

We will look into the relationship between people's choice under uncertainty and each of the two measures of risk aversion. First, in order to understand the measure of absolute risk aversion, consider a simple lottery with $E(X) = 0$ for the lottery $(E(X) + h, 0.5; E(X) - h, 0.5)$ we used in the last section. A holder of this lottery receives h dollars with probability 0.5 and pays h dollars with probability

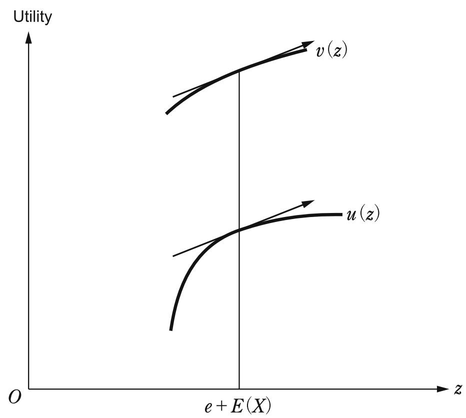


Fig. 3.3 Degrees of risk aversion

0.5. The fact that a risk averter prefers not to receive this lottery for free of charge can be expressed by an inequality:

$$0.5u(e+h)+0.5u(e-h) < u(e).$$

As we saw earlier, the certainty equivalent y is a real number y such that

$$0.5u(e+h)+0.5u(e-h) = u(e+y).$$

The risk premium ρ is the difference between this lottery's expected value (which is zero in this case):

$$\rho = -y$$

If the individual is risk averse, and his expected function is a concave function, then the certainty equivalent is negative for the (risky) lotteries with the expected value of 0, and risk premium is positive. It can be shown that an individual with a greater measure of absolute risk aversion requires a greater risk premium for the example lottery and that, conversely, a person who requires a greater risk premium has a greater measure of absolute risk aversion (See Appendix 2 at the end of this chapter).

Next, in order to understand the measure of relative risk aversion, consider a lottery whose holder receives h^*e dollars with probability 0.5, and pays h^*e dollars with probability 0.5. For the example lottery we used to understand the measure of absolute risk aversion, the prize money did not depend on the amount of initial endowment. For this example lottery we use to understand the measure of relative risk aversion, the prize money proportionally changes with the amount of initial endowment. The fact that a risk averter prefers not to receive this lottery for free of charge can be expressed by an inequality:

$$0.5u(e+h^*e)+0.5u(e-h^*e)<u(e)$$

The certainty equivalent for the lottery is a real number y such that

$$0.5u(e+h^*e)+0.5u(e-h^*e) = u(y)$$

holds.

The relative risk premium ρ^* is defined by the certainty equivalent end initial endowment, so that

$$y = (1-\rho^*)e$$

is satisfied. It can be shown that an individual with a greater measure of relative risk aversion requires a greater relative risk premium for the example lottery and that, conversely, a person who requires a greater relative risk premium has a greater measure of absolute risk aversion (See Appendix 2 at the end of this chapter).

3.3.2 Properties of Measures of Risk Aversion

Arrow and Pratt proposed the following hypothesis based on theoretical considerations:

Hypothesis (A): The function of the measure of absolute risk aversion $R(z)$ is monotonically decreasing.

For most people, a lottery for which a holder gains or loses 1,000 dollars must be a big risk but is likely to be a small risk for a billionaire such as Bill Gates. If so, then Hypothesis (A) holds. Empirical research after Arrow and Pratt's works also generally supports Hypothesis (A). Arrow proposes the following hypothesis based on theoretical considerations:

Hypothesis (B): The function of the measure of relative risk aversion $R^*(z)$ is monotonically increasing.

Friend and Blue (1975), however, did empirical research based on household asset data in the United States and showed that both rich and poor people hold about the same fraction of their total assets as risky assets. Their empirical evidence supported the hypothesis that the measure of relative risk aversion is almost constant and is about two. From the definition equations of the two measures, $R(z) = R^*(z)/z$. Therefore, if $R^*(z)$ is constant, then Hypothesis (A) also holds. Namely, their empirical evidence is more consistent with

Hypothesis (C): the function of the measure of relative risk aversion $R^*(z)$ is constant.

If we imagine a lottery to gain or lose 10% of total asset, then the risk may seem similar to both a typical American and to Bill Gates. In developed countries, the hypothesis of the constant relative risk aversion [Hypothesis (C)] at least seems to approximately hold.

Poor people in most developed countries with social programs, however, are richer than poor people in many developing countries. If people in poor countries live near their minimum subsistence levels, and if they take risk, then there is a possibility that their consumption falls below their subsistence levels. For this reason, it is likely that the measure of absolute risk aversion is very high near minimum subsistence levels. Because $R^*(z) = zR(z)$, if the measure of absolute risk aversion is very high, then the measure of relative risk aversion must be also very high. Therefore,

Hypothesis (D): The function of the measure of relative risk aversion $R^*(z)$ is decreasing near the subsistence level.

seems plausible. Ogaki and Zhang (2001) obtained empirical evidence that supports this hypothesis from household data in villages in India and Pakistan.

Pratt (1964, p. 123) stated that the measure of relative risk aversion may tend to decrease first and then increases as the level of asset (or consumption) increases as in Hypothesis (B). Combining his idea with the empirical evidence explained above, we can support the elements of Hypotheses (A), (B), and (C) for different levels of assets by a composite hypothesis: the measure of relative risk aversion is decreasing in the range of very low levels of asset, almost constant once the level of asset reaches a certain level, and is increasing for very high levels of assets. The empirical evidence, however, for the Hypothesis (B) part of this composite hypothesis has not been found.

If we adopt Hypothesis (C) and assume that the measure of relative risk aversion is constant at σ, then $-zu''(z)/u'(z) = \sigma$. When we integrate this equation, we obtain

$$
\begin{aligned}
u(z) &= \mathrm{z}^{1-\sigma} (\text{if } 0 < \sigma < 1) \\
u(z) &= \log(z) \quad (\text{if } \sigma = 1) \\
u(z) &= -z^{1-\sigma} \quad (\text{if } \sigma > 1).
\end{aligned}
$$

One case that is of theoretical interest is the case in which the measure of absolute risk aversion is constant. If this measure is constant at γ, then $-u''(z)/u'(z) = \gamma$. When we integrate this equation, we obtain

$$
\begin{aligned}
u(z) &= -e^{-\gamma z} \quad (\text{if } \gamma > 0) \\
u(z) &= z \quad (\text{if } \gamma = 0) \\
u(z) &= e^{-\gamma z} \quad (\text{if } \gamma < 0)
\end{aligned}
$$

If $\gamma > 0$, then an individual with the first utility function is risk averse. If $\gamma = 0$, then an individual with the second utility function is risk neutral. If $\gamma < 0$, then an individual with the third utility function is risk loving. Because $R^*(z) = zR(z)$, if the measure of absolute risk aversion is constant, then the measure of relative risk aversion increases as z increase. Therefore, such a utility function is not consistent with empirical findings mentioned above.

In many studies, researchers use the quadratic utility function:

$$u(z) = a + bz - cz^2 \quad (a \geq 0, b > 0, c > 0, 0 \leq z < b/(2c))$$

If the parameters of the utility function (a, b, c) satisfy the above conditions, and if the variable z stays in the domain $0 \leq z < b/(2c)$, then $u(z)$ is monotonically increasing and is a concave utility function. The measure of absolute risk aversion and the measure of relative risk aversion are both monotonically increasing functions of z, which is not consistent with empirical findings mentioned above nor our intuition that the measure of absolute risk aversion must be decreasing.

Because their functional forms are convenient for theoretical analysis, both the constant absolute risk aversion utility function and the quadratic utility function are often used. Even though the measure of absolute risk aversion is thought to be decreasing in reality, these utility functions have implications that the measure is either constant or increasing. Thus, these utility functions have unrealistic properties for the measure of absolute risk aversion. It is necessary to carefully interpret theoretical results when these utility functions are used.

3.4 Estimating Measures of Risk Aversion

Friend and Blume (1975) used panel data for U.S. households (data that are collected at different points in time from the same households). As stated above, because the ratio of risky assets to total assets is about constant, they assumed that the measure of relative risk aversion is constant. From this ratio and a degree of riskiness of the rate of return on the risky asset, they estimated that the measure of relative risk aversion is about two. Hansen and Singleton (1982) used aggregate consumption in the United States and rates of return from stock and bonds. Assuming that aggregate consumption in the United States is determined by a representative consumer with constant relative risk aversion, they applied a statistical method called Generalized Method of Moments that is similar to nonlinear regression to a condition for maximizing the expected utility.[6] Because of data errors in their 1982 paper, they published corrected empirical results in *Econometrica* as an Erratum in 1984 (pp. 267–268). Even though their estimates for the measure of relative risk aversion are different depending on which stocks and bonds are used, they fell in the range of 1.59 and −1.26 according to their corrected results. However, their standard errors are large, and the hypothesis that the true value of the measure is zero cannot be rejected at the 5% level. In this sense, they did not precisely estimate the measure of relative risk aversion, but their empirical results support relatively low values of the measure.

Barsky et al. (1997) used a method of conducting a survey with hypothetical questions for individuals. Using this method, we can estimate different values of the measure of relative risk aversion of individuals rather than the representative consumer of the economy.

3.5 Expected Utility Paradoxes

In the context of decision theory, actual human behaviors that cannot be explained by expected utility theory are called paradoxes. Many paradoxes have been found in experiments and surveys with hypothetical questions. If one takes the view that expected utility theory represents human rationality, then these paradoxes are interpreted to show that people are irrational. If one takes the view that the expected

[6]Because Hansen and Singleton (1982) used a multi-period model, the condition is a Euler equation explained in Chap. 6.

utility theory is not necessarily correct in explaining human behaviors, then these paradoxes are interpreted to show limitations of expected utility theory. In this case, we need other decision theories that can explain paradoxes. It is also important to gain knowledge from neuroeconomics in order to construct or verify such theories. One theory in behavioral economics with the latter view is prospect theory. This section explains the Allais paradox, which is closely related to prospect theory, and the Ellsberg paradox for which research in neuroeconomics has been making progress.

3.5.1 Allais Paradox

Maurice Allais, a French winner of the Nobel Prize in Economics, designed choice problems for which many people's choices are inconsistent with expected utility theory. Because such choices cannot be explained by expected utility theory even with very unusual utility functions, they are called Allais paradox.[7] Allais (1953) divided the following four lotteries into two groups. The first group has:

Lottery 1: 1 billion francs for sure
Lottery 2: 0 franc with probability 0.01, 5 billion francs with probability 0.10, and 1 billion francs with probability 0.89.

According to many studies that follow, many people choose Lottery 1 when these two lotteries (or lotteries in which the prize amounts are proportionally changed) are presented to them as surveyed by Machina (1987) and Camerer (1995).[8] The second group has

Lottery 3: 1 billion francs with probability 0.11, and 0 franc with probability 0.89
Lottery 4: 5 billion francs with probability 0.10, and 0 franc with probability 0.90.

Many people choose Lottery 4 when these two lotteries are presented to them.

Let e be the initial endowment. By expected utility theory, the choice by many people to choose Lottery 1 in the first group can be expressed as

$$u(e + 1\,\text{billion}) > 0.01 \times u(e) + 0.1 \times u(e + 5\,\text{billion}) + 0.89 \times u(e + 1\,\text{billion}). \tag{3.1}$$

[7]This section explains the most famous choice problem even though Allais (1953) gave other examples.

[8]Allais used huge amounts of prize money in his example. Not only in experiments in which hypothetical huge amounts were used, but also in experiments with much smaller amounts of prize money that are actually paid to participants, many people make choices that support the Allais paradox. Here, "many" does not necessarily mean "the majority".

On the other hand, the choice by many people to choose Lottery 4 in the first group can be expressed as

$$0.11 \times u(e + 1\,\text{billion}) + 0.89 \times u(e) < 0.1 \times u(e + 5\,\text{billion}) + 0.9 \times u(e) \quad (3.2)$$

Subtracting 0.89 × u(e+1 billion) from both sides of (3.1) results in

$$0.11 \times u(e + 1\,\text{billion}) > 0.01 \times u(e) + 0.1 \times u(e + 5\,\text{billion}). \quad (3.3)$$

Inequalities (3.2) and (3.3) are inconsistent. Therefore, no matter what kind of utility function an individual has, expected utility theory can never explain the combination of the choice of Lottery 1 and Lottery 4. This inconsistency of actual choice of many people with expected utility theory is the Allais paradox.

3.5.2 Ellsberg Paradox and Knightian Uncertainty

In this book, we have explained about uncertainty when probabilities are known. Frank Knight (1885–1972) distinguished between uncertainty when probabilities are known and uncertainty when probabilities are not known. He called the former risk, and the latter uncertainty, which is also called Knightian uncertainty. The degree of Knightian uncertainty is called ambiguity.

Regarding Knightian uncertainty, Ellsberg (1961) proposed the following thought experiment. There are two urns, and there are 100 balls in each urn. A participant can randomly draw one ball from either of these urns. The participant knows that Urn A contains 50 red balls and 50 black balls. The participant knows that Urn B contains red and black balls with a total of 100 balls, but does not know the ratio of red and black balls. The participant can bet on either a red or black ball being drawn from one of these urns, and wins 100 dollars if the right color ball is drawn. Ellsberg reported that the majority of people whom he asked preferred to draw from Urn A even though he did not do any formal experiment. In expected utility theory, the participant is predicted to put a subjective probability of half to draw a red ball even from Urn B. Therefore, these thought experiment results are inconsistent with expected utility theory. When an individual dislikes ambiguities from Knightian uncertainty more than risk with known probabilities as in this example, the individual is said to have *ambiguity aversion*. Camerer (1995) surveyed experiments (many of which actually paid prize money) that followed Ellsberg and reported that ambiguity aversion is a robust result.

A decision theory that includes ambiguity aversion is Gilboa and Schmeidler's (1989) Max min expected utility theory. They formalize Knightian uncertainty as various subjective probability distributions that are deemed possible before the decision maker observe an event. In their theory, the decision maker maximizes his expected utility based on the worst case subjective probability distribution.

An example of this theory's application is Hansen and Sargent's (2001) macroeconomic model with the model uncertainty that economic agents do not know which model is true.

3.5.3 A Model of Temptation and Self-control

If a preference ordering satisfies a set of axioms, then it can be proved that expected utility function represents the ordering (See Appendix 1 at the end of this chapter). The Allais paradox and Ellsberg paradox suggest that these axioms do not hold for real people. A theory that can explain the Allais paradox is prospect theory, which is explained in the next chapter. In this section, we introduce Gul and Pesendorfer's (2001, GP hereafter) theory that is based on a set of axioms that is different from that for expected utility theory in order to explain people's behavior of self-control when they face temptation. Even though the original GP model cannot explain the Allais paradox, Noor and Takeoka (2015) explain that their model that extends the GP model can explain the paradox.

As an example of self-control under temptation, consider preferences for menus such as preferences for restaurants with different menus for lunch by an individual who just finished breakfast and thinks that he should eat a healthy diet. Here, we think of the situation without any uncertainty for simplicity. Imagine that he has the following preferences. He prefers a restaurant whose menu only lists salads to a restaurant whose menu only lists hamburgers. If he goes to a restaurant whose menu list both salads and hamburgers, then he needs to exercise self-control because he is tempted to have a hamburger. So he prefers to go to a restaurant whose menu only lists salad. The worst case is when he goes to the restaurant whose menu only lists hamburgers.

An economic man of traditional economics is only interested in ultimate consumption. So he will not care whether or not hamburgers are on a menu. Therefore, he should be indifferent between a menu which only lists salads and a menu which only lists hamburgers. If self-control under temptation is costly in terms of willpower, however, then a menu which only lists salads is preferred.

In GP theory, preferences are for menus rather than for ultimate consumption or lotteries for consumption. This makes it possible to express preferences when there are temptations. A menu is a subset of the set of all lotteries in this theory. Under a set of axioms for such preferences, a preference ordering can be represented by utility functions. Let x be a lottery for consumption and Z be a set of the lotteries. Suppose that a preference ordering is defined over the subsets of Z. As a special case of the example above of salad and hamburger, let a lottery to obtain a salad with probability one be x_1, a lottery to obtain a hamburger with probability one be x, and $Z = \{x_1, x_2\}$. For subsets of Z, consider $B = \{x_1\}, \mathrm{C} = \{x_1, x_2\}$, and

$D = \{x_2\}$. GP proves that a preference ordering can be represented by a utility function $U(A)$:

$$U(A) = \mathrm{Max}(u(x) + v(x)) - \mathrm{Max}\, v(x)$$

where A is a subset of Z, u is a commitment utility function, v is a temptation function, $\mathrm{Max}(\cdot)$ takes the maximum value of the function of its argument over A. For the salad and hamburger example, we consider the following numerical example: $u(x_1) = 2, u(x_2) = 1, v(x_1) = 0.8$, and $\mathrm{v}(x_2) = 1.2$. Then $U(B) = u(x_1) + v(x_1) - v(x_1) = 2, U(C) = u(x_1) + v(x_1) - v(x_2) = 1.6$, and $U(D) = u(x_2) + v(x_2) - v(x_2) = 1$. This example expresses preferences of an individual who has been having a healthy diet and feels temptations. The commitment utility function expresses a preference order such that he prefers salad to hamburger because he is on a diet, while the temptation utility expresses a preference order such that he prefers hamburger to salad if he does not think about his health.[9]

3.6 Summary and Further Reading

The expected utility hypothesis is a useful theory of decisions under uncertainty. There have been paradoxes, found in experiments and hypothetical surveys, that cannot possibly be explained by the expected utility hypothesis no matter what functional forms and parameters are used for the utility function. Two prominent examples are the Allais and Ellsberg paradoxes. These paradoxes have motivated researchers to develop other decision theories.

Camerer (1995) gives a review of experimental studies of individual decision making many of which are very closely related to the theme of this chapter. Chapters 1–14 of a graduate level textbook of Gilboa (2009) covers important aspects of the expected utility theory that are not covered in this chapter.

3.7 Question and Problems

3.7.1 Multiple-Choice Problems

1. Assume that the expected utility hypothesis holds, that person A has a higher measure of absolute risk aversion than person B at any income level, and that person B has a higher measure of relative risk aversion than person C at any income level. Suppose lottery 1 brings two outcomes, with the equal probability

[9]There are models that express decisions under temptations that are different from the GP framework. For example, the tough-love model introduced in Chap. 9 can be interpreted as a model of values and temptation.

50%: $x + h$ and $x - h$. Lottery 2 also brings two outcomes with 50% probability for each, $x(1 + h^*)$ and $x(1 - h^*)$. Choose the most appropriate answer.

(A) Depending on the value of x and h, person A may ask for a lower risk premium than person B for lottery 1.
(B) Person A will always ask for a higher risk premium than person B for lottery 1.
(C) Depending on the value of x and h^*, person B may ask for a lower relative risk premium than person C for lottery 2.
(D) Person B will always ask for a higher relative premium than person C for lottery 2.
(E) A and C
(F) A and D
(G) B and C
(H) B and D

2. Choose the most appropriate answer according to empirical evidence on how the measures of absolute and relative risk aversion change with income increases.

(A) The measure of absolute risk aversion tends to increase.
(B) The measure of absolute risk aversion tends to decrease.
(C) Based on Friend and Blume (1975), the measure of relative risk aversion tends to decrease in American households.
(D) Based on Friend and Blume (1975), the measure of relative risk aversion tends to stay constant in American households.
(E) According to Ogaki and Zhang (2001), the measure of relative risk aversion tends to decrease when income is near the lowest subsistence level.
(F) According to Ogaki and Zhang (2001), the measure of relative risk aversion tends to stay constant when income is near the lowest subsistence level.
(G) A, C and E
(H) A, C and F
(I) A, D and E
(J) A, D and F
(K) B, C and E
(L) B, C and F
(M) B, D and E
(N) B, D and F

3. Choose the most appropriate answer regarding the shape of the utility function and the measures of absolute and relative risk aversion.

(A) Under the utility function with constant relative risk aversion, the measure of absolute risk aversion is also constant.
(B) Under the utility function with constant relative risk aversion, the measure of absolute risk aversion decreases as income increases.

(C) Under the utility function with constant relative risk aversion, the measure of absolute risk aversion increases as income increases.
(D) Under the utility function with constant absolute risk aversion, the measure of relative risk aversion is also constant.
(E) Under the utility function with constant absolute risk aversion, the measure of relative risk aversion decreases as income increases.
(F) Under the utility function with constant absolute risk aversion, the measure of relative risk aversion increases as income increases.
(G) A and D
(H) A and E
(I) A and F
(J) B and D
(K) B and E
(L) B and F
(M) C and D
N) C and E
(O) C and F

4. When the utility function is a quadratic function:

(A) Both measures of absolute and relative risk aversion are constant.
(B) With income increase, the measure of absolute risk aversion increases whereas the measure of relative risk aversion declines.
(C) With income increase, both measures of absolute and relative risk aversion increase.
(D) With income increase, the measure of absolute risk aversion increases whereas the measure of relative risk aversion is constant.
(E) With income increase, the measure of absolute risk aversion increases whereas the measure of relative risk aversion is constant.

3.7.2 Short Answer/Essay Problems

According to expected utility expectation theory, assuming relative risk aversion is constant, which of the following three pairs of lotteries will be chosen? Answer this question for each of the following combination of the initial endowment and the degree of risk aversion: the initial endowment of 1,000 dollars or 100,000 dollars, and the degree of relative risk aversion of 0.88, 1, 2, 5, or 10. Use Microsoft Excel or similar software for calculation.

1. Lottery (500, 0.6; −500, 0.4) and lottery (0, 1)
2. Lottery (500, 0.7; −500, 0.3) and lottery (0, 1)
3. Lottery (10,000, 0.5; 1,000, 0.4; −500, 0.1) and lottery (0, 1)

Appendix 1: Axioms for Expected Utility Theory

This Appendix explains axioms for expressing a preference ordering by an expected utility function. Consider a lottery that gives x dollars (or x units of a good) with probability p and y dollars with probability (1 − p). Let this lottery denoted by $(x, p; y, 1-p)$, p be a real number in [0, 1], and Y be a set of all lotteries. When we mix two lotteries $(x, p; y, 1-p)$ and $(x, r; y, 1-r)$ by a lottery that gives the former lottery with probability q and the latter lottery with probability $(1-q)$, the mixed lottery is assumed to be the same as $(x, qp+(1-q)r; y, q(1-p)+(1-q)(1-r))$. An individual's preference ordering over the lotteries is denoted by $\gtrsim$. We write $(x, p; y, 1-p) \succsim (x, r; y, 1-r)$ when the individual prefers to $(x, p; y, 1-p)$ to $(x, r; y, 1-r)$ or is indifferent between them. If $(x, p; y, 1-p) \succsim (x, r; y, 1-r)$ and $(x, p; y, 1-p) \precsim (x, r; y, 1-r)$, then he is indifferent between the two lotteries, and we write $(x, p; y, 1-p) \sim (x, r; y, 1-r)$. If $(x, p; y, 1-p) \succsim (x, r; y, 1-r)$, but $(x, p; y, 1-p) \precsim (x, r; y, 1-r)$ does not hold, then $(x, p; y, 1-p)$ is strictly preferred, and we write $(x, p; y, 1-p) > (x, r; y, 1-r)$.

The four axioms of expected utility theory are:

Axiom 1: (Completeness): For any two lotteries $(x, p; y, 1-p), (x, q; y, 1-q)$, either $(x, p; y, 1-p) \succsim (x, q; y, 1-q)$ or $(x, p; y, 1-p) \precsim (x, q; y, 1-q)$ holds.

Axiom 2 (Transitivity): For any three lotteries $(x, p; y, 1-p), (x, q; y, 1-q)$, if $(x, r; y, 1-r)$, *if* $(x, p; y, 1-p) \succsim (x, q; y, 1-q)$ and $(x, q; y, 1-q) \succsim (x, r; y, 1-r)$, then $(x, p; y, 1-r) \succsim (x, q; y, 1-r)$.

Axiom 3 (Independence): For any two prizes x and y, if $x \succsim y$, then for any prize z and for any probability $p(0 \leq p \leq 1), (x, p; z, (1-p)) \succsim (y, p; z, (1-p))$.

Axiom 4 (Continuity): for any three prizes x, y, z, if $x \succsim y \succsim z$, then there exists a probability p such that $(x, p; z, 1-p) \sim y$.

According to the expected utility theorem under these four axioms, there exists a real valued function U on Y with the following two properties:

1. For any two lotteries L, M, a necessary and sufficient condition for $L \succsim M$ is $U(L) \geq U(M)$.
2. Let $U((x, 1)) = u(x)$. Then $U((x, p; y, 1-p)) = pu(x) + (1-p)u(y)$.

Here, by Property (2), U is an expected utility. By Property (1), this expected utility represents the individual's preference ordering.

Appendix 2: Properties of the Measure of Absolute Risk Aversion

This appendix explains two propositions regarding properties of the measure of absolute risk aversion. As in the text, we consider a lottery ($E(X) + h$, 0.5;

$E(X) - h$, 0.5) with $E(X) = 0$. Because risk premium depends on the values of e and h, we write it as a function $\rho(e, h)$.

Proposition 3.1 Given e, if h is sufficiently small, then

$$R(e) \simeq \frac{2}{h^2} \rho(e, h)$$

This is a special case of Pratt's (1964) Eq. (5).[10] According to Proposition 3.1, the measure of absolute risk aversion is approximately positively proportional to risk premium for small h. Therefore, an individual with a higher measure of absolute risk aversion requires a higher risk premium for a lottery. Since this property holds for small h, it is a local property of the measure of absolute risk aversion.

Global properties that hold for any h as long as $z - h > 0$ are also known. Let $i = 1, 2$ denote two individuals. For an individual with utility function $u_i(z)$. Let $\mathrm{R_i(z)}$ be her measure of absolute risk aversion and $\mathrm{\rho_i(z, h)}$ be her risk premium.

Proposition 3.2 The following two conditions are equivalent.

i. $R_{a1}(z) > R_{a2}(z)$
ii. For all he, $\rho_1(z, h) > \rho_2(z, h)$

This proposition is a special case of part of Pratt's (1964) Theorem 1.[11] According to this proposition, an individual with a higher measure of absolute risk aversion requires a higher risk premium for a lottery. Conversely, an individual who requires a higher risk premium has a higher measure of absolute risk aversion.

Appendix 3: Properties of the Measure of Relative Risk Aversion

This appendix explains two propositions regarding properties of the measure of relative risk aversion. As in the text, we consider a lottery $(E(X) + eh^*, 0.5; E(X) - eh^*, 0.5)$ with $E(X) = 0$ when endowment e is given. Because relative risk premium depends on the values of e and h^*, we write it as a function $\rho^*(e, h^*)$.

Proposition 3.3 Given e, if h^* is sufficiently small, then

$$R^*(e) \simeq \frac{2}{h^{*2}} \rho^*(e, h^*)$$

[10]This is also part of Sakai's (1982) Proposition 5.1.

[11]This is also part of Sakai's (1982) Proposition 5.3.

This is a special case of Pratt's (1964) Eq. (42).[12] According to Proposition 3.3, the measure of relative risk aversion is approximately positively proportional to relative risk premium for small h^*. Therefore, an individual with a higher measure of relative risk aversion requires a higher risk premium for a lottery. Because this property holds for small h^*, it is a local property of the measure of relative risk aversion.

Global properties that hold for any h^* as long as $z - eh^* > 0$ are also known. Let $i = 1, 2$ denote two individuals. For an individual with utility function $u_i(z)$, let $R_i^*(z)$ be her measure of relative risk aversion and $\rho_1^*(z, h^*)$ be her risk premium.

Proposition 3.4 The following two conditions are equivalent.

i. $R_1^*(z) > R_2^*(z)$
ii. For all $h^*, \rho_1^*(z, h^*) > \rho_2^*(z, h^*)$

This proposition is a special case of part of Pratt's (1964) Theorem 6.[13] According to this proposition, an individual with a higher measure of relative risk aversion requires a higher relative risk premium for a lottery. Conversely, an individual who requires a higher relative risk premium has a higher measure of relative risk aversion.

References

Allais, M. (1953). Le comportement de 1'Home rationnel devant le risque: Critique des postulats et Axiomes de l'Ecole Americaine. *Econometrica, 21*(4), 503–546.
Arrow, K. J. (1965). Aspects of the theory of risk-bearing, Yrjo Jahnssonin Saatio.
Barsky, R., Juster, F., Kimball, M., & Shapiro, M. (1997). Preference parameters and behavioral heterogeneity: An experimental approach in the health and retirement survey. *Quarterly Journal of Economics*, 537–579.
Camerer, C. (1995). Individual decision making. In J. H Kagel & A. E. Roth (Eds.), *Handbook of experimental economics*. Princeton University Press.
Ellsberg, D. (1961). Risk, ambiguity, and the savage axioms. *Quarterly Journal of Economics, 75* (4), 643–669.
Friend, I., & Blume, M. (1975). The demand for risky assets. *American Economic Review, 65*(5), 900–922.
Gilboa, I., & Schmeidler, D. (1989). Maxmin expected utility with non-unique prior. *Journal of Mathematical Economics, 18*(2), 141–153.
Gilboa, I. (2009). *Theory of decision under uncertainty*. New York: Cambridge University Press.
Gul, F., & Pesendorfer, W. (2001). Temptation and self-control. *Econometrica, 69*(6), 1403–1435.
Hansen, L. P., & Sargent, T. J. (2001). Robust control and model uncertainty. *American Economic Review, 91*(2), 60–66.
Hansen, L. P., & Singleton, K. (1982). Generalized instrumental variables estimation of nonlinear rational expectations models. *Econometrica, 50,* 1269–1286.

[12]This is also part of Sakai's (1982) Proposition 5.1.
[13]This is also part of Sakai's (1982) Proposition 5.3.

Machina, M. J. (1987). Choice under uncertainty: Problems solved and unsolved. *Journal of Economic Perspectives, 1*(1), 121–154.

Noor, J., & Takeoka, N. (2015). Menu-dependent self-control. *Journal of Mathematical Economics, 61,* 1–20.

Ogaki, M., & Zhang, Q. (2001). Decreasing risk aversion and tests of risk sharing. *Econometrica, 69,* 515–526.

Pratt, J. W. (1964). Risk Aversion in the small and in the large. *Econometrica, 32,* 122–136.

Sakai, Y. (1982). *Fukakujitsusei no Keizaigaku (Economics under Uncertainty)*. Tokyo: Yuuhikaku.

Chapter 4
Prospect Theory

Abstract This chapter explains prospect theory, which modifies expected utility theory in important ways. Prospect theory can be consistent with economic behaviors that cannot be explained by the expected utility theory such as those in the Allais Paradox.

Keywords Prospect theory · Value function · Decision weight function Reference point · Loss aversion

As the Allais paradox explained in Chap. 3, real people sometimes make decisions under uncertainty that expected utility theory can never explain. Some alternative decision theories can explain actual decisions of the Allais paradox. The theory that has been regarded as most important in behavioral economic is prospect theory that Kahneman and Tversky (1979) proposed.[1]

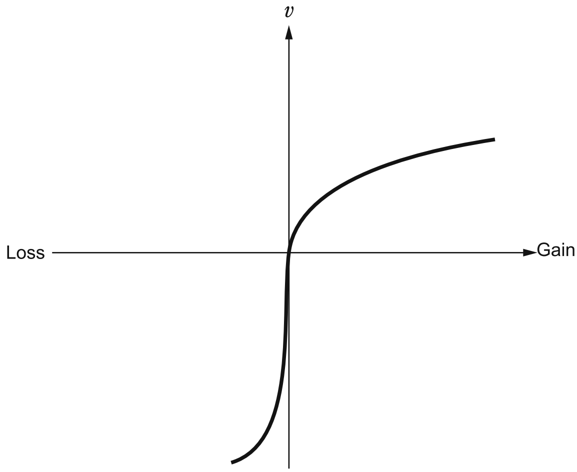
4.1 The Value Function and the Reference Point

Two pillars of prospect theory are the value function and the decision weight function. The value function corresponds to the utility function in expected utility theory. Compared with the utility function in expected utility theory, the value function has three properties: (1) the focus is on changes from a *reference point*, (2) *loss aversion*, and (3) *diminishing sensitivity*. The decision weight function corresponds to probabilities in expected utility theory. An individual is assumed to use subjective decision weights rather than objective probabilities when she calculates the overall value of a lottery (which is called a prospect in prospect theory) as weighted sum of values.

[1]For an explanation of advancements in prospect theory proposed by Tversky and Kahneman (1992) such as introduction of a rank-dependent way of calculating weights and more recent empirical work, see Takemura (2014).

M. Ogaki and S.C. Tanaka, *Behavioral Economics*, Springer Texts in Business and Economics, DOI 10.1007/978-981-10-6439-5_4

Fig. 4.1 Value function



The first property of the value function of prospect theory is that the argument x of a value function $v(x)$ is a change from a reference point. In contrast, the argument z of a usual utility function $u(z)$ is the absolute level. For example, suppose that an individual has an initial endowment of e dollars, and that this initial endowment is her reference point. When she receives x dollars, the value of her utility is $u(e+x)$ while the value of her value function is v(x). When she loses x dollars, the value of her utility is $u(e-x)$ while the value of her value function is $v(-x)$. In many countries that experienced rapid economic growth, such as Japan, per capita income increased dramatically during the rapid growth period, but average subjective well-being values answered in surveys did not change much (see Chap. 10). This empirical evidence is consistent with an interpretation that the reference point of a typical person rises as national income rises and that there is a positive relationship between the value function and subjective well-being. Figure 4.1 gives a graph of a typical value function for which the origin is the reference point.

In the figure, the rate of increase of $v(x)$ as x increases in the right side of the origin is smaller than the rate of decrease of $v(x)$ as x decreases in the left side of the origin. This illustrates the second property of the value function that satisfaction from gain is smaller than satisfaction from avoiding loss. This is called *loss aversion*. For example, many individual investors in stock markets seem to strongly dislike losses from their investment. This is interpreted as a result of loss aversion. The endowment effect that was explained in Chap. 1 is closely related to the reference point and loss aversion. Hence, we will explain details about the endowment effect later in this chapter.

In Fig. 4.1, the value function is a concave function in the domain of gains (to the right of the origin), and a convex function in the domain of losses (to the left of the origin). This is the third property of the value function, which is called *diminishing sensitivity*. Because the value function is concave in the domain of gains, decisions made by evaluations in this domain will show risk averseness. In contrast, the value function is convex in the domain of losses, so decisions made by evaluations in this domain will show risk lovingness. For example, when a person who keeps on holding a stock when its price has been falling and its price fluctuation is large, then it is likely that his risk lovingness in the domain of losses is an important reason (Camerer 2000).

Tversky and Kahneman (1992) used experiment data from 25 graduate students from the University of California at Berkley and Stanford University to estimate the value function.[2] Tanaka et al. (2010) used experiment data from low income villages of Vietnam to estimate the value function and obtained similar results. These researchers used the following functional form for the value function.

$$v(x) = \begin{cases} x^{\alpha} & (if\, x \geq 0) \\ -\lambda(-x)^{\beta} & (if\, x < 0) \end{cases}$$

They estimated values for the preference parameters were $\alpha = \beta = 0.88$, and $\lambda = 2.25$. For the domain of gains, the value function is convex, and shows risk aversion. The measure of constant relative risk aversion is equal to $1 - \alpha$ and is estimated to be $1 - 0.88 = 0.12$. For the domain of losses, the value function shows risk lovingness. Because $\lambda = 2.25$, the slope of the value function in the domain of losses is 2.25 times greater than that in the domain of gains at each same absolute value of x. This indicates a strong degree of loss aversion.

4.2 The Decision Weight Function

In this section, we explain the other pillar of prospect theory, the decision weight function. In prospect theory, an individual does not maximize the expected value that uses the objective probabilities as weights to calculate the weighted sum of the value function over the different events. An individual maximizes an overall value that uses the decision weight function π(p), which is a subjective evaluation of the probability, as weights to calculate the weighted sum.

Now, let us compare how an individual evaluates a lottery that pays a random variable X as the prize money. Let e dollars as initial endowment of the individual. In expected utility theory, if $u(z)$ is the utility function, then her expected utility is

$$\begin{aligned} E(u(e+X)) &= P_1 u(e+X_1) + \ldots + P_m u(e+X_m) \\ &= \sum_{i=1}^{m} P_i u(e+X_i). \end{aligned}$$

[2]Tversky and Kahneman (1992) developed an extension of prospect theory and used this theory in their estimation. This extension is called cumulative prospect theory as explained in Sect. 4.7.

In contrast, if the initial endowment is the reference point in prospect theory, then the lottery is evaluated by

$$\pi(P_1)v(X_1) + \ldots + \pi(P_m)v(X_m) \\ = \sum_{i=1}^{m} \pi(P_i)v(X_i)$$

If $\pi(p_i) = p_i$, then this is equal to the expected value of the value function.

Some properties of the decision weight function are especially important. First, when the probability is 1, then the value of the decision weight function is 1 ($\pi(1) = 1$), but for the probability p that is near and smaller than 1, the value of the decision weight function is smaller than p ($\pi(p) < p$). As a result, a change from certainty to a smaller probability has a greater psychological effect than the probability change that does not involve certainty. This was called a *certainty effect* by Tversky and Kahneman (1986), who used an example of the 20% change of the probability from 1 to 0.8 having greater psychological effect of the 20% change of the probability from 0.25 to 0.2 for lotteries. Many people prefer a smaller gain with certainty than a larger gain with a lower probability more than expected utility theory predicts because of the certainty effect.

Second, when the probability is zero, then the value of the decision weight function is zero ($\pi(0) = 0$), but for the probability p that is near and greater than 1, the value of the decision weight function is greater than p ($\pi(p) > p$). Just as the certainty effect above, a change from zero probability to a small positive probability has a greater psychological effect than the probability change that does not involve certainty has. This can be used to explain why many people buy longshots on horse races as explained in Sect. 4.6 of this chapter.

Third, another important property is

$$\pi(p) + \pi(1 - p) < 1,$$

which is called *subcertainty*. As we will see in the next section, this property is necessary for prospect theory to explain the Allais paradox explained in the last chapter without using changes in the reference point.

4.3 The Allais Paradox and Prospect Theory

In the last chapter, we saw that expected utility theory is inconsistent with real people's behavior in the Allais paradox, no matter what type of utility functions they are assumed to have. In this section, we explain two factors in prospect theory that makes it avoid such inconsistency with the Allais paradox. First, we will see that, if the decision weight function satisfies subcertainty, then prospect theory can be consistent with the Allais paradox. Second, we will see that, if the reference point changes when an individual is offered an opportunity to choose a sure gain, then loss aversion of the value function helps prospect theory explain the Allais paradox.

In this chapter, we denote the value function by $v(\cdot)$ and the decision weight function by $\pi(\cdot)$, and assume that $v(0) = 0$. We will consider the following two sets of lotteries like the ones we considered for the Allais paradox in the last chapter:[3]

(A) Lottery 1: 100 million dollars for sure
Lottery 2: 0 dollars with probability 0.01, 500 million dollars with probability 0.10, and 100 million dollars with probability 0.89
(B) Lottery 3: 100 million dollars with probability 0.11, and 0 dollars with probability 0.89
Lottery 4: 500 million dollars with probability 0.10, and 0 dollars with probability 0.90

Many people choose Lottery 1 when the two lotteries in group A are presented to them, and choose Lottery 4 when the two lotteries in group B are presented to them. In expected utility theory, this combination of choices by an individual leads to a contradiction: this is the Allais paradox as we explained in the last chapter. We will see if prospect theory can avoid such a contradiction.

First, we focus on the decision weight function by assuming that the reference point does not change. In the case of group A, the choice by many people can be expressed as $v(100\,\text{million}) > \pi(0.01)\times v(0) + \pi(0.1) \times v(500\,\text{million}) + \pi(0.89) \times v(100\,\text{million})$, or

$$(1 - \pi(0.89)) \times v(100\,\text{million}) > \pi(0.1) \times \text{v}(500\,\text{million}) \tag{4.1}$$

In the case of B, $\pi(0.11) \times v(100\,\text{million}) + \pi(0.89) \times v(0) < \pi(0.1) \times v(500\text{million}) + \pi(0.9) \times v(0)$, or

$$\pi(0.11) \times v(100\,\text{million}) < \pi(0.1) \times v(500\,\text{million}) \tag{4.2}$$

If $(1 - \pi(0.89)) > \pi(0.11)$, then (4.1) and (4.2) can simultaneously hold without any contradiction. Because the decision weight function in prospect theory has a property of subcertainty, $\pi(p) + \pi(1 - p) < 1, \pi(0.89)) + \pi(0.11) < 1$. Therefore, (4.1) and (4.2) can simultaneously hold without any contradiction. This means that subcertainty is a necessary condition for prospect theory to explain the Allais paradox if the reference point does not change. Because expected theory can never explain the Allais paradox, this is an important advantage of prospect theory.

It is also important that subcertainty is not a sufficient condition for an individual making decisions according to prospect theory to choose Lottery 1 and Lottery 4. To see this, let

[3] In this chapter, we are converting the example in the last chapter by the exchange rate of 100 French francs per 1 dollar. This exchange rate is chosen for exposition purposes rather than for realism.

$$\begin{array}{l}\pi(0.1)v(500\,\text{million}) = X \\ \pi(0.11)v(100\,\text{million}) = Y \\ \{1-\pi(0.89)\}v(100\,\text{million}) = Z\end{array}.$$

From (4.1), $Z > X$, and from (4.2), $Y < X$. Therefore, $Z > Y$ is a necessary condition for (4.2) and (4.3) to simultaneously hold. Even if $Z > Y$, X must take a value in between Y and Z in order for (4.2) and (4.3) to hold simultaneously. This shows that subcertainty is not a sufficient condition. In cases where X does not take a value in between Y and Z in spite of subcertainty, a change in the reference point helps prospect theory to explain the Allais paradox.

Second, we see how the loss aversion property of the value function can contribute in explaining the Allais paradox if the reference point changes. For this purpose, assume that the reference point of an individual moves from endowment to a gain of 100 million dollars when Lotteries 1 and 2 are presented to her because she can choose to obtain 100 million dollars without any uncertainty. Also assume that the reference point stays at endowment when Lotteries 3 and 4 are presented to her because there is no sure gain irrespective of which lottery she chooses in this case. Then in the case of A, the choice by many people can be expressed as $v(0) > \pi(0.01) \times v(-100\,\text{million}) + \pi(0.1) \times v(500\,\text{million} - 100\,\text{million}) + \pi(0.89) \times v(0)$, or

$$-\pi(0.01) \times v(-100\,\text{million}) > \pi(0.1) \times v(400\,\text{million}) \tag{4.3}$$

In case of B, $\pi(0.11) \times v(100\,\text{million}) + \pi(0.89) \times v(0) < \pi(0.1) \times v(500\,\text{million}) + \pi(0.9) \times v(0)$, or

$$\pi(0.11) \times v(100\,\text{million}) < \pi(0.1) \times v(500\,\text{million}) \tag{4.4}$$

Because loss aversion means that $-v(-100\,\text{million})$ is greater than $v(100\,\text{million})$, we can see that it is helpful for (4.3) and (4.4) to simultaneously hold.

Thus, in prospect theory, actual choices of real people in the Allais paradox do not lead to a contradiction as long as the decision weight function satisfies subcertainty even if the reference point does not change. However, subcertainty alone may not be sufficient in explaining why many people make such choices. If we assume that the reference point can change, then the loss aversion of the value function can also be helpful in understanding the Allais paradox.

4.4 Mental Accounting

Thaler (1985) proposed mental accounting as a theory that is closely related to and supportive of prospect theory. When we apply prospect theory to real world problems, we can often explain real people's behaviors better when we think that various income and spending are psychologically divided into narrow areas. In traditional economics, methods of earning income cannot affect spending by an economic man. In mental accounting, however, we think that the money one earns from work is in a different psychological account than the money one wins from a lottery. For spending, Thaler calls the price that is usually expected in a situation a "reference price". He thinks that a consumer focuses on "transaction utility," which is the difference between the reference price and the price that the consumer actually pays. In contrast, traditional economics assumes that a consumer will buy a good when her willingness to pay (WTP) for a good is greater than the price of the good.

Thaler used the following two versions of a hypothetical question to examine his theory:

> You are lying on the beach on a hot day. All you have to drink is ice water. For the last hour you have been thinking about how much you would enjoy a nice cold bottle of your favorite brand of beer. A companion gets up to go make a phone call and offers to bring back a beer from the only nearby place where beer is sold (a fancy resort hotel) [a small, run-down grocery store]. He says that the beer might be expensive and so asks how much you are willing to pay for the beer. He says that he will buy the beer if it costs as much or less than the price you state. But if it costs more than the price you state he will not buy it. You trust your friend, and there is no possibility of bargaining with (the bartender) [store owner]. What price do you tell him?

The theory of traditional economics predicts that WTP will be the same in the two versions: there is no reason for WTP to change when the beer is purchased in the fancy resort hotel or the run-down grocery store. The results of Thaler's survey were very different from this theoretical prediction. The median price given in the fancy resort hotel version was 2.65 dollars while the median for the run-down grocery store was 1.50 dollars. The theory of mental accounting explains this by saying that the reference price is higher when the beer is purchased in the hotel, and that people focus on transaction utility.

Next, let us consider flat rate pricing with the theory of mental accounting. For internet access and cell phone service, there is flat rate pricing which charges a fixed price per period and pay-per-use pricing which charges a price for each use. Even when the pay-per-use pricing is cheaper, many people tend to prefer the flat rate pricing. The theory of mental accounting explains this tendency by assuming that a separate mental accounting is set for each service, and it is evaluated by prospect theory. With the pay-per-use pricing, the consumer feels the psychological cost of loss each time she pays. With the flat rate pricing the psychological costs are smaller because they are integrated.

4.5 Endowment Effect

In the mug cup experiment of Kahneman et al. (1990) explained in Chap. 1, WTA of participants who received mug cups tended to be much higher than WTP of participants who did not receive mug cups. For a long time, this result has been interpreted to show the endowment effect due to loss aversion in prospect theory. This interpretation is based on a hypothesis that the reference point is always equal to the endowment. According to this hypothesis, the reference point is equal to the endowment of zero mug cup for a participant who does not receive any mug cup. Therefore, such a participant evaluates the mug cup in the domain of gains of the value function when she considers buying a mug cup. This evaluation is equal to her WTP. For a participant who has received a mug cup, the reference point is equal to the endowment of one mug cup. Therefore, such a participant will evaluate the mug cup in the domain of losses of the value function when she considers selling a mug cup. This evaluation is equal to her WTA. When a participant receives a mug cup, her endowment is equal to one mug cup. Because of loss aversion, WTA is predicted to be much higher than WTP. This is the explanation of the endowment effect based on prospect theory.

Plott and Zeiler (2005) showed that mere changes in experimental procedures result in a disappearance of the gap between WTA and WTP. If participants are to report their WTA and WTP in a survey, then they do not have incentives to report their true values. It is possible to use an auction between sellers and buyers to measure WTA and WTP. Depending on auction methods, a seller may be able to earn more money by announcing a selling price that is higher than his WTA, and a buyer may be able to save more money by announcing a buying price that is lower than his WTP. Namely, sellers and buyers may have incentives to lie. In the Becker–DeGroot–Marschak (BDM) mechanism, it is to their best interests for a seller to report his true WTA and a buyer to report his true WTP. When an auction method such as the BDM mechanism removes incentives to lie, such a mechanism is said to be incentive compatible. There are many methods to employ the BDM mechanism. Plott and Zeiler used the following: (1) the price is randomly chosen from a price list in each round; (2) if a buyer has announced a buying price that is higher than or equal to the chosen price, then the buyer is making a transaction at the chosen price; (3) there is no transaction for the buyers who have announced buying prices that are lower than the chosen price; (4) if a seller has announced a selling price that is lower than or equal to the chosen price, then the seller is making a transaction at the chosen price; and (5) there is no transaction for the sellers who have announced selling prices that are higher than the chosen price. In this BDM mechanism, the price is randomly chosen, so no buyer nor seller can manipulate the price by lying. Some participants, however, may not understand and have misconceptions of their ability to manipulate the price. So Plott and Zeiler trained the participants by explaining this with numerical examples and by having two rounds of practice sessions without any payment. Then they had 14 rounds of practice sessions with actual transactions with lotteries for which money was actually paid. After this training, they performed their experiment for mug cups. Another element is anonymity. Without anonymity, participants may be affected by thoughts of how they are viewed by others. So Plott and Zeiler made decisions and payments anonymous. There had been many experiments to measure WTA–WAP gaps, but theirs was the first to satisfy the following four properties: (1) Incentive compatible mechanism, (2) Training, (3) Practice with actual payments of money, (4) Anonymity.

Plott and Zeiler used plastic travel mug cups in the experiment. Both the sellers and buyers examined the mug cups at the beginning of the mug session. It was announced that each seller owns a mug cup and each buyer does not own a mug cup. In their experiment, the difference between WTA and WTP was not statistically significant. Under the assumption that the reference point is always equal to the endowment, prospect theory predicts that the difference between WTA and WTP is not affected by Plott and Zeiler's changes in the experimental procedures. Therefore, Plott and Zeiler argued that the reason for the WTA–WTP gap in the experiment by Kahneman et al. (1990) was not the endowment effect but other effects such that participants lied about WTA and WTP and that they cared about how others viewed them.

On the other hand, Isoni et al. (2011) showed that both in their own experiment following the Plott and Zeiler procedures and in the data of Plott and Zeiler's experiment, the differences between WTA and WTP were statistically significant for lotteries that pay money as their prizes. For lotteries that pay goods as their prizes, however, the differences between WTA and WTP were not significant. For many experiments that are not about the endowment effect, the value function with loss aversion can explain their results very well [see, e.g., Tversky and Kahneman (1992) for U.S. university students and Tanaka et al. (2010) for non-students in Vietnam)].

Because it is difficult to measure WTA and WTP, Knetsch (1989) conducted an exchange experiment in order to examine the endowment effect. The participants were randomly divided into two groups. A mug cup was given to each participant of the first group. After a while, each of them was given an opportunity to exchange the mug cup for a candy bar. A candy bar was given to each participant of the second group. After a while, each of them was given an opportunity to exchange the candy bar for a mug cup. Among 76 participants in the first group, 89% held their mug cups. Among 87 participants in the second group, 90% held their candy bars. These and similar results in the exchange experiments had been interpreted as evidence for the endowment effect.

Plott and Zeiler (2007) showed that mere changes in experimental procedures can make these results disappear even in these exchange experiments. One change is about the placement of the endowed good. Plott and Zeiler argued that transaction cost may explain Knetsch's (1989) experiment result. If an endowed good is in front of a participant, then she may prefer it to the other good just because of the lower transaction cost. For this reason, Plott and Zeiler employed the following procedure. A good X is given to a participant as an endowment. After she examines it, it was replaced by a good Y. The participant was informed that she still had the ownership of X even though it was not in front of her. This placement change had a more important effect on decisions to exchange than the announcement of ownership. This result is not consistent with the endowment effect. Plott and Zeiler interpreted this result by transaction cost, but other interpretations might be more plausible given the other results that support prospect theory.

Nakada (2012) proposed a hypothesis that the reference point changes when attachment changes: for example, if a participant holds and touches a good or freely looks at a good in front of her, then she tends to feel more attachment to the good. If money is endowed, then attachment to high-budget-share goods increases even though attachment does not happen to money itself. In both cases, increases in attachment to goods make the reference point increase. Nakada's attachment hypothesis can explain all experiment results explained in this section.

The theory of the endowment effect needs to be modified given the experiment results by Plott and Zeiler. The basic ideas of prospect theory, however, does not seem to need modification as long as we consider changes in the reference point caused by changes in attachment. What we need is further theoretical and empirical research on how reference points change.

4.6 Applications of Prospect Theory

Camerer (2000) describes a bias toward betting on longshots, which are horses with a relatively small chance of winning. The only explanation from expected utility theory is that people are risk loving. In prospect theory, one can use the decision weight function for an explanation.[4] Giving higher weights than probabilities for low positive values of probabilities helps to explain this bias. Camerer also describes another racetrack anomaly that can be explained by prospect theory: bettors tend to shift their bets toward longshots later in the racing day. This end-of-the-day effect is an anomaly because the first races in the racing day are not fundamentally different from the last races in the racing day from the point of view of expected utility theory. If an individual whose decisions are following prospect theory is using zero daily profit as a reference point for a mental account of a day of racing, then prospect theory can explain this end-of-the-day effect. Most bettors are behind by the last race of the day, and are operating in the domain of loss aversion and risk loving.

Camerer et al. (1997) used data for New York City cabdrivers in order to investigate the relationship between wages and hours worked. They found a significantly negative relationship. This is in contrast with the prediction of the labor

[4]Camerer (2000) also explains estimation results for cumulative prospect theory.

supply model of traditional economics that hours worked are higher when wages are high.[5] Their interpretation of these findings is that cabdrivers (1) set a mental accounting of "one day at a time" for labor supply and (2) set a loose daily income target as the reference point and quit working once they reach that reference point. In this interpretation, cabdrivers are evaluating daily income in the domain of losses, and loss aversion works until daily income reaches the reference point.

Farber (2005) collected a new set of data for New York City cabdrivers, and claimed that he did not find a big effect of the reference point unlike Camerer et al. (1997). Faber (2008) estimated a labor supply model that includes reference points for income. He found tendencies for cabdrivers to stop supplying labor when they reached their reference points. Daily reference points, however, fluctuated greatly, and the shift for a cabdriver was over before he reached his reference point in most cases. From these two points, Farber concluded that preferences including reference points do not play an important role in determining labor supply of New York City cabdrivers.

Crawford and Meng (2011) estimated Köszegi and Rabin's (2006) theoretical labor supply model in which reference points for income and time are determined by rational expectations. In their results, reference points for income are stable. Thus their results escape Farber's (2008) criticism that reference points are unstable.

4.7 Summary and Further Reading

Prospect theory modifies the expected utility theory in crucial ways. In order to understand various empirical results such as those from experimental data for the endowment effect and those from data for New York City cabdrivers, it was important to consider changes in reference points. At this point, the most important shortcoming of prospect theory seems that the theory of how reference points are determined and change has not been completed. We need to develop the theory further by examining and modifying models by Köszegi and Rabin (2006, 2009) in which reference points are determined by expectations and Nakada's (2012) theory of reference points and attachment. Moreover, given that a reference point for a particular decision problem seems to depend on mental accounting, a complete theory of reference points should explain how mental accounts are determined.

An important extension of prospect theory, called cumulative prospect theory, was proposed by Tversky and Kahneman (1992), which includes an introduction of a rank-dependent way of calculating weights. For the explanation of why this rank-dependent way is desirable, see Gilboa (2009). For concrete examples of this

[5]This prediction is clearer in dynamic models of labor supply for transitory wage changes as mentioned in Camerer et al. (1997) than static models of labor supply in which income effects complicate theoretical predictions.

way of calculation and more empirical evidence for prospect theory and cumulative prospect theory, see Takemura (2014).

4.8 Questions and Problems

4.8.1 Multiple-Choice Problems

1. Choose the most appropriate answer for the value function of prospect theory.

   (A) The argument of the value function x in $v(x)$ is the absolute level of income.
   (B) The argument of the value function x in $v(x)$ is the difference from the reference point.
   (C) Because of loss aversion, the slope of the value function $v(x)$ is larger when x is negative than that when x is positive.
   (D) Because of the loss aversion, the slope of the value function $v(x)$ is smaller when x is negative than that when x is positive.
   (E) The typical value function implies risk aversion for the domain of the losses and risk lovingness for the domain of the gains.
   (F) The typical value function implies risk aversion for the domain of the gains and risk lovingness for the domain of the losses.
   (G) A, C, and E
   (H) A, C, and F
   (I) A, D, and E
   (J) A, D, and F
   (K) B, C, and E
   (L) B, C, and F
   (M) B, D, and E
   (N) B, D, and F

2. For the case in which the reference point does not move, choose the most appropriate answer for the relationship between the prospect theory and the Allais paradox explained in the text.

   (A) As long as the decision weight function satisfies subcertainty, prospect theory can explain the Allais paradox irrespective of functional forms and parameters of the value function.
   (B) Even if the decision weight function does not satisfy subcertainty, prospect theory can explain the Allais paradox for some functional forms and parameters of the value function.
   (C) In order for prospect theory to explain the Allais paradox for some functional forms and parameters of the value function, it is necessary for the decision weight function to satisfy subcertainty.

4.8.2 Short Answer/Essay Problems

1. Explain why the Allais paradox occurs by using the decision weight function of prospect theory. To be more concrete, suppose that an individual makes decisions according to prospect theory and that his reference points do not change when the two sets of lotteries explained in the text are presented to him. Explain what property is necessary for the decision weight function to satisfy for him to make the choices called the Allais paradox.
2. Explain why the Allais paradox occurs by using an idea of changing reference points of prospect theory. To be more concrete, suppose that an individual makes decisions according to prospect theory and that his reference point changes when he is presented with an opportunity to receive money for sure. Explain what property of the value function is helpful for prospect theory to predict that he will make the choices called the Allais paradox.

Appendix: The Brain Representation of Utility Function

In the previous studies of experimental psychology and biology, it is suggested that the features of reward, such as the size, uncertainty, and delay, is involved in decision making. Suppose that with the reward as a reward probability and as a functional production evaluating the delay of rewarding, the equation is as follows:

$$\upsilon(x)\,\omega(p)\,F(D)$$

Here x is the quantity of reward, p is the probability of obtaining a reward, and D is the delay of receiving a reward. $F(D)$ can be a time discount function to be mentioned in Chap. 6. From the view of prospect theory, $\upsilon(x) = v(x)$ is value function, and $\omega(p) = w(x)$ is decision weight function. From the point of view of expected utility theory, $\upsilon(x) = u(e+x)$ is the utility function given initial endowment e, and $\omega(p) = p$ is probability. In other words, studying the brain mechanisms of decision-making based on reward can be equivalent to studying brain representation of utility function. The past studies contributed to specify the location in brain parts of so-called reward system.

A1 Brain Areas Relating to Reward and Loss

"Brain reward system" is a term describing brain areas or structures involving information processing on rewards. For instance, we can identify the specific brain area by measuring the neural activities of volunteers by fMRI, when they get some rewards, e.g., juice and money. In the experiments, they have to learn a relationship between a specific stimulus and a reward and respond correctly to the stimulus for a better option or maximizing the total outcome. Many studies report that the striatum is deeply related to the information processing of rewards through a series of animal and human experiments. The striatum is a part of basal ganglia, which is a medial part of the brain (see Fig. 2.3 in Chap. 2). The striatum receives inputs from the cortex, it processes the information, and sends the modified information back to the brain cortex via the thalamus or directly. In addition, a specific part of the cortex, the frontal lobe and the front parietal lobe, is also reported to be involved in reward processing. Because the striatum is the main part of the projection from dopamine neurons producing dopamine, it is suggested that the network between the cortex and striatum (cortico-striatum network) is the main locus of reward processing.

Loss or punishment has the opposite effect to reward. In traditional economics, the loss is simply expressed as a minus reward and is considered as the opposite to reward symmetrically. Delgado et al. measured the brain activities on monetary reward and loss by fMRI, and found that the striatum exhibited activities on gaining reward, but on the loss of the reward the striatum was not activated (Delgado et al. 2000). On the other hand, it is reported that the parts processing reward and loss are different respectively. Seymour et al. (2005) reported that through a series of conditioning experiments using painful stimuli there is a correlation between the activities of insular cortex and the prediction of receiving punishment.

A2 Brain Areas Related to Uncertainty

Recent studies revealed that the brain has a mechanism to compute probability and expected values of reward, and to make a decision based on the values. Hsu et al. reported that two different brain areas were activated on two kinds of selective assignments, in which one had an obvious risk with a precious probability and another had a vagueness the probability of which no one can presume (Hsu et al. 2005). Sugrue et al. also reported that a part of the parietal lobe represents the difference of expected values including probability by measuring neural activities while monkeys are performing a matching task (Sugrue et al. 2004). Other studies, in addition, reported that the lower frontal lobe, the orbital cortex, and the other brain areas represent neural activities on the assignment of probabilities (Padoa-Schioppa and Assad 2006).

A3 Application to Prospect Theory

Tom et al. (2007) have a more direct experiment that examines biological evidence of prospect theory. They focused on the experimental evidence that the loss usually gives a psychological effect on participants twice as big as gain and reward, and measured the brain activities while in the gambling task. In the gambling task, the experimenters showed two different values of reward and loss, and asked the volunteers to evaluate how much to accept the value in the four scales. Predicting the degree of risk aversion from judging from the accepting of probability, the mean was 1.93 and this was almost the same mean of other empirical economic studies on prospect theory. Observing the brain activity, the striatum activation was correlated positively to the intensity of rewards; the bigger the reward was, the more striatum was activated, and the bigger the loss was, the less the striatum was activated. Additionally, after defining the degree of loss aversion in brain activity according to the correlation coefficients of striatum activities toward gain and the loss, it was found that these values showed a positive correlation with the degree of predicted loss aversion. In other words, it indicated that the difference of sensitivity in brain activity toward the gain and loss could explain well real choice behavior. This also showed that loss aversion might be caused by the asymmetry of striatum activities toward gain and loss.

The neural mechanisms of decision weight function have been investigated. Paulus and Frank have a test of brain activities corresponding to nonlinear recognition toward the probability of humans (Paulus and Frank 2006). Measuring brain activities during a gambling task, which was used for the empirical study of prospect theory, they estimated the decision weight function[6] of volunteers from their choice behaviors. The researchers found that the smaller was the difference of brain activity in the cingulate gyrus (CG) between to the gambles with high probability and with low probability, the more nonlinearity of decision weight function was based on their choice behaviors. In a sense, this presented the possibility that the difference of the sensitivity in brain activities in the CG toward probability could reflect real actions or selective behaviors. This result suggested that the decision weight function depended on the nonlinearity of the CG's activities to probability rate.

References

Camerer, C. F. (2000). Prospect theory in the wild. In D. Kahneman & A. Tversky (Eds.), *Choices, values and frames* (pp. 288–300). New York: Cambrige University Press.

Camerer, C., Babcock, L., Loewenstein, G., & Thaler, R. (1997). Labor supply of New York city cabdrivers: One day at a time. *Quarterly Journal of Economics, 112*(2), 407–441.

Crawford, V. P., & Meng, J. (2011). New York city cabdrivers' labor supply revisited: Reference-dependent preferences with rational-expectation targets for hours and income. *American Economic Review, 101*(5), 1912–1932.

Delgado, M. R., Nystrom, L. E., Fissell, C., Noll, D. C., & Fiez, J. A. (2000). Tracking the hemodynamic responses to reward and punishment in the striatum. *Journal of Neurophysiol, 84*(6), 3072–3077.

[6]They estimated the probability weighting function of Tversky and Kahneman's (1992) cumulative prospect theory. The probability weighting function is equal to the decision weight function in special cases, and we ignore the difference in the text for the ease of presentation.

Farber, H. S. (2005). Is tomorrow another day? The labor supply of New York City cabdrivers. *Journal of Political Economy, 113*(1), 46–82.

Farber, H. S. (2008). Reference-dependent preferences and labor supply: The case of New York City taxi drivers. *American Economic Review, 98*(3), 1069–1082.

Gilboa, I. (2009). *Theory of decision under uncertainty*. New York: Cambridge University Press.

Hsu, M., Bhatt, M., Adolphs, R., Tranel, D., & Camerer, C. F. (2005). Neural systems responding to degrees of uncertainty in human decision-making. *Science, 310*(5754), 1680–1683.

Isoni, A., Loomes, G., & Sugden, R. (2011). The willingness to pay-willingness to accept gap, the "Endowment Effect", subject misconceptions, and experimental procedures for eliciting valuations: comment. *American Economic Review, 101*(2), 991–1011.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*(2), 263–292.

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1990). Experimental tests of the endowment effect and the Coase theorem. *Journal of Political Economy, 98*(6), 1325–1348.

Knetsch, J. L. (1989). The endowment effect and evidence of nonreversible indifference curves. *American Economic Review, 79*(5), 1277–1284.

Köszegi, B., & Rabin, M. (2006). A model of reference-dependent preferences. *Quarterly Journal of Economics, 121*(4), 1133–1165.

Köszegi, B., & Rabin, M. (2009). Reference-dependent consumption plans. *American Economic Review, 99*(3), 909–936.

Nakada, M. (2012). Attachment or ownership: Reference point shifts and an experimental test of attachment. Keio/Kyoto Joint Global Center of Excellence Program DP 2012-012.

Padoa-Schioppa, C., & Assad, J. A. (2006). Neurons in the orbitofrontal cortex encode economic value. *Nature, 441*(7090), 223–226.

Paulus, M. P., & L. R. Frank. (2006). Anterior cingulate activity modulates nonlinear decision weight function of uncertain prospects. *Neuro Image, 30*(2), 668–677.

Plott, C., & Zeiler, K. (2005). The willingness to pay-willingness to accept gap, the endowment effect, subject misconceptions, and experimental procedures for eliciting valuations. *American Economic Review, 95*(3), 530–545.

Plott, C., & Zeiler, K. (2007). Exchange asymmetries incorrectly interpreted as evidence of endowment effect theory and prospect theory? *American Economic Review, 97*(4), 1449–1466.

Seymour, B., O'Doherty, J. P., Koltzenburg, M., Wiech, K., Frackowiak, R., Friston, K., et al. (2005). Opponent appetitive-aversive neural processes underlie predictive learning of pain relief. *Nature Neuroscience, 8*(9), 1234–1240.

Sugrue, L. P., Corrado, G. S., & Newsome, W. T. (2004). Matching behavior and the representation of value in the parietal cortex. *Science, 304*(5678), 1782–1787.

Takemura, K. (2014). *Behavioral decision theory: Psychological and mathematical descriptions of human choice behavior*. Tokyo: Springer Japan.

Tanaka, T., Camerer, C. F., & Nguyen, Q. (2010). Risk and time preferences: Linking experimental and household survey data in Vietnam. *American Economic Review, 100*(1), 557–571.

Thaler, R. (1985). Mental accounting and consumer choice. *Marketing Science, 4*(3), 199–214.

Tom, S. M., Fox, C. R., Trepel, C., & Poldrack, R. A. (2007). The neural basis of loss aversion in decision-making under risk. *Science, 315*(5811), 515–518.

Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *Journal of Business, 59*(4), S251–S278.

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty, 5*(4), 297–323.

Chapter 5
Bounded Rationality

Abstract This chapter explains bounded rationality, which is rationality bounded by human abilities. For the purpose of studying bounded rationality, the optimization approach of traditional economics has difficulties such as the infinite regress problem. Hence it has been complemented by the descriptive approach in which intuitive judgment such as heuristics is shown to often lead to biases in experiments.

Keywords Beauty contest game · Level-k model · Infinite regress problem
Heuristics

In this chapter, we consider the problem of how we should think about real people's rationality compared with economic man-style rationality we explained in Chap. 1. In particular, an economic man is assumed to have infinite cognitive abilities (such as logical thinking and calculation abilities) for the purpose of maximizing his utility.[1] Because real people only have finite cognitive abilities, we will focus on *bounded rationality*, which is rationality bounded by human abilities. Bounded rationality should be distinguished from irrationality. For example, People's behaviors are irrational when they are controlled by emotions, and deviate completely from reasons. Irrationality has been studied in experiments in behavioral economics, and many books for the general audience on behavioral economics relate it to irrationality. The mainstream research in behavioral economics, however, has been on bounded rationality rather than irrationality.

[1]It should be noted that, for other purposes such as work, an economic man's abilities are assumed to be limited, so that there can be unskilled workers and so on.

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5.1 Beauty Contest Game

An economic man is assumed to able to perform infinite steps of reasoning without spending any time or effort. Bounded rationality recognizes that real people may perform only a few steps of reasoning even when more steps are necessary for maximizing monetary gain. We will consider Nagel's (1995) *beauty contest game* in this section. This game is also called a mean guessing game. Many participants choose a number in the closed interval [0, 100], and vote it. The winner is the one who has voted the closest number to the average X of all numbers that the participants voted multiplied by a positive number p. For example, if $p = 2/3$, then it is announced in advance that "the winner is the one who votes the closest number to $(2/3)X$" to all participants. The prize money amount is also announced in advance. If there is more than one participant who has voted for the winning number, then the prize money is divided equally among the winners.

The reason this game is called the beauty contest game is that it captures the essence of the parable of the beauty contest game explained by Keynes (1936). Keynes wrote that the stock market is like a beauty contest in which the winner is the ones who voted for the woman who attracted the most votes. In order to win this type of beauty contest, it is not important who you think is the most beautiful. The first step of reasoning is which woman that the other people think to be most beautiful on average. The next step of reasoning is how an average person thinks that the other people think to be most beautiful on average. It is possible to think further to perform many more steps of reasoning. In Nagel's mean value guessing game, it is necessary to think about how others think in order to win the game.

If $p < 1$, and if all players are assumed to be economic men, then there is only one Nash equilibrium in which all players choose and vote for zero, and all players equally divide the prize money. When all the other players are voting for zero, then the optimal strategy is to vote for zero because voting for any other positive number does not win. Therefore, it is a Nash equilibrium for all players to vote for zero. Before thinking about whether or not there is any other Nash equilibrium, consider a possible type of reasoning process that real participants may use.

Nagel proposed a model of bounded rationality about a reasoning process, which we call a *Level-k model*. First, suppose that a player does not think about the other players' reasoning process and assumes that the other players are randomly choosing a number between 0 and 100. We call this the Level-0 step in the reasoning process. A Level-1 step player thinks that all the other players are in the Level-0 step, and thinks about how to win. The average of the numbers chosen by the Level-0 step players is expected to be 50. Therefore, a Level-1 player chooses 50p to win. For example, in a game with p = 1/2, then a Level-0 player will choose 25. A Level-2 player uses the next step of the reasoning process: a player at this level assumes that all the other players are Level-1 players, and thinks about how to win. In this case, the other players are expected to choose 50p, so a Level-2 player chooses $50p^2$. For example, in a game with p = 1/2, then a Level-0 player will choose 12.5. In a similar way, a Level-*k* player assumes that all other players are

Level-(k-1) players, and thinks about how to win. So a Level-k player chooses $50p^k$.

If a player continues this reasoning step, then $50p^k$ becomes smaller and smaller to approach zero. Therefore, if all players were economic men who performed this reasoning process at the infinite level, then every player would choose zero. Theoretically, we need to think about possible other reasoning steps. For this reason, this argument is not a proof. It should help us intuitively understand, however, that the only Nash equilibrium when all players are economic men who perform infinite steps of reasoning is when all players choose zero.

Real experiment participants may of course adopt a reasoning process that is different from Nagel's model. It will be useful, however, to use Nagel's model as a benchmark, and it interprets a player who chooses a number near $50p^k$ as a Level-k player.[2]

Nagel reported results two cases for $p < 1 : p = 1/2$ and $p = 2/3$. Nagel conducted three experiment sessions with $p = 1/2$ and four sessions with $p = 2/3$. In each experiment session, four rounds were repeated for the same participants. In the first round, most of the chosen numbers were between $50p$ and $50p^2$. Thus, most of the participants in the first round could be interpreted to be about Level-1 and Level-2. For $p = 1/2$, the median of the first round for the three sessions was 17, and in between the predicted number of 25 from Level-1 and the predicted number of 12.5 from Level-2. For $p = 2/3$, the median was 33, and this was also between the predicted number of $50 \times (2/3) = 33.333\ldots$ from Level-1 and the predicted number of $50 \times (2/3)^2 = 22.222\ldots$ from Level-2.

As the experiment round was repeated, many participants came to choose smaller numbers. The median chosen numbers in the fourth round for $p = 1/2$ were 2, 0.98, and 0.97. The median chosen numbers in the fourth round for $p = 2/3$ were 10, 3, and 8.8. Thus, when we interpret these results by Nagel's model, we see that experienced players advance in reasoning steps as they experience more.

We would like to stress a few lessons from Nagel's experiments. First, in any of his experiment sessions, choosing zero did not lead to a win. Under the assumption that all players are economic men, if a player performs infinite steps of reasoning, then it is rational to choose zero. In reality, however, none of the other players is an economic man. Because the assumption is wrong, no matter how much reasoning a player does, he cannot win. Thus, an economic man-style rationality is "rationality" that does not necessarily achieve the goal of making money, and is not the same as rationality in the original sense.

Second, a real person does not perform infinite steps of reasoning, but tends to stop at a shallow stage of Level-1 or Level-2 in situations where they have no experience. We need to recognize that this is a human tendency when we face such a problem: we should try to deepen our thinking, learn from people who have experienced the problem, and learn from history. Many countries in the world are

[2]A more complicated model of bounded rationality in which the levels of reasoning of other players follow a probability distribution was proposed by Camerer et al. (2004).

moving into aging societies that no country has experienced in history. As a result, pension and medical expenses are increasing, which is creating current and future government budget problems. It is important to think deeply about these problems.

5.2 Deliberation Cost and Infinite Regress Problem

As we saw in the last section, a real human being often cannot perform infinite steps of reasoning. One reason is that it is costly to deliberate in terms of time and effort. This cost is called *deliberation cost*. In traditional economics, the deliberation cost is assumed to be zero, and an economic man in an economic model performs infinite steps of reasoning without spending any time. If there is deliberation cost, however, we need to introduce bounded rationality into an economic model. In this section, we will explain a difficult problem when we try to construct a decision model in the presence of deliberation costs.

Consider a decision model for an optimization problem when the deliberation cost is zero and call it Model 1. Next, consider a model when an economic agent incurs a deliberation cost to solve the optimization problem, which we call Model 2. However, because deliberation cost exists, there must be a deliberation cost in order to solve the optimization problem for Model 2. So, consider a decision model when such a cost exists, and call it Model 3. Thus, if we allow for deliberation cost for a decision model, then we will need a model of the next stage that considers deliberation cost for that model. This is called a regression problem. Model 3 requires Model 4, however, and this process continues infinitely. This is the *infinite regress problem* explained in Conlisk (1996).

The infinite regress problem shows a limitation in using an economics approach when we consider an optimization model with deliberation costs. For example, we can analyze Model 2 which only allows for the deliberation cost in one stage. In that case, we need to understand that we are making an ad hoc assumption to avoid the infinite regress problem. This is one reason why the psychology approach to bounded rationality is useful: this approach does not use optimization models, but concepts are clarified and applicability is verified by experiments and other methods.

5.3 Intuitive Judgment and Biases

Kahneman (2003) explains the approach to bounded rationality he used in his joint research with A. Tversky.[3] The approach distinguishes two systems of reasoning, which are called System 1 and System 2. System 1 corresponds roughly to intuition

[3]Kahneman noted that Simon (1955) had proposed much earlier that decision makers should be viewed as boundedly rational.

and System 2 corresponds roughly to reasoning. System 1 is between System 2 and the perception system and reflects various properties of perception. To perception, some attributes are directly accessible, and others are not. For example, let us imagine that a deck of cards is taken out of a box. The attributes that are directly accessible to perception include (1) the area of a card and (2) the thickness of a card. The attributes that are not accessible to perception include (3) the total area of the cards when you add up all areas of the cards in the deck. For (1) and (2), System 1's intuitive judgment is possible. For (3), we need to use System 2.

A chess master can walk past a game and intuitively judge which side is better without slowing. Thus trained intuition can be very fast and accurate. On the other hand, System 1 can also perform very poorly in many situations, which leads to biases and errors.

A general property of the perception system is that it focuses on changes, and basically ignores things that do not change. As a simple example, immersing the hand in lukewarm water will feel pleasantly warm after prolonged immersion in much colder water, and pleasantly cold after immersion in much warmer water. Kahneman and Tversky considered various properties of perception and predicted various biases in judgments by System 1. They studied their predictions by experiments and surveys in order to study decisions under bounded rationality. In some cases, this psychology approach leads to the construction of new optimization models in the economics approach. For example, the idea that value function evaluates changes from a reference point came from their prediction that the property of perception to focus on changes will affect decision making.

This subsection reviews some of the major types of intuitive judgment, which often lead to biases.

5.3.1 Two Definitions of Heuristics

One type of important intuitive judgment used by System 1 is called heuristics. Tversky and Kahneman (1974) examined heuristics under uncertainty and introduced three types of heuristics: representativeness, availability, and anchoring. Kahneman and Frederick (2002) extended the definition of heuristics to cases in which there is no uncertainty, and provided a new definition of heuristics as *attribute substitution* in which an individual assesses a specified *target attribute* of a judgment object by substituting another property of that object—a *heuristic attribute*—which comes more readily to mind. Tversky and Kahneman's (1974) representativeness and availability heuristics are special cases of attribute substitution, as we explain below.

5.3.2 Representativeness

In representativeness heuristics, the target attribute of "the probability of belonging to a particular category" is substituted by the heuristic attribute of "the degree of similarity with the representative member of the particular category." Therefore, representative heuristics is a special case of attribute substitution heuristics.

As an example, we will consider a case in which "the probability of a person to belong to a particular category" is substituted by "the degree of similarity with a representative person in the category." In an experiment of Tversky and Kahneman (1983), participants were given the following personality sketch and a set of occupations and avocations.

> Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.
>
> (a) Linda is a teacher in elementary school.
> (b) Linda works in a bookstore and takes yoga classes.
> (c) Linda is active in the feminist movement.
> (d) Linda is a psychiatric social worker.
> (e) Linda is a member of the League of Women Voters.
> (f) Linda is a bank teller.
> (g) Linda is an insurance salesperson.
> (h) Linda is a bank teller and is active in the feminist movement.

They were asked to rank all eight statements according to their probability, using 1 for the most probable and 8 for the least probable. It should be noted that answer (h) is the conjunction event of answer (c) and the answer is (f). According to the conjunction rule in probability theory, the probability of the answer (h) must be smaller than or equal to the probability of the answer (f). The average ranking of the doctoral students in the decision science program of the Stanford Business School for answer (h) was 3.2 and that for answer (f) was 4.3 (it should be noted that the lower rank means more probable). Thus, these rankings are inconsistent with probability theory. The average participant was asked to judge probability, but probably substituted the probability of belonging to the category in the answer by the degree of similarity to the representative person in the category.

Another example of representative heuristics is to substitute the target attribute of "the probability that an event happens" by the heuristic attribute of "how many times that the event happens." In an experiment of Tversky and Kahneman (1974), the following question was used to examine this type of heuristics:

> A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50% of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50%, sometimes lower.
>
> For a period of 1 year, each hospital recorded the days on which more than 60% of the babies born were boys. Which hospital do you think recorded more such days?
>
> (a) The larger hospital
> (b) The smaller hospital
> (c) About the same (that is, within 5% of each other).

Most participants (53%) judged the probability of obtaining more than 60% boys to be about the same (that is, within 5% of each other) in the small hospital and in the large one. Probability theory, however, predicts that the expected number of days on which more than 60% of the babies are boys is much greater in the small hospital than in the large one, because a large sample is less likely to stray from the expected value (50%). Thus, many people seem to be using the representative heuristics that both small and large hospitals will be equally representative of the general population.

5.3.3 *Availability*

In availability heuristics, the target attribute of the probability of an event is substituted by the heuristic attribute of the ease with which instances or occurrences can be brought to mind—how easily the situation comes to mind. An example in Tversky and Kahneman (1974) is from a question, "Suppose one samples a word (of three letters or more) at random from an English text. Is it more likely that the word starts with r or that r is the third letter? Most people answer that the word starts with r is more likely even though consonants (such as r and k) are actually more frequent in the third position than in the first position. Many people try to answer this question by recalling words that begin with r (e.g., "road") and words that have r in the third position (e.g., "car"). It is much easier to recall words that start with r, they incorrectly judge by the availability heuristics.

5.3.4 *Anchoring and Adjustment*

In many cases, people make estimates by starting from an initial value and then adjust the value to yield the final answer. In such a case, the initial value is called an *anchor*, and the effect of the initial value on the final answer because of insufficient adjustment is called the *anchoring effect*.[4] In an example given by Tversky and Kahneman (1974), participants were asked to estimate the percentage of African countries in the United Nations. First, a number between 0 and 100 was given to a group of participants by spinning a wheel of fortune in their presence. Then they were instructed to indicate first whether the number was higher or lower than the percentage, and then to estimate the percentage. Different groups were given different numbers. For example, the median estimate of a group that received 10 as the starting number was 25, and that of a group that received 65 was 45. Thus, these arbitrary starting numbers had a clear effect on their estimates.[5]

Another example in the same paper is by from two groups of high school students. They estimated a numerical expression within 5 s. One group estimated the product

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$$

While another group estimated the product

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$$

For both groups, the correct answer is 40,320. The median answer of the first group was 2550, and that of the second group was 512. It is likely that they used the product of some of the left-hand numbers as the anchor and adjusted to make estimates.

A field experiment (an experiment conducted in a real-world setting rather than in laboratories) by Northcraft and Neale (1987) showed that the anchoring effect can exist even when experts make pricing decisions that are important in economics. Each participating real estate agent visited a real estate property, was given a 10-page packet of information about the property, and was asked to estimate the value of the property. The packet information included standard information such as square footage and other characteristics of the property and other properties in the same neighborhood of the property. The packet was same except for the listing price, which varied in two conditions: 65,900 dollars, and 83,900 dollars.[6] The mean estimate of the appraisal value of the experts who were given 65,900 dollars as the listing price was lower than that of the experts who were given 83,900 dollars by more than 7000 dollars. This difference was statistically significant at the 1% level. Thus it is obvious that there was an anchoring effect in which the listing price was the anchor. The participants were asked to describe their decision processes. Only 14.3% of experts indicated that listing price was one of their "top three"

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[4]Anchoring is a heuristics in Tversky and Kahneman's (1974) definition, but not heuristics in Kahneman and Frederick's (2002) definition because anchoring is not an attribute substitution.

[5]The correct answer at the time of the experiment is not written in the paper, but the correct answer in 2006 was about 28%.

[6]They also conducted the same experiment for amateur participants in four conditions.

considerations. Thus, even experts are unconsciously affected by the anchoring effect.

Tversky and Kahneman (1974) listed "anchoring and adjustment" judgment as one kind of heuristics. This judgment method, however, does not fit the new definition of heuristics because it is not an attribute substitution. There seem to be many cases in which an attribute substitution gives an initial value, and then the "anchoring and adjustment" method is used based on the initial value.

5.3.5 Framing Effects

If decisions are rationally made, how the same contents are communicated should not affect the decisions. When the frame of communication changes, however, the focus on perception system can change. For this reason, if System 1 is affected by perception and is used for decisions, then decisions can change depending on the frame of communication for the same contents. This is called *framing effect*. Kahneman (2003) explained that he and Tversky had used the following Asian disease problem in their two versions of the hypothetical question survey to examine framing effects.

> The Asian disease
> Imagine that the United States is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:
> If Program A is adopted, 200 people will be saved.
> If Program B is adopted, there is a one-third probability that 600 people will be saved and a two-thirds probability that no people will be saved.

In this version of the problem, a substantial majority of respondents favored Program A, indicating risk aversion. The other version of the problem was given to other respondents in which the same story is followed by a different description of the options:

> If Program A′ is adopted, 400 people will die.
> If Program B′ is adopted, there is a one-third probability that nobody will die and a two-thirds probability that 600 people will die.

A substantial majority of respondents favored Program B′, indicating risk lovingness.

These two versions communicate the same contents, but the frame of communication affects decisions. Prospect theory can explain this framing effect by thinking where the reference point is set for the value function. In the first version, the emphasis is on "saved" and the reference point tends to be set at the situation in which 600 people die. In this case, the evaluation is done in the domain of gains. In the second version, the emphasis is on "die," and the reference point tends to be set at the situation in which nobody dies. In this case, the evaluation is done in the domain of losses.

5.4 Summary and Further Reading

For the purpose of studying bounded rationality, the optimization approach of traditional economics has difficulties such as the infinite regress problem. In the descriptive approach taken by Kahneman and Tversky, the idea of two systems of reasoning (often called a *dual system model of reasoning*) has been used as a model in order to sharpen our understanding even though no unified mathematical model is constructed.[7] Intuitive judgment by System 1 such as heuristics is shown to often lead to biases in experiments that are guided by this model.

For further reading of a book for the general reader, we recommend Kahneman (2011), and especially his explanations of the "What You See Is All There Is (WYSIATI)" bias. Another related book for the general reader, Tetlock and Gardner (2015), is on forecasting, which is a key element in economic behavior under uncertainty. The book explains how the WYSIATI bias can be overcome for becoming better forecasters.[8]

5.5 Questions and Problems

5.5.1 Multiple-Choice Problems

1. In the experiment of Nagel's (1995) beauty contest game, the winner will be the one who chooses the score that is the closest to the mean times p. Choose the most appropriate answer for this experiment.

[7]The mathematical model of prospect theory, however, was born from the consideration that System 1 focuses on changes. Prospect theory is a good example of how the optimization approach can be combined with the descriptive approach.

[8]The WYSATI bias is closely related to the concept of the worldview we explain in Chap. 9 in the sense that a person tends to believe his worldview is all there is. Tetlock and Gardner's (2015, Chap. 10) discussion about the dilemma of the leader that she needs to make decisions with confidence and at the same time to be humble to avoid the WYSATI bias is closely related to virtue ethics that we will explain in Chap. 11 below.

(A) If we assume that all participants are economic men, there is only one Nash equilibrium if $p < 1$, and every participant will vote 50.
(B) If we assume that all participants are economic men, there is only one Nash equilibrium if $p < 1$, and every participant will vote 0.
(C) In the actual experiments reported in Nagel (1995), when p is 1/2, the winner was always the one who vote 0 following the theoretical prediction of the Nash equilibrium.
(D) In the actual experiments reported in Nagel (1995), when p is 1/2, the ones who voted 0 following the theoretical prediction of the Nash equilibrium were never winners.
(E) A and C
(F) A and D
(G) B and C
(H) B and D

2. In Tversky and Kahneman's (1974) experiment of representativeness heuristic, they asked the following question. "A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50% of all babies are boys. However, the exact percentage varies from day to day. For a period of 1 year, each hospital recorded the days on which more than 60% of the babies born were boys. Which hospital do you think recorded more such days?" Choose the most appropriate answer about this experiment.

(A) According to probability theory, the larger hospital has a higher probability of recording such days.
(B) According to probability theory, the smaller hospital has a higher probability of recording such days.
(C) According to the experiment, the majority of participants answered that the larger hospital would measure such days with higher frequency.
(D) According to the experiment, the majority of participants answered that both hospitals would measure such days with about the same frequencies (that is, within 5% of each other).
(E) According to the experiment, the majority of participants answered that the smaller hospital would measure such days with higher frequency.
(F) A and C
(G) A and D
(H) A and E
(I) B and C
(J) B and D
(K) B and E

3. In the experiment on availability heuristic (Tversky and Kahneman 1974) they asked "If you pick a word (with three letters or more) at random from the dictionary, do you believe it is more likely that the word you picked begins with the letter r or one that has r in the third place?" Choose the most appropriate answer.

(A) In reality, there are more words that start with r.
(B) In reality, there are more words that have r in the third place.
(C) In the experiment, more participants answered "There are more words that begin with r."
(D) In the experiment, more participants answered "There are more words that have r in the third place."
(E) A and C
(F) A and D
(G) B and C
(H) B and D

5.5.2 Short Answer/Essay Problems

1. Explain the infinite regress problem in bounded rationality modelling.
2. Explain the definition of the framing effect and give one example.
3. Explain the definition of a representativeness heuristic and give one example.
4. Explain the definition of an availability heuristic and give one example.
5. Explain the definition of the anchoring effect and give one example.

References

Camerer, C. F., Ho, T.-H., & Cho, J.-K. (2004). A cognitive hierarchy model of games. *Quarterly Journal of Economics, 119*(3), 861–898.

Conlisk, J. (1996). Why bounded rationality? *Journal of Economic Literature, 34*(2), 669–700.

Kahneman, D. (2003). Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review, 93*(5), 1449–1475.

Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus, and Giroux.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intutive judgement. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment.* Cambridge: Cambridge University Press.

Keynes, J. M. (1936). *The general theory of employment, interest and money*. Basingstoke: Palgrave Macmillan.

Nagel, R. (1995). Unraveling in guessing games: An experimental study. *American Economic Review, 85*(5), 1313–1326.

Northcraft, G. B., & Neale, M. A. (1987). Experts, amateurs, and real estate: An anchoring-and-adjustment perspective on property pricing decisions. *Organizational Behavior and Human Decision Processes, 39*(1), 84–97.

Simon, H. (1955). A behavioral model of rational choices. *Quarterly Journal of Economics, 69*(1), 99–118.

Tetlock, P. E., & Gardner, D. (2015). *Superforecasting: The art and science of prediction*. New York: Crown.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, New Series, 185*(4157), 1124–1131.

Tversky, A., & Kahneman, D. (1983). Extensional versus intuitive reasoning: The conjunctional fallacy in probability judgment. *Psychological Review, 90*(4), 293–315.

Part III
Time Discounting and Social Preferences

Chapter 6
Intertemporal Behavior

Abstract This chapter explains economic models of intertemporal behavior. We first show the exponential time-discounting model in traditional economics and its limitations. Then we introduce the hyperbolic time discounting model in behavioral economics. The hyperbolic discounting model can explain why some people tend to procrastinate on doing unpleasant tasks such as saving instead of consuming, doing homework, or quitting smoking.

Keywords Exponential discounting · Hyperbolic discounting · Quasi-hyperbolic discounting · Dynamic inconsistency

This chapter explains economic models of intertemporal behavior. We will first see the exponential time discounting model in traditional economics and its limitations. Then we will introduce the hyperbolic time discounting model in behavioral economics. The hyperbolic discounting model can explain why some people tend to procrastinate on doing unpleasant tasks such as saving instead of consuming, doing homework, or quitting smoking. A solution to procrastination is a commitment such as declaring one's intention to quit smoking to friends to increase the cost of not carrying out one's own plan in the future.

6.1 Fisher's Indifference Curve Analysis

6.1.1 The Two-Period Model's Budget Constraint

First, consider a simple model in which a consumer lives for two periods (period 0 and period 1). Assume that labor income is exogenously given as Y_0 in period 0 and Y_1 in period 1. The interest rate is denoted by r; consumption in period 0, by C_0; consumption in period 1, by C_1; the utility function is denoted by $U(C_0, C_1)$. In period 0, the consumer can save. Saving is defined by the difference between income and consumption:

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$$S = Y_0 - C_0 \tag{6.1}$$

If C_0 is greater than Y_0 and if S is negative, then we consider that the consumer has borrowed money. In the two-period model, the consumer cannot borrow in the last period of period 1, and it is necessary that consumption in period 1 is smaller than or equal to the sum of saving S, the interest income rS, and labor income Y_1:

$$C_1 \leq Y_1 + (1 + r)S \tag{6.2}$$

When we combine (6.1) and (6.2), we obtain

$$C_0 + \frac{1}{1 + r}\mathrm{C}_1 \leq Y_0 + \frac{1}{1 + r}Y_1. \tag{6.3}$$

This is the intertemporal budget constraint. If we compare this with the budget constraint for different goods in the same period such as apples and oranges, and if we view the same good in different periods as different goods, then we see that $1/(1 + r)$ is the relative price between C_1 and C_0. In the left-hand side of this budget constraint, we are discounting future consumption by $(1 + r)$ to make it measured by the same unit as present consumption. Therefore, the left-hand side of (6.3) is called the *discounted present value* of current and future consumption. Similarly, its right-hand side is the discounted present value of current and future labor income. For example, suppose that labor income in period 0 is 9,000 dollars, that labor income in period 1 is 10,500 dollars, and that the interest rate is 5%. Then the present discounted value of labor income in period 1 is 10,500/1.05 dollars, which is equal to 10,000 dollars. Adding this to labor income in period 0, the present discounted value of income in the two periods is 19,000 dollars. The intertemporal budget constraint is that the discounted present value of current and future consumption must not exceed the present discounted value of current and future labor income.

6.1.2 *Optimal Consumption in the Two-Period Model*

In traditional economics, a consumer is assumed to have exogenous and stable preferences for various combinations of nonnegative consumption C_0 and C_1, which is denoted by (C_0, C_1). It is also assumed that the preferences are represented by a utility function $U(C_0, C_1)$. The consumer prefers (C_0, C_1) that gives a high value of $U(C_0, C_1)$. Hence the consumer chooses the combination of C_0 and C_1 that maximizes the utility function $U(C_0, C_1)$ under the budget constraint (6.3). Let a diagram describe this decision making.

We assume that if C_0 increases while C_0 is constant, then the utility increases. We also assume that if C_1 increases while C_0 is constant, then the utility increases. With these assumptions, (6.3) should hold with an equality when the utility is maximized. In this equation, if we set $C_0 = 0$ in order to see what happens when all

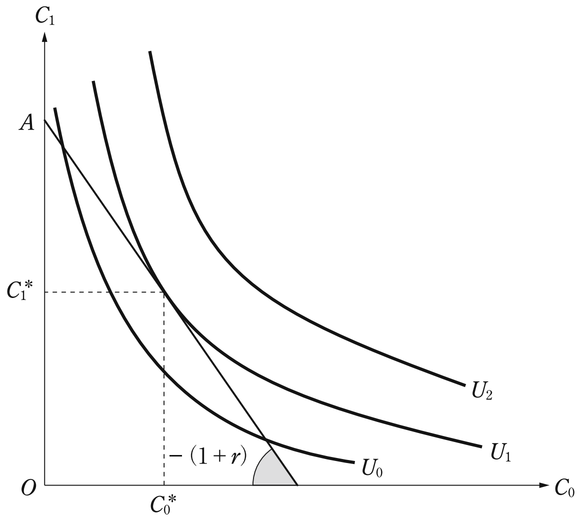

Fig. 6.1 Optimal Consumption over Two Periods

income in period 0 and period 1 are spent on consumption in period 1, then $C_1 = (1+r)Y_0 + Y_1$. Define $A = (1+r)Y_0 + Y_1$. In Fig. 6.1, we take C_0 on the horizontal axis and C_1 on the vertical axis and draw the graph of the budget constraint equation. This graph has the slope of $-(1+r)$, and its vertical intercept is A. This is because (6.3) with equality can be written as

$$C_1 = -(1+r)C_0 + A. \tag{6.4}$$

The graph expressing Eq. (6.4) is called the intertemporal budget line.

Let U_i be a level of the utility. Then the collection of (C_0, C_1) such that $U(C_0, C_1) = U_i$ is called an indifferent curve. Figure 6.1 draws three indifference curves for three levels of the utility, U_0, U_1, U_2. These intertemporal indifference curves were studied by the economist Irving Fisher (1867–1947), and are called Fisher's indifference curves. In economics we think that the shape of the indifference curves are convex toward the origin as in Fig. 6.1. Because the utility is assumed to increase when C_1 increases while C_0 is constant, $U_0 < U_1 < U_2$. All (C_0, C_1) combinations that are on the line expressing Eq. (6.4) and all (C_0, C_1) that are below the line satisfy the budget constraint (6.3). Among all (C_0, C_1) combinations that satisfy the budget constraint, the one that maximizes the utility is the one at which the indifference curve is tangent with the budget constraint line. In the figure $\left(C_0^*, C_1^*\right)$ is the combination that maximizes the utility under the budget constraint. If C_0^* is smaller than income Y_0, then the consumer saves the difference. If C_0^* is greater than income Y_0, then the consumer borrows the difference.

A patient consumer's indifference curve's slope is relatively gradual. When present consumption (C_0) increases by one unit, future consumption (C_1) needs to decrease by a relatively small amount in order to keep the same utility level. Other things being equal, a patient consumer tends to have smaller present consumption and save more. An inpatient consumer's indifference curve's slope is relatively steep. When present consumption (C_0) increases by one unit, future consumption (C_1) needs to decrease by a relatively large amount in order to keep the same utility level. Other things being equal, a patient consumer tends to have greater present consumption and save less (or borrow more).[1] Thus the slope of the indifference curve is important for saving and borrowing decisions.

The slope of the indifference curve is negative, and its absolute value is called the *marginal rate of substitution*. The marginal rate of substitution can be expressed by the ratio of the marginal utility of present consumption and the marginal utility of future consumption. The marginal utility of present consumption is defined as the derivative of $U(C_0, C_1)$ with respect to C_0 when C_1 is kept constant (which is called the partial derivative), which is denoted by

$$\frac{\partial U(C_0, C_1)}{\partial C_0}. \tag{6.5}$$

The marginal utility of future consumption is defined as the derivative of $U(C_0, C_1)$ with respect to C_1 when C_0 is kept constant:

$$\frac{\partial U(C_0, C_1)}{\partial C_1} \tag{6.6}$$

The marginal rate of substitution is defined as the ratio of the marginal utility of present consumption to the marginal utility of future consumption:

$$\frac{\partial U(C_0, C_1)/\partial C_0}{\partial U(C_0, C_1)/\partial C_1} \tag{6.7}$$

As in Fig. 6.1, the slope of the indifference curve is equal to the slope of the intertemporal budget line when utility is maximized. Therefore, the marginal rate of substitution evaluated at the optimal combination of present and future consumption (C_0^*, C_1^*) is equal to the absolute value of the slope of the budget line, which is 1 plus the interest rate. Namely,

$$\frac{\partial U\left(C_0^*, C_1^*\right)/\partial C_0}{\partial U\left(C_0^*, C_1^*\right)/\partial C_1} = 1 + r \tag{6.8}$$

This is an application of the utility optimization condition in microeconomics that the marginal rate of substitution between two goods is equal to the relative price to the intertemporal utility optimization. This condition is called the Euler equation.

[1]See the practice problem 1 (D) in Sect. 6.7.2.

6.2 Exponential Discounting Model

Paul Samuelson proposed a model of utility function for Fisher's indifference curve analysis:

$$U(C_0, C_1) = u(C_0) + \delta u(C_1) \tag{6.9}$$

in which $u(C_t)$ is a period utility function for period t, and the future utility is discounted by a positive number δ which is less than 1. Here δ is the discount factor. Let $u'(C)$ denote the derivative of $u(C)$, then

$$\frac{\partial U(C_0, C_1)}{\partial C_0} = u'(\mathrm{C}_0) \tag{6.10}$$

$$\frac{\partial U(C_0, C_1)}{\partial C_1} = \delta u'(C_1). \tag{6.11}$$

Therefore,

$$\frac{u'(C_0)}{\delta u'(C_1)} = 1 + r \tag{6.12}$$

is the Euler equation for the time discounting model.

The two-period model is easy to understand and to analyze, and for some application problems, the insight we obtain from a more general multi-period model with 3 periods and more may be essentially the same. For other application problems, however, results from a two-period model may not be appropriate. For example, consider a businessperson who will retire in 3 years. He is thinking about how much to consume and save this year. One option is to enjoy consuming much this year and to start to save for retirement in the next year. This option looks attractive. Namely, there is a temptation to procrastinate saving for retirement. In order to think about this type of problem, it is necessary to use models that deal with three periods or more.

Let us look at a multi-period model. The budget constraint equation is:

$$C_0 + \frac{1}{1+r}C_1 + \cdots + \frac{1}{(1+r)^T}C_T = Y_0 + \frac{1}{1+r}Y_1 + \cdots + \frac{1}{(1+r)^T}Y_T. \tag{6.13}$$

This intertemporal budget constraint is similar to that of the two-period model in that it states that the discounted present value of current and future consumption must not exceed the present discounted value of current and future labor income. The consumer in a multi-period model maximizes his utility function, $U(C_0, C_1, \ldots, C_T)$, subject to the intertemporal budget constraint (6.13). The Euler equation for this optimization is

$$\frac{\partial U/\partial C_{t+k}}{\partial U/\partial C_t} = \frac{1/(1+r)^{t+k}}{1/(1+r)^t} = \frac{1}{(1+r)^{\mathrm{k}}}. \tag{6.14}$$

This Euler equation shows that the marginal rate of substitution of consumption in period t and consumption in period (t + k) is equal to their relative price.

As the time discounting utility function for a multi-period model, we consider

$$U(C_0 \ldots, C_t) = u(C_0) + \delta u(C_1) + \delta^2 u(C_2) + \ldots + \delta^T u(C_T). \tag{6.15}$$

We call this the *exponential discounting* model because the utility from period t is discounted by the exponential function δ^t of δ. In this model, the Euler equation that equates the marginal rate of substitution of consumption in period t and consumption in period $(t+k)$ to their relative price is

$$\frac{u'(C_t)}{\delta^k u'(C_{t+k})} = (1+r)^k. \tag{6.16}$$

If we set $k = 1$ in this equation, then we obtain the Euler equation for two neighboring periods:

$$\frac{u'(C_t)}{\delta u'(C_{t+1})} = 1 + r. \tag{6.17}$$

In traditional economics, especially in macroeconomics, the exponential discounting model has been used as the standard model. Both the permanent income hypothesis and life cycle hypothesis, which are the key consumption theories in macroeconomics, depend on Eq. (6.17). As a simple case, assume that $\delta(1+r) = 1$. Then the marginal utility does not change over two neighboring periods. The marginal utility is thought to satisfy the *law of diminishing marginal utility* that the marginal utility decreases as consumption increases, and $u''(C) \leq 0$. Here, we assume that the strict inequality $u''(C) < 0$ holds. Then in order for the marginal utility to stay the same over two neighboring periods, consumption should stay the same. Because this holds for all two neighboring periods, consumption does not change in all periods. In Eq. (6.13), we can let all C_t be constant at C, and solve for C to obtain the optimal level of consumption. The optimal level of consumption depends on the right-hand side of Eq. (6.13), which is the present discounted value of current and future labor income, which is permanent income, but not on income in each period beyond its contribution to permanent income. The permanent income hypothesis applies this model to responses of consumption to temporary changes in income due to business cycle fluctuation and other such factors. Even when income decreases much because of a recession, as long as the change is temporary, consumption should not change. The consumer is predicted to borrow or draw funds from assets that he has accumulated in order to keep consumption at the same level. The life cycle hypothesis applies this model to the whole life of a consumer. Even when income is low during school years and retirement years, consumption is predicted to be the same as in work years. When the interest rate is high and $\delta(1+r) > 1$, then $u'(C_t) > u'(C_{t+1})$. Because the marginal utility decreases over time, the optimal level of consumption is predicted to increase over time. When the model is applied to actual data, various factors such as this need to be added for consideration. Equation (6.17), however, expresses the essence of the permanent income hypothesis and the life cycle hypothesis.

6.3 Hyperbolic Discounting Model

6.3.1 Hyperbolic Discounting

In reality, many people seem to feel the temptation to procrastinate to save by consuming today, and yield to the temptation on some occasions. Many people may be using commitment such as depositing money in time deposit accounts that charge penalties when they withdraw their money before the maturity date in order to resist againt the temptation. An economic man in the exponential discounting model does not even feel the temptation. In that model, an economic man knows that his plan for consumption and saving over time that he made at the beginning is optimal in the short run and in the long run. Therefore, he does not have any incentive to deviate from his plan.

In many intertemporal behavior decisions, real people feel temptations, try to self-control, and use commitments as a countermeasure for deficiency of self-control. Many people try and fail to quit smoking and drinking alcohol or to improve their health through more exercise and better diet. Many people declare their goals to people around them for their commitments, so that they can increase the cost of losing to temptations. Laibson (1997) focused on much experimental evidence in psychology for both animals and human beings that time discounting is better approximated by *hyperbolic discounting* than exponential discounting in psychology in order to develop an economic model for temptations and commitments. The important feature of a hyperbolic discounting model is that a consumer discounts the utility in the near future at high discount rates and the utility in the far-distant future at lower discount rates.

In order to define hyperbolic discounting, assume that the utility function can be written in the following form:

$$U(C_0, C_1, \ldots C_T) = F(0)u(C_0) + F(1)u(C_1) + F(2)u(C_2) + \cdots + F(T)u(C_T) \tag{6.18}$$

Here, $F(\tau)$ is the *time discounting function*, $F(\tau+1)/F(\tau)$ is the *time discounting factor*, and

$$-\frac{F(\tau+1)-F(\tau)}{F(\tau)} \tag{6.19}$$

is the *time discount rate*. In the exponential discounting model, $F(\tau)=\delta^{\tau}$, $F(\tau+1)/F(\tau)=\delta$, and

$$-\frac{F(\tau+1)-F(\tau)}{F(\tau)}=1-\delta. \tag{6.20}$$

Thus, the time discount rate is constant. In the hyperbolic discounting model,

$$F(\tau)=\frac{1}{1+k\tau}. \tag{6.21}$$

where k is a positive constant. For the hyperbolic discounting model, it is more convenient to think of the model as a continuous time model rather than a discrete time model. In a continuous time model, the instantaneous time discount rate is defined as

$$-\frac{dF(\tau)/d\tau}{F(\tau)}. \tag{6.22}$$

The instantaneous time discount rate for the hyperbolic discounting model is

$$-\frac{dF(\tau)/d\tau}{F(\tau)}=\frac{k}{1+k\tau}. \tag{6.23}$$

Thus, in the hyperbolic discounting model, the time discount rate is not constant but decreases as τ increases.

Ainslie (1992) and Lowenstein and Prelec (1992) showed that many experimental results in psychology for animals and human beings could be explained by the hyperbolic discounting model.[2] Then the time discount rate is smaller for greater τ. This means that, from the point of view of the time of decision making, the time discount rate is high in the short-run and it is low in the long-run.

6.3.2 *Quasi-Hyperbolic Discounting*

For the purpose of economic analysis, Laibson (1997) adopted the quasi-hyperbolic discounting model that can be more easily analyzed than the hyperbolic discounting

[2] Some of the experimental evidence is more consistent with the generalized hyperbolic discounting, which allows one more free parameter for the discounting function, as mentioned in Lowenstein and Prelec (1992) and Laibson (1997).

model while retaining the qualitative feature of the hyperbolic discounting model. In this model, $F(\tau) = 1$ if $\tau = 0$ (at the time of decision making), and

$$F(\tau) = \beta\delta^{\tau} \tag{6.24}$$

if $\tau > 0$, where both β and δ are positive real numbers that are smaller than or equal to 1. The time discount rate is

$$-\frac{F(\tau+1) - F(\tau)}{F(\tau)} = \begin{cases} 1 - \beta\delta(\tau = 0) \\ 1 - \delta\,(\tau > 0) \end{cases}. \tag{6.25}$$

For example, let $\beta = 0.5$, $\delta = 0.95$. Then the values of the time discounting function are $F(0) = 1, F(1) = 0.5 \times 0.95 = 0.475$, $F(2) = 0.5 \times 0.952 = 0.45125$, $F(3) = 0.5 \times 0.953 = 0.428688,\ldots$. The time discount rate is 0.525 if $\tau = 0$, and 0.05 if $\tau > 0$. Thus if $\beta < 1$, then the consumer's time discount rate for future utility is high at the time of decision making, and low after that.

6.3.3 Time Inconsistency

In both the hyperbolic discounting and the quasi-hyperbolic discounting models, the preferences exhibit *time inconsistency* (or dynamic inconsistency). For example, consider a consumer who makes an intertemporal consumption plan for three periods in period t where 1 period is 1 year. In period t, his time discount rate is high for his utility in period $t + 1$, and comparing with this time discount rate, his time discount rate for period $t + 2$ utility relative to his $t + 1$ utility is lower. When period $t + 1$ actually arrives, however, his discount rate for $t + 2$ utility is high. For this reason, he does not wish to carry out his plan he made in period t. For example, imagine a consumer who retires in 2 years. Assume that his optimal plan 2 years before retirement is to consume much this year and save much in one year so that his consumption in the retirement year is about the same as his consumption 1 year before retirement even though income drops in the retirement year. After 1 year passes, however, his optimal consumption plan is different because his discount rate for the utility in the retirement year is very high now. His optimal plan one year before retirement is to consume much less in the retirement year. When the optimal plan in one period is not optimal in later years, preferences are time inconsistent.

In contrast, the time discount rate is constant in the exponential discounting model. The time discount rate for the utility in the retirement year relative to the utility 1 year before retirement used in his plan made 2 years before retirement is the same as that used in his plan made 1 year before retirement. Hence, his optimal consumption does not change. Hence preferences represented by an exponential time discounting model is time consistent.

Even if the time discounting function used to make plans 2 years before the retirement is quasi-hyperbolic, time inconsistency does not arise if the time discount rate used to make decision one year before retirement continues to be $1-\delta$ after 1 year. In the quasi-hyperbolic discounting model, it is assumed that "present" changes after 1 year. As a result, the time discount rate used to make plans 1 year before retirement is $1-\beta\delta$, which is different from $1-\delta$. This causes time inconsistency.

In many experiments for intertemporal decisions, a participant chooses the amount and the timing of reward as explained in detail in the next section. A typical setting is that if he chooses the reward at a later time, then the amount of the reward is larger. In some experiments, a participant can make a choice much before the actual time of the smaller reward, and then make a choice again just before the actual time of the smaller reward. Then a frequent observation is that a participant chooses a larger reward much before the actual time of smaller reward, but switches his choice to a smaller reward when the choice is made just before the actual time of smaller reward. This is called *preference reversal*. This is an example of time inconsistency that shows up as behavior in experiments.

We now consider two types of decision making by a consumer who has hyperbolic discounting. A *naïve* consumer makes decisions without understanding that he faces the problem of time inconsistency, that his future self will have different preferences from his present self, and that his future self will not carry out his present self's plan. A *sophisticated* consumer makes decisions with the understanding that he faces the problem of time inconsistency.

A naïve consumer at the time of decision making expects that his future self will carry out his present self's plan. Let us derive the Euler equation in this case for the quasi-hyperbolic model. Let the decision making period be period 0. Then the marginal utility for period 0 and that for period 1 are $\partial U/\partial C_0 = F(0)u'(C_0) = u'(C_0)$ and $\partial U/\partial C_1 = F(1)u'(C_1) = \beta\delta u'(C_1)$, respectively. Equating the marginal rate of substitution and the relative price (1 + the interest rate), we obtain

$$\frac{u'(C_0)}{\beta\delta u'(C_1)} = 1 + r. \tag{6.26}$$

Equating the marginal rate of substation for period 1 and period 2 with the relative price, we obtain

$$\frac{u'(C_1)}{\delta u'(C_2)} = 1 + r. \tag{6.27}$$

Thus, the period 1 utility is discounted greatly by the discount factor of $\beta\delta$ relative to the utility in period 0, while the period 2 utility is discounted less by the discount factor of δ. For this reason, the individual tends to consume much in period 0 and procrastinate saving to period 1. When period 1 arrives, the Euler equation is

$$\frac{u'(C_1)}{\beta\delta u'(C_2)} = 1 + r. \tag{6.28}$$

Comparing Eqs. (6.27) and (6.28), the individual is discounting the period 2 utility more in the decision making of period 1 than in the decision making of period 0. Thus the consumer tends to procrastinate saving further. This is an expression of the saving procrastination problem by the Euler equation. A naïve consumer discounts the near future utility greatly but does not discount the far distant future much. As a result, he tends to procrastinate any painful behavior such as decreasing consumption to increase saving. If we consider the utility from health by the same model, then we can analyze the procrastination behaviors for decisions to quit smoking or drinking and to start exercising and eating healthy food. If we consider higher utility levels from submitting homework reports, then the procrastination problem for writing a report is similar.

A sophisticated individual at the time of decision making expects that his future self will not wish to carry out his present self's plan. In this case, a commitment is useful. A commitment is a promise that the consumer will carry out the current plan in the future. Because preferences will change over time, it is necessary to have a device. For example, if the individual expects that he will watch TV tomorrow when he needs to write a homework report, then an effective scheme may be to wrap the TV in many layers of blankets and put it in a closet. There is a real story in which a gambling addict left all his salary in a trustworthy person's care. A marriage can be viewed as a commitment device. Romantic love is basically one of the emotions such that one does not see the partner's shortcomings and does not last forever just like other emotions. A pair of lovers want to love each other forever, but each of them can expect to be tempted to betray the partner and enjoy a new romantic love partner after the emotion is over. If the two have the will to love each other forever now, then each of them can use marriage with a high cost of divorce in order to fight against future temptations.

For the procrastination problem for saving, an effective device of commitment is investment in *illiquid assets*. *Liquidity* of an asset is the degree to which how quickly and cheaply an asset can be converted into cash. Cash is the most liquid asset, and checking deposits are almost as liquid as cash. Time deposits are less liquid because it is costly to withdraw before the maturity dates. Real estate is not liquid because it takes time to find buyers for it. These relatively less liquid assets are called illiquid assets. If you expect to spend money without saving in the next month, then you can make a commitment by investing in illiquid assets.

There is various evidence that hyperbolic discounting is actually affecting people's behaviors. Angeletos et al. (2001) reported results for simulations of two model economies in which income processes for life-cycles of various types of U.S. households are matched with a Panel Study of Income Dynamics (PSID). In one model economy, all households follow the quasi-hyperbolic discounting model. In the other model economy, all households follow the exponential discounting model. In both models, there are liquid and illiquid assets. In the quasi-hyperbolic model, the households are sophisticated, and can make commitments by investing in illiquid assets. The authors compared predictions from each model for consumption and asset holdings with U.S. data in PSID and the Survey of Consumer Finances (SCF).

In the quasi-hyperbolic discounting model, β is set to 0.7 from typical laboratory experiment results for one year (because the model's one period is 1 year). In both models, δ is picked so that the simulations generate a median wealth to income ratio of 3.2 for individuals between ages 50 and 59. The median of 3.2 is to match that from the SCF data. In the quasi-hyperbolic discounting model, δ is 0.957. In the exponential discounting model, δ is 0.944.

In their simulations, the average share of liquid assets divided by total assets is 51% in the exponential discounting model and is 41% in the quasi-hyperbolic discounting model. Because illiquid assets can be used for commitment in the latter model, the share is predicted to be smaller in the former model. The average share in the SCF data depends on the definition of liquid assets, but is 16% for one definition. In reality, the share of liquid assets is much smaller than the predicted value from the exponential discounting model. The reason for this discrepancy is not fully explained by the quasi-hyperbolic discounting model but is explained to some extent. Next, the effect of income change on consumption change is called the marginal propensity to consume. As explained in the last section, the standard exponential discounting model predicts that the marginal propensity to consume is 0.[3] In simulated data from the hyperbolic discounting model, it is estimated to be 0.166. The authors' estimates from the PSID data depend on the definition of consumption but lie between 0.19 and 0.33 and most are significant at the 5% level.[4] Thus, the quasi-hyperbolic discounting model explains the co-movement between consumption and income observed in real world data fairly well. As for the explanatory power of the hyperbolic discounting model for health and borrowing behaviors (such as procrastination behaviors for decisions to start to quit smoking and drinking alcohol) observed in survey data, see Ikeda (2016).

6.4 Measuring Time Preferences in Experiments

Models of time preferences were originally tested on animals in psychology experiments. We will explain in details the experiments to see how pigeons make decisions over time.

This experiment paradigm starts with a pigeon choosing actions to get either a small amount of food or a large amount of food at the same delay of time,

[3]In their simulated data from the exponential discounting model, the marginal propensity to consume out of predictable change in income is estimated to be 0.03 because liquidity constraints (limits in borrowings) are incorporated in their model.

[4]As explained in Angeletos et al. (2001), there is much empirical evidence for co-movement of consumption and income.

D. Because the time delay is the same, the pigeon naturally chooses the action to get a large amount of food. Then, the experimenter fixes the delay of time D for the small amount of food while making the delay for the large amount of food gradually longer. As the delay gets longer, the pigeon chooses the small amount of food at some delay, D'. Namely, around the delay of time D', we can think that the equation (the discounted value of the small amount of food with delay D) = (the discounted value of the large amount of food with delay D') holds. When we measure such D' while varying the value of D, the plot of D' on the vertical axis against D tends to be approximately a straight line. On this straight line, the discounted value of the small amount of food is the same at the discounted value of the large amount of food.

Let us consider this straight line from the point of view of the time discount model explained above. Here consumption C_t in the model corresponds with the reward R_t in the experiment. Assume that the utility function is linear: $u(R_t) = R_t$. For example, if we assume the hyperbolic discounting utility function, then the equation $R_S/(1+kD) = R_L/(1+kD')$ holds where D for the short delay and D' for the long delay, and R_S for the small amount of food and R_L for the large amount of food. When we transform this equation into the form

$$D' = \left(\frac{R_L}{R_S}\right)D + \left(\frac{R_L}{R_S} - 1\right)k,$$

this equation expresses the plotted straight line. By comparing the intercept in this equation with the estimated intercept from the experiment data, we can estimate the discount rate. Namely, in order to estimate the discount rate of a pigeon or an individual, we collect data on intertemporal choices in an experiment.

Intertemporal choice questions in surveys that are widely used in economics are also based on this paradigm. In such cases, questions are expressed in writing, but the main idea stays the same. Just as in the pigeon experiment, a researcher estimates the point in which the discounted value of a large reward and the discounted value of a small one are the same from the shift of the choice, and then derives the discount rate from this estimate. It should be noted that the framing effect exists by using questions in writing and presentations in tables, and solutions to this problem have been proposed.

6.5 The Function of the Brain Related to Time Preferences

The function of the brain for time preferences has been studied for several decades as the concept of time preferences was introduced from psychology. The fact that serotonin, a neurotransmitter, is deeply involved with this impulsive choice has been clinically indicated among scientists (Soubrie 1986) and biologically proved by various animal experiments. Serotonin is a kind of biogenic amine, which is produced in the metabolic process of tryptophan, an essential amino acid.

A large number of serotonin neurons exist in the raphe nuclei in the midbrain and release serotonin to the brain cortices, the basal nuclei, and the cerebellum. It is considered that about 2% of the serotonin of the whole body exist in the central nervous system and is involved in the physiological functions, such as sleep, pain, and maintenance of body temperature, as well as drug addiction and psychological conditions such as anxiety, impulsivity, and depression. In experiments with rats it has been shown that because of dysfunction of serotonergic pathways by injecting a specific neurotoxin to serotonin into the dorsal raphe nucleus where serotonin neurons are rich, the frequency of the impulsive choice over a small and immediate reward has increased more than a delayed but larger reward (Wogar et al. 1993; Bizot et al. 1999; Mobini et al. 2000). Moreover, it is also reported that by the increase of in-brain serotonin density the number of these impulsive choices can be decreased (Poulos et al. 1996; Bizot et al. 1999).

Examining these experiments, the model has been proposed that the density of serotonin determines the time discount rate (Ho et al. 1999). There are many previous studies showing that specific brain areas are closely related to impulsivity of animals. For example, Cardinal et al. gives a conditional assignment to rats in which they can obtain a reward according to the option they choose (Cardinal et al. 2001). When rats choose one option, they can gain a one-pellet reward, but when they choose another option, after 10–50 s they can obtain a four-pellet reward. In this experiment, the rats tended to choose the smaller reward more often than the larger one resulting from the delay, after damage to the ventral striatum. Thus, Cardinal et al. reported that the ventral striatum is deeply related to impulsive choice. In addition, the experiment conducted by Mobini et al. indicated that the rats with damage to the orbitofrontal cortex (OFC) displayed impulsive choice (Mobini et al. 2002).

Schweighofer et al. (2008) examined the function of serotonin in humans (Fig. 6.2). They manipulated the concentration of serotonin in the participants and asked them to choose an immediate but smaller reward or a delayed but larger reward. All the participants had to take the tryptophan in liquid form, which is one of the essential amino acids to produce serotonin in the body, and the experiments performed after 8 h were likely to increase the serotonin concentration in the brain. In the case of low serotonin concentration, participants frequently tended to choose an immediate but small reward. Moreover, the lower the serotonin concentration, the larger the discount rate that was presumed by the action of the participants. Using the same experimental paradigm, Tanaka et al. (2007) measured brain activity by fMRI. They found that with a lower level of serotonin concentration, the ventral striatum was involved in reward prediction with smaller discount factor; on the other hand, with the higher level of serotonin concentration, the dorsal striatum was involved in reward prediction with larger discount factor (Fig. 6.3) (Tanaka et al. 2007). Serotonin has been well focused upon as a chemical substance related to psychiatric disorders, such as depression and obsessive-compulsive disorder; however, its function has not been completely revealed. Thus, the author believes that the biological evidence of impulsiveness in decision making is applicable to psychiatric disorders and to the social problems caused by impulsiveness.

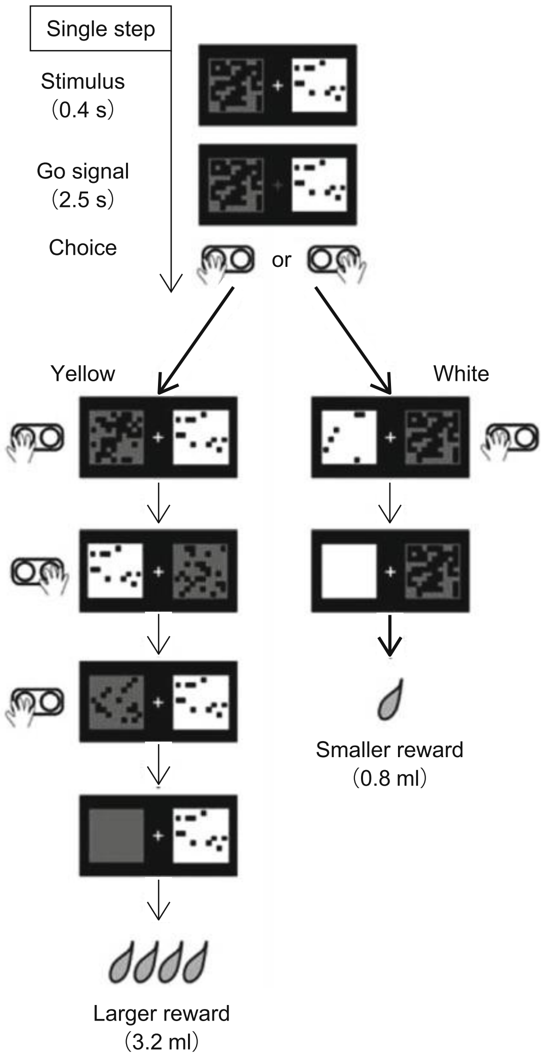

Fig. 6.2 Experimental task of the intertemporal choice experiment. A subject was asked to select either a white or yellow square by pressing a button on the corresponding side. In the example shown here, if the subject chooses a white square at each step, a small amount of juice (0.8 ml) is delivered in two steps (2.5 x 2 = 5 sec). If the subject chooses a yellow square, four yellow choices (2.5 x 4 = 10 sec) must be repeated to obtain a larger amount of juice (3.2 ml). The position of the squares (left or right) was changed randomly at each step (*Source* Tanaka et al. 2007)

In addition to the above studies, there is research regarding the biological evidence with a detailed discount model. McClure et al. measured the brain activities by fMRI when the participants chose one of two different time points such as 10 dollars today or 110 dollars after one month (McClure et al. 2004). As a result, the lateral frontal areas and the parietal areas were activated no matter when either of the two choices was selected. On the other hand, the striatum and the medial prefrontal lobe were more strongly activated when the participants chose the immediate options. This result indicates that one person has both of the two

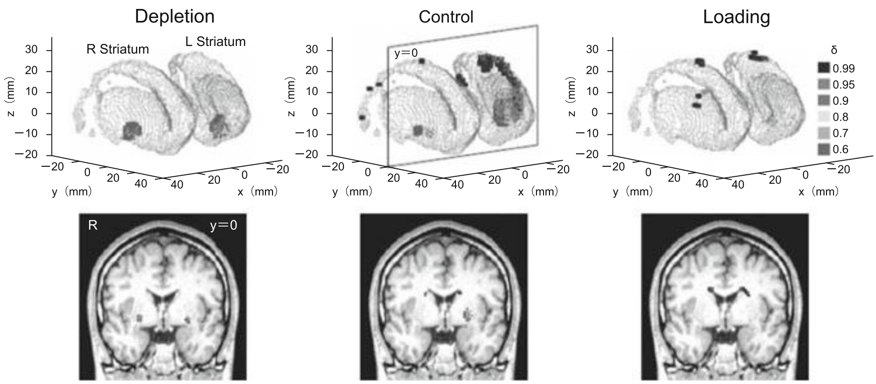

Fig. 6.3 Results of the regression analysis of BOLD signal by expected future reward with different discount rates. Voxels within the striatum (3D mesh surface) showing a significant correlation ($P < 0.001$ in one sample t-test, uncorrected for multiple comparisons, $n = 12$ subjects) with $V(t)$ at different settings of discount rate are shown with gray scales. The voxels correlated with reward prediction at shorter time scales are predominantly located in the ventral part of the striatum (ventral putamen and nucleus accumbens), while the voxels correlated with reward prediction at longer time scales are located in the dorsal part of the striatum (dorsal putamen and caudate body) (*Source* Tanaka et al. 2007)

different roles in the brain: a role that causes a rational choice and a role that causes an impulsive choice.

The evidence of neuroscience suggests that in one's brain there is a self that determines the right choice according to multiple criteria. This interpretation leads to a gap between general economic models assuming that one person has a single discount rate and real phenomena occurring inside that person's brain. From the further development of research, we can expect new economic models based on biological phenomena.

6.6 Summary and Further Reading

The hyperbolic discounting model can explain procrastinating behavior that the exponential discounting model in traditional economics cannot. In neuroeconomics, there is evidence indicating that there are many different exponential discount rates in different parts of our brains. An interpretation is that people whose behavior is consistent with the hyperbolic discounting model are using different parts of their brains for short and long horizons. We expect that future interactions with neuroeconomics and behavioral economics will deepen our understanding of intertemporal choices.

For further reading, Ikeda (2016) discusses empirical evidence for decisions that harm decision makers themselves in the long run that range from financial to health issues such as overborrowing, overeating, and addiction. Ikeda also discusses the relationship between the empirical evidence and theoretical models such as hyperbolic discounting models in this chapter and self-control models in Chap. 3 above. Ikeda also offers discussions about how we can cope with self-control problems from the insights obtained by empirical evidence and theoretical models. Thaler and Sunstein (2008) describe many examples of problems caused by hyperbolic discounting and solutions based on a nudge tool that will be discussed in Chap. 11 below.

6.7 Questions and Problems

6.7.1 Multiple-Choice Questions

Assume that a consumer X has a quasi-hyperbolic discounting function: he discounts the near-future by $\beta\delta$, and the distant future by δ ($0<\beta<1$ and $0<\delta<1$). A consumer Y has an exponential discount function, and his discount factor is δ. Assume that β is the only difference between the two consumers in their preferences and their exogenous labor income. For example, δ is assumed to be same for X and Y. Assume that X is sophisticated but has imperfect commitment. Answer the following two questions.

1. Choose the most appropriate description regarding the comparison of X and Y for their choices of consumption, saving, and asset holdings.
   (A) X will choose to hold more illiquid assets compared to Y.
   (B) X will choose to save more money than Y.
   (C) The correlation between income and consumption would be higher for X than the one for Y.
   (D) X's consumption at the time of retirement will drop more greatly than Y's consumption.
   (E) A, B, and C
   (F) A, C, and D
   (G) B, C, and D
2. Choose the most appropriate reason why X will choose to hold more illiquid assets.
   (A) X faces time-inconsistency problem, while Y does not.
   (B) X prefers to save more than Y does.
   (C) X at the present point in time will make a commitment to influence him-or herself's future.
   (D) Illiquid assets can be used as a tool of commitment.
   (E) A, B, and C
   (F) A, C, and D
   (G) B, C, and D

6.7.2 Short Answer/Essay Questions

Define r as the interest rate, C_t as consumer's consumption at time t, Y_t as labor income at time t. Answer the following two questions.

1. Assume that the consumer lives two periods, 0 and 1, and that his utility function is $U(C_0, C_1)$.
   (A) Describe the budget constraint.
   (B) Draw a figure to describe the utility maximization under the budget constraint using a budget constraint line and three Fisher's indifference curves. Put the description of the label on the X and Y axes.
   (C) In the figure you drew in (B), add the combination of (Y_0, Y_1) which causes saving at t = 0.
   (D) Using a different color from the previous figure [from (B) and (C)], draw an indifference curve that is much steeper than the previous ones but facing the same budget constraint line. Confirm that C_0 to maximize the utility will be larger than (B), thus saving becomes less.
   (E) Write down the Euler equation for utility maximization.
   (F) Write down the Euler equation for utility maximization when the utility function follows the exponential time discounting model. For this purpose, let $u(C_t)$ be the period utility function in period t and δ be the discount factor.
2. Assume that a consumer lives multiple periods (T period), thus his utility function is $U(C_0, C_1, \ldots, C_T)$.
   (A) Write down the budget constraint.
   (B) Write down the Euler equation for utility maximization.
   (C) Write down the utility function when it follows the exponential discounting model with $u(C_t)$ as the period utility function in period t and δ as the discount factor. Write down the Euler equation in this case.
   (D) Write down a utility function under the quasi-hyperbolic discounting model.
   (E) Assume that an individual with this utility function can make the complete commitments for all future periods: at $t = 0$, the "present self" makes decisions as the dictator for all "future selves" for entire consumption for $t \geq 0$ by maximizing his utility under the budget constraint at $t = 0$. Write down the Euler equation of two consecutive periods (hint: the Euler equations with C_0, C_1, and C_t, C_{t+1} when t > 0 is different, so you need to write two equations.).

References

Ainslie, G. (1992). *Picoeconomics: The strategic interaction of successive motivational states within the person*. Cambridge: Cambridge University Press.

Angeletos, G.-M., Laibson, D., Repetto, A., Tobacman, J., & Weinbert, S. (2001). The hyperbolic consumption model: Calibration, simulation, and empirical evaluation. *Journal of Economic Perspectives, 15*(3), 47–68.

Bizot, J., Le Bihan, C., Puech, A. J., Hamon, M., & Thiebot, M. (1999). Serotonin and tolerance to delay of reward in rats. *Psychopharmacology (Berl), 146*(4), 400–412.

Cardinal, R. N., Pennicott, D. R., Sugathapala, C. L., Robbins, T. W., & Everitt, B. J. (2001). Impulsive choice induced in rats by lesions of the nucleus accumbens core. *Science, 292*(5526), 2499–2501.

Ho, M. Y., Mobini, S., Chiang, T. J., Bradshaw, C. M., & Szabadi, E. (1999). Theory and method in the quantitative analysis of "Impulsive choice" behaviour: Implications for psychopharmacology. *Psychopharmacology (Berl), 146*(4), 362–372.

Ikeda, S. (2016). *The economics of self-destructive choices*. Berlin: Springer.

Laibson, D. (1997). Golden eggs and hyperbolic discounting. *Quarterly Journal of Economics, 112*(2), 443–477.

Lowenstein, G., & Prelec, D. (1992). Anomalies in intertemporal choice: Evidence and an interpretation. *Quarterly Journal of Economics, 107*(2), 443–477.

McClure, S. M., Laibson, D. I., Loewenstein, G., & Cohen, J. D. (2004). Separate neural systems value immediate and delayed monetary rewards. *Science, 306*(5695), 503–507.

Mobini, S., Body, S., Ho, M. Y., Bradshaw, C. M., Szabadi, E., Deakin, J. F., et al. (2002). Effects of lesions of the orbitofrontal cortex on sensitivity to delayed and probabilistic reinforcement. *Psychopharmacology (Berl), 160*(3), 290–298.

Mobini, S., Chiang, T. J., Ho, M. Y., Bradshaw, C. M., & Szabadi, E. (2000). Effects of central 5-hydroxytryptamine depletion on sensitivity to delayed and probabilistic reinforcement. *Psychopharmacology (Berl), 152*(4), 390–397.

Poulos, C. X., Parker, J. L., Le, A. D. (1996). Dexfenfluramine and 8-OH-DPAT modulate impulsivity in a delay-of-reward paradigm. implications for a correspondence with alcohol consumption. *Behavioral Pharmacology, 7*(4), 395–399.

Schweighofer, N., Bertin, M., Shishida, K., Okamoto, Y., Tanaka, S. C., Yamawaki, S., et al. (2008). Low-serotonin levels increase delayed reward discounting in humans. *The Journal of Neuroscience, the Official Journal of the Society for Neuroscience, 28*(21), 4528–4532.

Soubrie, P. (1986). Serotonergic neurons and behavior. *Journal of Pharmacology, 17*(2), 107–112.

Tanaka, S. C., Schweighofer, N., Asahi, S., Shishida, K., Okamoto, Y., Yamawaki, S., et al. (2007). Serotonin differentially regulates short- and long-term prediction of rewards in the ventral and dorsal striatum. *PLoS ONE, 2,* e1333.

Thaler, R. H. & Sunstein, C. R. (2008) *Nudge: Improving decisions about health, wealth, and happiness*. Baltimore: Penguin Books.

Wogar, M. A., Bradshaw, C. M., & Szabadi, E. (1993). Effect of lesions of the ascending 5-hydroxytryptaminergic pathways on choice between delayed reinforcers. *Psychopharmacology (Berl), 111*(2), 239–243.

Chapter 7
Learning Theory and Experiments in Neuroeconomics

Abstract Learning is an important factor in decision making under a novel or unstable environment. Reinforcement learning theory is a promising framework as a computational model of the brain in the process of the decision making in humans and animals. The hypothesis of dopamine in learning signals has been established by a huge amount of experimental evidence in animal neurophysiology and human imaging studies. The quest for the detailed neural mechanism of decision making is the first step to develop an economic theory that can explain real human behavior including individual preference.

Keywords Reinforcement learning · Prediction error · Reward circuit

In studies on economic decisions and behaviors, "learning" is an important keyword. On the other hand, in basic economic models, a consumer is assumed to have complete information about environments and to maximize his utility based on the information without any learning elements. In reality, we do not have complete information about the environments and need to learn from experience. For the purpose of theorizing such learning under the expected utility theory of traditional economics, the most logically natural way is to use the Bayesian learning theory in a sense.[1] For game theory analysis in experiments, Bayesian learning theory is complicated, and simpler reinforcement learning and brief learning (e.g., Cournot Learning, fictitious play) are often used. This chapter mainly explains reinforcement learning, which is widely used in psychology and neuroeconomics.

[1]For Bayesian learning (also called rational learning) in economics, see, e.g., a survey paper by Evans and Honkapohja (1999).

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7.1 Conditioning and Learning Theory

A series of experiments on conditioning with animals since the early twentieth century has verified effects of rewards. A Russian physiologist, Ivan Pavlov, found that after repeatedly ringing a bell before giving food to dogs, the animals began to salivate just by hearing the sound of the bell. This was later called *classical conditioning* or Pavlovian conditioning. Thorndike (1911) placed a cat in a cage that could be opened when the cat pressed a lever. After repeated trial and error a cat happened to press the lever, get out, and get food. Thorndike found that the cat gradually got out of the cage after a shorter period of trial and error with the lever. This was later called *instrumental conditioning*. Skinner (1938) formalized these conditionings, and defined the effect of reward as strengthening (reinforcing) the association between a stimulus and a response with a reward and causing the response to become more probable. In psychology, a reward is also called a reinforcer.

In the field of experimental psychology, research has been conducted to understand the functions of the brain. A series of learning theories of animals including effects of reward affected various fields. The learning theories of animals made important contributions to the development of artificial intelligence. One of them is *trial-and-error learning*. This originated from Thorndike's experiment mentioned above and creates a computer program that "intelligently" learns by trial and error like the cats in the experiment. Later, many algorithms have been proposed to realize functions of human and animal learning theory in artificial intelligence, especially in the field called machine learning. Among these, *reinforcement learning theory* is especially prominent as a computational model of the brain that is related to human and animal decision making (Sutton and Barto 1998). This is to learn a behavioral rule that maximizes the sum of rewards in the future by trial and error. Reinforcement learning can be interpreted as a computational framework for instrumental learning under an ideal environment.

7.2 Reinforcement Learning Theory

For example, how do we evaluate the restaurants we visited? When we first visit a restaurant, we do not have any experience with the tastes of their food (namely, we cannot predict), and we evaluate how good the food is. On the other hand, at restaurants we frequently visit, we can evaluate the difference from our predictions like "this is not good as usual." If such a negative prediction error continues, then we will lower the evaluation of the restaurant, and will not visit the restaurant anymore.

This process of evaluation can be explained by the reinforcement learning theory. In this theory, there exist two concepts: environment and agent. For example, in a card game, the game's rules and the opponent are the environment and you yourself is the agent. The agent at time t takes action $a(t)$ toward the state $s(t)$ given by the environment. Then the environment gives the reward $r(t)$ and the state transitions into the next state $s(t+1)$. In this environment, the agent (a human or a robot) learns behavior that maximizes the expected sum of the rewards over time. The expected sum of the rewards is called the e*xpected reward*, or the *value function*. At time t with state $s(t)$, the expected reward is defined as

$$V(s(t)) = E\left[r(t) + \delta r(t+1) + \delta^2 r(\mathrm{t}+2) + \ldots\right]$$

$$\begin{aligned}(\text{Present value}) = {} & (\text{Present reward}) + \delta \times (\text{reward in one period}) \\ & + \delta^2 \times (\text{reward in two periods}) + \ldots\end{aligned}$$

Here, the future reward is discounted by the discount factor δ $(0 < \delta < 1)$. Namely, the further in the future that the reward is expected, the less value is estimated for the reward. This is the concept of time preferences explained in Chap. 6.

The temporal difference of the value function is called the *reward prediction error*:

$$\varepsilon(t) = r(t) + \delta V(s(t+1)) - V(s(t))$$

$$(\text{reward prediction error}) = (\text{present value}) - (\text{value predicted in the last period})$$

The reward prediction error shows how much the present value deviates from the predicted value. When the agent learns the optimal strategy that maximizes the expected reward, the reward prediction error will eventually become zero. So this reward prediction error can be used as a learning signal. This is the representative method of the reinforcement learning theory. Namely, if the reward prediction error is positive, the strategy should be revised to increase the probability of taking the action. If the reward prediction error is negative, then the strategy is revised to decrease the probability of taking the action. This way, it is possible to learn the optimal strategy by trial and error without any knowledge of the environment.

7.3 Reinforcement Learning Theory as a Computational Model of the Brain

This reinforcement learning theory fascinates many researchers as a computational model of the brain in order to understand the brain function in the process of decision making in humans and animals. Dopamine, a neurotransmitter, is released from the dopaminergic neurons in the substantia nigra compacta and ventral tegmental area in the brain stem. Dysfunction of the dopaminergic system leads to

Parkinson disease inviting dyskinesia. Recently, the correlation of dopamine and reinforcement learning theory was demonstrated by several experiments. Schultz et al. reported that, in monkey neurophysiological experiments, the activity of dopamine neurons represented the reward prediction error of reinforcement learning (Schultz et al. 1997).

In the classical conditioning experiment, monkeys received a juice reward after a flashing light. In the early stage of the experiment, dopamine neurons were activated at the timing of receiving a juice reward. As the experiment proceeded, the dopamine neurons were activated strongly at the timing of lightning, although at the timing of receiving the juice the dopamine neurons were not activated. In addition, it was found that when the juice reward was omitted, the activity of dopamine neurons decreased at the timing of expecting the juice. This decreased activity of dopamine neurons can be explained as the negative reward prediction error. In the early stage of the experiment, the prediction was impossible, so the value of reward itself becomes the reward prediction error. This leads to the activity of dopamine neurons reacting to a juice reward itself. Along with the learning process, the light can make the animals predict obtaining the juice, or the positive reward prediction error. This also leads to the increase of activity of the dopamine neurons at the timing of the light. However, if the monkeys do not receive juice after the learning cue, the reward prediction error turns negative value. This fact illustrates the decrease of dopamine neuron activity at the time of missing the juice. Because they did not receive any reward, this may be interpreted as their disappointment in spite of their expectation.

There are mainly three phases in this reinforcement learning: (1) evaluation, (2) action selection based on the evaluation, and (3) the computation of prediction error and updating the evaluation. Each stage is well tested in the following brain parts linking to others:

(1) Evaluation: frontal lobe, parietal lobe, striatum
(2) Behavior selection: the brain structures of evaluation and/or areas receive those projections
(3) The computation of prediction error and updating the value: the dopaminergic system and/or areas receive those projections.

This approach, to reveal the neural mechanism of action learning and decision making in humans and animals based on the computational models of the brain, is one of the research areas of *computational neuroscience*. The foundation of this approach was adapted to neuroeconomics recently.

7.4 Neural Mechanism of Prediction Error

The research of neuroscience based on the computational model of decision making such as reinforcement learning is often categorized in neuroeconomics now. In this section, we introduce several studies on fMRI experiment of human subjects.

McClure et al. examined the brain activity reflecting prediction error by fMRI, using a classical conditioning paradigm (McClure et al. 2003). Before entering the MRI scanner, all the participants had a training task to receive a reward several seconds after they saw some stimuli on a computer display. After this preparatory stage, the researchers considered the conditioning to be completed. After this training, participants entered the MRI scanner and had another experimental task. The following task included an unexpected trial in which the reward was delayed comparatively later than the trials in the training task. What would happen to them in this unexpected trial? When the reward in the following task was not given at the expected timing as in the training task, a negative prediction error should occur. On the other hand, when the delayed reward was given, a positive prediction error should have occurred. Based on this hypothesis, they tested the brain activities at the timing of those positive and negative prediction errors and found that the activity of striatum reflected the prediction error. In other words, at the timing that the negative prediction error occurred, the activity of the striatum decreased, and at the timing of the positive prediction error, the activity of the striatum increased.

Additionally, O'Doherty et al. examined the brain activity measured by fMRI reflecting the prediction error, using a classical conditioning paradigm (O'Doherty et al. 2003). In the MRI experiment, the participants were required to choose one of two figures shown on the computer display. Upon choosing each figure a different amount of reward was given. None of the participants knew how much the reward would be given based on their choice, so everyone had to learn the relationship between the figures and the reward through trial-and-error. During this learning process, the brain activity was measured to examine the assumption of the change in the prediction error and its linkage to brain activity. As a result, they found a significant correlation between the prediction error and the activities of the striatum and frontal lobe.

7.5 Time Discount and Brain Structure in Reinforcement Learning

The value function of reinforcement includes the concept of discount preference in Chap. 6. Here we will see how the computation of value and behavior can be transformed by the rate of discount with several examples. In both of exponential and hyperbolic discounting the basic idea is the same. In the problem that a large reward comes after a small punishment as in Fig. 7.1a, in the case of the discount rate $\delta = 0.3$, the weight of the future reward declines rapidly. Therefore, the weight to the large reward at $t = 4$ is smaller and the weights to the punishment at $t =$ 1,2,3 are bigger. The value in the $t = 1$ turns to be $V = -20 + 0.3 \times (-20) + 0.3^2 \times (-20) + 0.3^3 \times 100 = -25.1$, which is negative value. If so, the agent's strategy in this problem should be "it is better not to do." On the other hand, in case the $\delta = 0.9$, because the weight to the future reward cannot decrease so rapidly, the

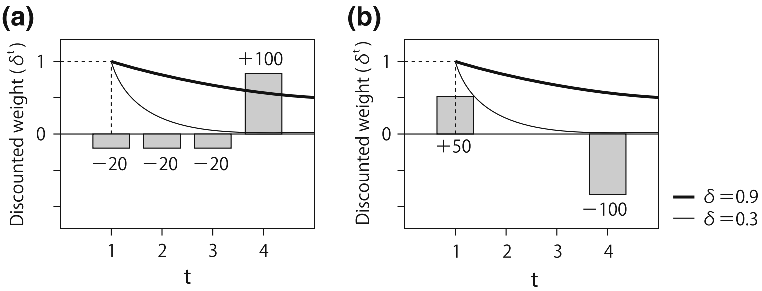

Fig. 7.1 The effect of the discount rate on the behavior of the reinforcement learning agent. **a** A case where a large reward comes after a small punishment and **b** a case where a large punishment comes after the reward. When the value of the discount rate is small, the weight for the immediate reward is large. Thus the agent cannot take the optimal action that maximizes total outcome in either case

value is positive as $V = 18.7$, and this "lose a fly to catch a trout" action should be chosen. Moreover, in the problem that large punishment comes after the reward as in Fig. 7.1b, if the value of δ is small ($\delta = 0.3$), the value will be positive ($V = 47.3$), so it will be the action of "doing without deep thinking". However, if δ is large ($\delta = 0.9$), the value will be negative ($V = -22.9$), so the actor's judgment can be "avoiding the risk." Thus, discount rate δ is small and the action could have an aspect of "impulsive.".

Tanaka et al. measured the brain activity by fMRI using a learning paradigm with a dynamic state transition (Tanaka et al. 2004). Each of 20 participants performed an experimental task in an MRI scanner. The task was that after selecting a figure among three in the display by pressing either a left or right button, its own reward and the different figure was displayed (Fig. 7.2a).[2] The participants had to learn the rule of state transition and figure–action–reward mapping by trial and error and acquire as much reward as possible. In the condition of short-term reward prediction (SHORT condition in Fig. 7.2b), the participants simply had to learn to press the button to provide a larger reward at the time of choosing a figure. On the other hand, in order to draw a figure that gave a larger positive reward in the condition of long-term reward prediction (LONG condition in Fig. 7.2b), first of all participants had to choose the button that gave a small negative reward and then the larger positive reward. This means that if they were obsessed with the immediate reward, they would miss the right action in the long run. In these two conditions, the researcher requested the participants to learn the optimal actions maximizing the total outcome, and compared their brain activities in both conditions. As a result, in short-term reward prediction, activities increased in the ventral parts of the frontal lobe and in a part of the basal ganglia; and in the condition of long-term reward

[2]The technical term is "Markovian decision problem.".

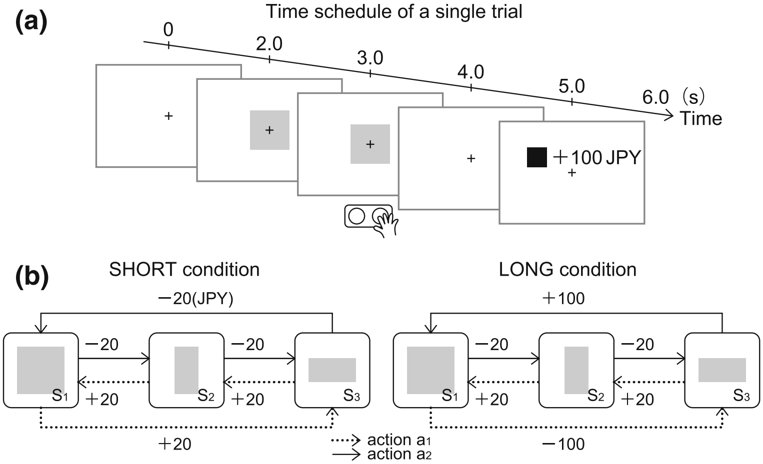

Fig. 7.2 **a** Sequences of stimulus and response events in the experimental task. In each trial step, a fixation point is presented on the screen, and after 2 s, one of three figures (*square, vertical rectangle*, and *horizontal rectangle*) is presented. As the fixation point vanishes after 1 s, the subject presses either the right or left button within 1 s. After a short delay (1 s), a reward for the current action is presented by a number and the past cumulative reward is shown by a bar graph. Thus, one trial takes 6 s. **b** The rules of the reward and state transition for action a_1 (*dotted arrow*) and action a_2 (*line arrow*) in the SHORT and LONG conditions. The small reward r_1 is either 10, 20, or 30 yen, with equal probability, and the large reward r_2 is either 90, 100, or 110 yen. The rule of state transition is the same for all conditions; $s_3 \to s_2 \to s_1 \to s_3 \ldots$ for action a_1, and $s_1 \to s_2 \to s_3 \to s_1 \to \ldots$ for action a_2. Although the optimal behaviors are opposite (SHORT: a_1, LONG: a_2), the expected cumulative reward during one cycle of the optimal behavior is 60 yen in both the SHORT (+20 × 3) and LONG (−20 − 20 + 100) conditions (*source* Tanaka et al. 2004)

prediction, activities increased in the lateral frontal lobe, parietal lobe, basal ganglia, amygdala, and the brain stem.

Next, in order to examine how each part of the brain is involved in reward prediction with a different timescale, the researchers analyzed the brain activity data based on the reinforcement learning model. As a result, they found a map of brain activity correlating to reward prediction value from short- to long-term scale in the insular cortex (Fig. 7.3, left). They also found an activity map of correlating reward prediction error in a short- to long-term scale in the striatum that is an input area of the basal ganglia, specifically, from its ventral region to dorsal region (Fig. 7.3, right). This result is consistent with the anatomical finding that there are topographical connections between the insular cortex and the striatum (Chikama et al. 1997). The result of this experiment suggests that the neural networks including the ventral striatum associating emotion links to the short-term reward prediction, and the networks including the dorsal striatum associating higher cognitive functions are involved in the long-term reward prediction. In other words, the functional segregation in the timescale of these networks is indicated. The presence of these networks is consistent with the findings shown by McClure et al. in Chap. 6.

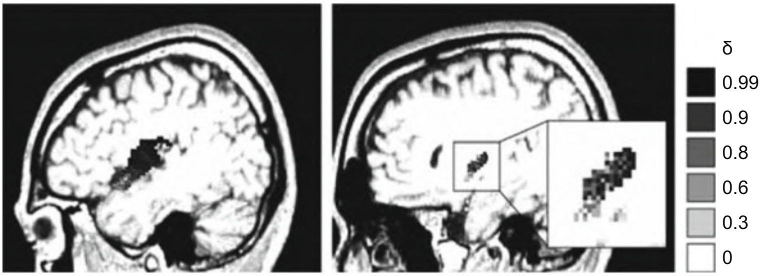

Fig. 7.3 Voxels with a significant correlation (height threshold of $p < 0.001$, uncorrected; extent threshold of 4 voxels) with reward prediction and prediction error are shown in different gray scales for different settings of the discount factor δ. Voxels correlated with two or more regressors are shown by a mosaic of colors. Significant correlation with reward prediction in the insula (*left*). Significant correlation with reward prediction error restricted to a region of interest of the striatum (*right* slice at white line in *horizontal* slice at z = 2 mm). Note the ventroanterior to dorsoposterior gradient with the increase in discount rate δ both in the insula and the striatum (*source* Tanaka et al. 2004)

7.6 Summary and Further Reading

"Learning" is an important factor in decision making under a novel or unstable environment. Reinforcement learning theory is a promising framework as a computational model of the brain in the process of the decision making in humans and animals. The hypothesis of dopamine in learning signals has been established by huge experimental evidence in animal neurophysiology and human imaging studies. The quest for the detailed neural mechanism of decision making is the first step to develop an economic theory that can explain real human behavior including individual preference.

Many outstanding studies demonstrating the neural mechanism of decision making based on reinforcement learning can be found in *Neuroeconomics* (Glimcher et al. 2013) including both human and non-human animal studies. However, this research area is continually advancing, thus a good way to follow the latest findings is to use a search engine for academic journals.

7.7 Questions and Problems

7.7.1 Multiple-Choice Problems

In reinforcement learning, let $\varepsilon(t) = r(t) + \delta V(s(t+1)) - V(s(t))$ be the reward prediction error. Let $r(t)$ be the reward received in period t, δ be the discount factor, $s(t)$ be the state in period t, and $V(s(t))$ be the value function when $s(t)$ is the state.

Choose the most appropriate answer when the reward prediction error is used as a learning signal.

(A) If $\varepsilon(t+1) < 0$, then the action taken can be considered favorable, and the strategy should be revised to increase the probability of taking the action.
(B) If $\varepsilon(t+1) > 0$, then the action taken can be considered favorable, and the strategy should be revised to increase the probability of taking the action.
(C) If $\varepsilon(t+1) = 0$, then the action taken can be considered favorable, and the strategy should be revised to increase the probability of taking the action.
(D) If $\varepsilon(t+1) = 0$, then there is no prediction error, and the strategy should not be revised.
(E) A and C
(F) A and D
(G) B and C
(H) B and D

7.7.2 Discussion Questions

1. Describe your personal experiences that are consistent with reinforcement learning theory.
2. In each of your experiences in the previous question, describe your reward prediction error and how you changed your behavior in response to the error.

References

Chikama, M., McFarland, N. R., Amaral, D. G., & Haber, S. N. (1997). Insular cortical projections to functional regions of the striatum correlate with cortical cytoarchitectonic organization in the primate. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience, 17*(24), 9686–9705.

Evans, G. W., & Honkapohja, S. (1999). Learning dynamics. In Taylor, J. B., & Woodford, M (Eds.), *Handbook of macroeconomics, Volume 1*. Amsterdam: Elsevier.

Glimcher, P. W., & Fehr, E. (2013). *Neuroeconomics decision making and the brain* (2nd ed.). Amsterdam; Boston: Elsevier/Academic Press.

McClure, S. M., Berns, G. S., & Montague, P. R. (2003). Temporal prediction errors in a passive learning task activate human striatum. *Neuron, 38,* 339–346.

O'Doherty, J. P., Dayan, P., Friston, K., Critchley, H., & Dolan, R. J. (2003). Temporal difference models and reward-related learning in the human brain. *Neuron, 38*(2), 329–337.

Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. *Science, 275*(5306), 1593–1599.

Skinner, B. F. (1938). *The behavior of organisms: An experimental analysis*. Cambridge, Massachusetts: B.F. Skinner Foundation.

Sutton, R. S., & Barto, A. G. (1998). Reinforcement learning. Cambridge: MIT Press.

Tanaka, S. C., Doya, K., Okada, G., Ueda, K., Okamoto, Y., & Yamawaki, S. (2004). Prediction of immediate and future rewards differentially recruits cortico-basal ganglia loops. *Nature Neuroscience, 7*(8), 887–893.

Thorndike, E. L. (1911). *Animal intelligence; experimental studies*. New York: The Macmillan Company.

Chapter 8
Social Preferences

Abstract There are many experiment results that seem to indicate the necessity of considering social preferences models such as the inequality aversion model. There are also many experiment results that can be explained very well with the models with selfish economic men when competition is introduced. The inequality aversion model explains results of both of these categories of experiments.

Keywords Social preferences · Public goods game · Trust game
Double auction · Inequality aversion model

As explained in Chap. 1 with experiments for the ultimatum and dictator games, many people do not behave thinking exclusively about their own consumption and leisure. In the real world, which is different from special situations in laboratory experiments, many people make donations and volunteer for strangers when there are major disasters such as earthquakes and tsunami. The mainstream method to explain altruistic behaviors in behavioral economics is to use models with preferences that are not selfish.[1] If arguments of a utility function that represents an individual's preferences include not only his own consumption and leisure (or payoffs in the context of the game theory) but also other people's consumption and leisure (or payoffs), his preferences are *social preferences* or other-regarding preferences.[2] In contrast, the standard model in traditional economics assumes that each economic agent is a selfish economic man whose utility functions' arguments include only his own consumption and leisure. When we consider models of social preferences, an important fact is that many experiments for market transactions yield results that can be adequately explained by models that assume selfish economic men while other experiments such as ultimatum and dictator games yield

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[1]As we will see in Chap. 9, we can also explain altruistic behaviors by norms or worldviews of groups. These theories can be used either as substitutes or complements for the theory of social preferences.

[2]It should be noted that social preferences explained in this chapter and the social welfare function explained in Chap. 11 are totally different concepts. The social welfare function evaluates the welfare of a society rather than the welfare of an individual.

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results that cannot be explained by such models. Therefore, models of social preferences should simultaneously explain altruistic behaviors in dictator games and selfish behaviors in market experiments. In this chapter we will explain these experimental results that seem to be contradictory in terms of altruism, and models of social preferences that can simultaneously explain them.

The mainstream model of social preferences in current behavioral economics is the inequality aversion model developed by Fehr and Schmidt (1999) and Bolton and Ockenfels (2000). This model can explain not only altruistic behaviors but also why altruistic behaviors disappear in market experiments. In this model, preferences are exogenously given and stable, and depend only on consequences of actions. This model is a special case of economic externalities that have been analyzed in traditional economics. Therefore, the market and game theory equilibria can be analyzed by the same methods as in traditional economics.

When economic externalities are considered in traditional economics, however, the attention has been limited to externalities that "selfish" people normally have such as altruism toward one's own descendants, the satisfaction that gardens give to people other than their owners, and dissatisfaction and health damages from secondhand smoke to non-smokers. The main attention of social preferences in behavioral economics is on a broader sense of externalities. Moreover, models of social preferences have been developed in which preferences depend on intentions behind other people's behaviors or on types of other people. These models clearly deviate from the framework of traditional economics in which economic men's preferences depend only on consequences of actions.

8.1 Evidence for Social Preferences

Many experiments including ultimatum and dictator games show that many people are not only concerned about their own material satisfaction but also about the material satisfaction of other people including people they do not know who happen to participate in the same experiment as they do. These experiments also show that people are not the same in this respect. Some people show strong interest in other people's payoffs while others show little or no interest. This section explains experiments other than ultimatum and dictator games that can be interpreted as evidence for social preferences.

Results that show participants' interests in other participants' payoffs are robust, and are not restricted to the laboratory experiments for students with small payoffs. For example, similar results are obtained for payoffs that are large compared with available daily wage rates in developing countries. As we saw in Chap. 1 for ultimatum and dictator games, proposers seem to have some altruistic motives. Rejecting low proposals by responders in ultimatum games, however, are not from altruistic motives but from retaliatory motives. A selfish economic man has neither altruistic nor retaliatory motives.

8.1.1 Public Goods Game

The theory of traditional economics predicts that public goods such as parks and national defense will not be provided voluntarily in markets. This is because of two properties of public goods. First, public goods are non-excludable: Once a public good is provided, then individuals cannot be effectively excluded from its use. Second, public goods are non-rival: use by one individual does not reduce availability to others. Because of these two properties, each potential beneficiary has an incentive to receive benefits without bearing any cost by relying on other people who bear the cost. This is the *free-rider* problem. For example, the prisoner dilemma game can be viewed as a special case of the public goods game in which there are only two players. This can be easily seen in the environment protection game that has the same structure as the prisoner dilemma game explained in Chap. 1. In the environment protection game, the environment is the public good. Each country has an incentive to free-ride on another country's contribution to environment protection. In the theoretical prediction of traditional economics, all countries will selfishly try to free-ride, and no country will make any contribution to environment protection.

In order to test these predictions by the theory of traditional economics, many experiments of voluntary contributions for public goods have been conducted. Here, we explain a standard public goods game with N players. Each participant is told that she has an initial endowment of a certain amount, say 20 tokens (a token serves as a unit of money in an experiment), in her private account. Because the collected tokens in a private account will be converted into cash by an exchange rate such as 1 token is 10 cents at the end of the experiment, participants have incentives to collect more tokens. Each participant makes a decision on how many tokens to contribute to the public account. When a participant makes a contribution to the public account, each of the participants (including herself) receives a private return of α token ($0 < \alpha < 1 < N\alpha$) per 1 token contribution to the public account at the end of the experiment session. For example, suppose that $N = 4$ and $\alpha = 0.4$. When one participant contributes 10 tokens and no other participant contirbutes any token, each of the four participants receives $10 \times 0.4 = 4$ tokens as a result. The group as a whole receives 16 tokens. As another example, if every participant makes a contribution of 20 tokens, then each one receives 32 tokens, but if only one participant makes a contribution of 20 tokens and no other participant makes any contribution, then each one receives 8 tokens from the public account.

If we assume that each participant is a selfish economic man, then the only Nash equilibrium for this game is that no player makes any contribution, and receives 20 tokens. Namely, every player has an incentive to free-ride, and the theoretical prediction of the theory of free-riding in traditional economics is that no one will contribute to the public account at all.

Andreoni (1988) summarizes three types of robust results in many public goods game experiments. First, in single-shot games, participants generally contribute to the public account at levels much greater than the free-riding level. Second, when participants play a repeated game, a typical contribution decays toward the free-riding level with each repetition. Third, free-riding is often approximated after participants play several trials.

From traditional economics, a possible explanation for these results is a *learning hypothesis*. This hypothesis states that participants do not clearly understand the structure of the game when they merely listen to the explanation by the experimenter, but that they learn it as they become more experienced. According to this hypothesis, the average contribution rate declines as rounds are repeated because their strategies gradually converge to the optimal strategies as they continue to learn the structure of the game. Andreoni (1988) tested this hypothesis by a procedure he called "restart." After the 10th round is over, a new set of 10 rounds were unexpectedly announced to restart. The average contribution rates were high in the first round in the setting of the same members in each group. This result cannot be explained by the learning hypothesis. Hence other explanations such as social preferences are necessary.

Fehr and Gächter (2000) introduced punishment to the standard public goods game. Every player has an opportunity to punish any other player. In their setting, the punishment is costly. If a player punishes, then she needs to pay a cost that increases with the amount of punishment. A selfish economic man does not have any incentive to implement costly punishment. Hence the theory of free-riding predicts no change in the results with or without punishment. In the actual experiments, however, the average contribution rate was higher in the experiment with punishment than that without punishment. In addition, the average contribution rate did not show the decay phenomenon in the experiments with punishment. It seems that the average contribution rate is higher with punishment because some players punish free-riders. The participants of the experiments were students of the University of Zurich. In later research for international comparisons, some of their results were robust and others were not for many countries, as we will explain in Chap. 9.

8.1.2 Trust Game

In the *trust game*, Player 1 can make an investment by sending money to Player 2. Player 2 can voluntarily return some money to Player1 but can choose to return no money. In Berg et al. (1995), who designed this game, the experiment was conducted as follows. Each of the participants in Rooms A and B receive 10 dollars as a show-up fee. The participants in Room A must decide how much of their 10 dollars to send to an anonymous counterpart in room B. The amount sent is then tripled and is given to the counterpart in room B. The counterpart must decide how much money to return.

According to the theory of traditional economics, an economic man as Player 2 is predicted to return no money. Then, expecting that no money will be returned from Player 2, Player 1 is predicted to invest no money. In actual experiments, many participants as Player 1 make an investment, expecting that some money will be returned. Most participants as Player 2 do return money.

8.2 Market Experiments

This section explains results from market experiments that can be readily explained by models of traditional economics with the selfish economic man assumption in contrast with the results in the last section. Chamberlin (1948) and Smith (1962, 1964) started market experiments with an imaginary good. A potential seller of an imaginary good was told the dollar amount that would be subtracted from his account if he sold one unit of the good (which we call the cost per unit). A potential buyer of an imaginary good was told an amount that the experimenters would pay him if he bought one unit of the good (which we call the value). This design motivated buyers and sellers to buy and sell the imaginary good. We will first focus on a simple case in which a buyer or a seller dealt with only one unit of the good in the experiments of Chamberlin and Smith.

In Chamberlin's experiment, students looked for a partner with whom to trade an imaginary good within a few minutes, and negotiated the price. Typical results from Chamberlin's experiment were far from the market equilibrium predicted by the theory of traditional economics. There were two typical main results. First, the prices in the experiment were far from the equilibrium price. Second, the numbers of goods traded in the experiment were greater than the number predicted from the equilibrium quantity.

Smith's insight was that these results were mainly to the fact that information about prices was not public, so Smith (1962, 1964) made two important modifications to Chamberlin's experiment. First, Smith repeated several practice rounds with the same participants, so that they could learn from experience. Second, Smith used an auction method called the double auction. In the double auction, a buyer makes an offer (which is called an bid) to buy at a stated price, and the price is publicized to the participants. A seller can accept this offer. A seller makes an offer to sell at a stated price, and the price is publicized to the participants. A buyer can accept this offer. Smith showed that the market equilibrium is approximately achieved when the double auction is used for experienced participants in his experiments.

We will explain the experiment procedure used in Smith (1964). The participants were students enrolled in sophomore-level courses in economics.[3] If a participant received a white card, he became a seller who owned one unit of the imaginary good in the experiment (the sales limit was one). The number written on this card was the cost per unit for the seller. The number was known only by the participant

[3]In the current U.S. ethical rules, there is a principle of voluntary participation for experiments for research purposes. Participating in classroom experiments is often interpreted as compulsory by students, and in general is not permitted because of this principle.

who received the card. Various costs were given to different participants. If a participant received a yellow card, he became a buyer with the purchase limit of one. The number written on this card was the value of the imaginary good for the participant. WTP explained in Chap. 1 coincides with the value. The number was known only by the participant who received the card. Various values were given to different participants.

For this experimental design, we can use the market equilibrium theory in traditional economics to predict the equilibrium price and quantity under the assumption of perfect competition that no individual participant can affect the market price (see Appendix 1). In the experiment of Smith (1964), five rounds of market transactions were conducted.[4] In his experiment results, observed transaction prices were far from the predicted price in the first round of transactions while the transaction prices in the fourth and fifth rounds were close to or even at the predicted price.

The standardized method of double auction that has developed following Smith's experiments is explained in Plott (1982). In the experiment of Holt et al. (1986), this standardized method was used, but the experimental designs for the costs and values were different from Smith's. The important aspect of the experiment of Holt et al. for the purpose of this chapter is that the theoretical prediction of the results implies an extreme inequality among the buyers and sellers in one of their experimental designs.

In this experimental design, all sellers were given the same cost per unit (5.70 dollars) and all buyers were given the same value (6.80 dollars). In addition, each of them was able to buy or sell more than one unit of the good up to certain specified maximum numbers of transactions per participant. Under this experimental design, there were two different settings. Depending on the setting, the experiment sessions were called the first and second weeks. The difference between the first and second weeks was the specifications of the maximum numbers of transactions. Table 8.1 summarizes this difference. In Week 1, the maximum number of transactions for each of three of the four sellers was three, while that for one seller was two. For the market as a whole, the maximum number of the good that could be supplied was 11. Each of the four buyers was given the value of 6.80 dollars and the maximum number of transactions was four. For the market as a whole, the maximum number of the good that could be demanded was 16. In Week 2, the maximum number of transactions for each of the four sellers was four. For the market as a whole, the maximum number of the good that could be supplied was 16. The maximum number of transactions for each of three of the four buyers was three, and that for one buyer was two. For the market as a whole, the maximum number of the good that could be demanded was 11.

Let us use the market equilibrium theory of traditional economics under the perfect competition assumption in order to find out the predicted values of the price and quantity for this experiment. First, we derive the market supply curve. For each

[4]For comparisons, six rounds of market transactions were conducted in one group.

Table 8.1 The experiment setting of Holt et al. (1986). The maximum number of goods for transactions. *Source* Ogaki and Tanaka (2014)

	First	Second	Third	Fourth	Market
Week 1					
Seller	3	3	3	2	11
Buyer	4	4	4	4	16
Week 2					
Seller	4	4	4	4	16
Buyer	3	3	3	2	11

seller, the cost per unit is WTA. Hence a seller does not wish to sell the good if the price is lower than 5.70 dollars. When the price is higher than 5.70 dollars, then the seller wishes to sell as many units as possible. When the price is exactly 5.70 dollars, a seller is indifferent between selling and not selling the good. The market supply at each price level is the sum of these individual supplies of all sellers. The market supply curve is obtained by calculating the market supply for various price levels. If the price is lower than 5.70 dollars, then the market supply is zero. If the price is higher than 5.70 dollars, then the market supply is equal to the maximum number of the good that can be supplied to the market (11 in Week 1, and 16 in Week 2). If the price is exactly 5.70 dollars, then the market supply is any number between zero and this maximum number.[5]

In Fig. 8.1, the market supply curve in Week 1 is displayed as solid line S. The market supply curve is infinitely elastic and horizontal at the price of 5.70 dollars for the quantity between 0 and 11. When the quantity reaches 11, however, the market supply curve is vertical for the price which is higher than or equal to 5.70 dollars because the supply cannot exceed 11. In Fig. 8.2, the market supply curve in Week 2 is displayed as solid line S. The market supply curve is infinitely elastic and horizontal at the price of 5.70 dollars for the quantity between 0 and 16 in this case. When the quantity reaches 16, however, the market supply curve is vertical for the price which is higher than or equal to 5.70 dollars because the supply cannot exceed 16.

Second, we derive the market demand curve. For each buyer, the value is WTP. Hence a buyer does not wish to buy the good if the price is higher than 6.80 dollars. When the price is lower than 6.80 dollars, the buyer wishes to buy as many units as possible. When the price is exactly 6.80 dollars, a buyer is indifferent between buying and not buying the good. The market demand at each price level is the sum of these individual demands from all buyers. The market demand curve is obtained by calculating the market demand for various price levels. If the price is lower than 6.80 dollars, the market demand is zero. If the price is lower than 6.80 dollars, then the market demand is equal to the maximum number of the good that can be demanded to the market (16 in Week 1 and 11 in Week 2). If the price is

[5]Strictly speaking, the market demand and supply quantities in this experiment are natural numbers, but we draw curves as if they are real numbers.

Fig. 8.1 Market equilibrium in Week 1

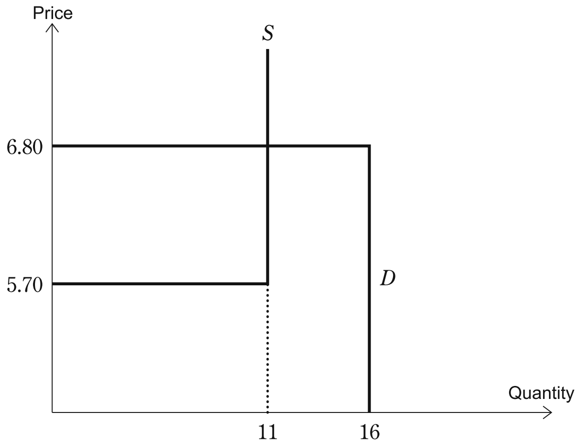
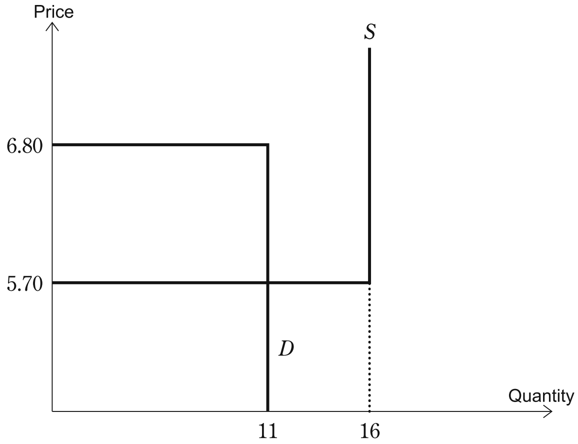


Fig. 8.2 Market equilibrium in Week 2



exactly 6.80 dollars, then the market demand is any number between 0 and this maximum number.[6]

In Fig. 8.1, the market demand curve in Week 1 is displayed as solid line D. The market demand curve is infinitely elastic and horizontal at the price of 6.80 dollars for the quantity between 0 and 16. When the quantity reaches 16, however, the market demand curve is vertical for the price which is lower than or equal to 6.80 dollars because the demand cannot exceed 16. In Fig. 8.2, the market demand curve in Week 2 is displayed as solid line D. The market demand curve is infinitely elastic and horizontal at the price of 6.80 dollars for the quantity between 0 and 11 in this case. When the quantity reaches 11, however, the market demand curve is vertical

[6]Strictly speaking, the market demand and supply quantities in this experiment are natural numbers, but we draw curves as if they are real numbers.

for the price which is lower than or equal to 6.80 dollars because the demand cannot exceed 11.

The market equilibrium price is obtained by the price on the vertical axis at the intersection of the market supply and demand curves. As shown in Fig. 8.1, it is 6.80 dollars in Week 1 and it is 5.70 dollars in Week 2. For the purpose of this chapter, what is important is the difference in profits that the sellers and buyers obtain. When the market demand is higher at the equilibrium price than the maximum level of supply as in Week 1, only the sellers obtain profits from market transactions, and the buyers obtain no profit. When the market supply is higher at the equilibrium price than the maximum level of demand as in Week 2, only the buyers obtain profits from market transactions, and the sellers obtain no profit. There are the predictions by the market equilibrium theory.

The experiment results were approximately as predicted after several rounds. Thus this experiment generated extreme inequality in its results just as predicted by the market equilibrium theory.

8.3 Introduction of Competition into the Ultimatum Game

Roth et al. (1991) introduced competition into the ultimatum game. They called this version the market setting. In their market setting, more than one proposers make offers to one responder. The responder makes a decision to either accept or reject the highest offer. The other offers are automatically rejected. Roth et al. conducted their experiments in Israel, Japan, the United States, and what was then Yugoslavia. In their experiment, 10 rounds were repeated for each session. In all four countries, the highest offer rate quickly converged to 100%. This meant that almost all profits went to the responder, and every proposer got almost no profit. Thus this experiment setting also generated extreme inequality in its results as in the market experiment of Holt et al. (1986) explained above.

Güth et al. (1997) introduced competition to the responders in the ultimatum game. In their experiment setting, one proposer made offers to five responders. Each responder chose a cutoff level, below which he rejected the offer. If multiple responders chose cutoff levels that were below the proposer's offer, then one of them was randomly chosen. Once one responder was chosen, the payoffs for the proposer and that responder were determined just as in the standard ultimatum game for two players. After five rounds in their experiment, the average cutoff rate was below 5%, and 71% of the responders set their cutoff level to zero. Thus, people reject unfair offers in the standard ultimatum game but accept them under competition.

8.4 Models of Social Preferences

Many people seem to have concerns about inequality in the participants' payoffs in some experiments, as we saw in Sect. 8.2, but behave as if they have little or no concerns about such inequality in other experiments as we saw in Sect. 8.3. Many models of social preference have been proposed to simultaneously explain these results. There are three broad types of the models: *intention-based social preferences*, *type-dependent social preferences*, and *outcome-based social preferences*. Rabin's (1993) model is an example of intention-based social preferences in which preferences of an individual depend on the intentions of other individuals. When an individual believes that a particular individual has kind intentions toward him, his utility becomes higher as he behaves more kindly toward this particular individual. On the other hand, when he believes that a particular individual has hostile intentions toward him, his utility becomes higher as he behaves less kindly toward this particular individual. Levine (1998) is an example of type-dependent social preferences in which preferences depend on types of other individuals. When an individual believes that a particular individual is altruistic, his utility becomes higher as this particular individual's utility becomes higher. On the other hand, when an individual believes that a particular individual is spiteful, his utility becomes higher as this particular individual's utility become lower. In contrast, the models of outcome-based social preferences focus only on the outcome of consumption or payoffs of individuals rather than on intentions or types. There are merits and demerits of these three types of models. In this textbook, we will explain models of outcome-based social preferences which have been used most in research.

The models of outcome-based social preferences assume that the preferences depend only on the outcome of consumption or payoffs and not on processes such as intentions. Therefore, these models can be thought of as special cases of *externalities* that have been studied in traditional economics. When an individual's economic activities in consumption and production directly affect other individuals' preferences without thorough transactions, we say that there are externalities. For example, when an individual's tobacco consumption decreases other people's utilities, then we have externalities. For example, if altruism such as an individual's utility is higher when other individuals' utilities are higher in some models of outcome-based social preferences, it is an externality. Therefore, models of outcome-based social preferences are at the boundary of behavioral and traditional economics. In traditional economics, main objects of studies for externalities are altruism toward one's own children and those externalities felt even by selfish people such as displeasure when other people consume tobacco around them. In contrast, altruism toward strangers that explain experimental results is also among the main objects of studies in behavioral economics.

In traditional economics, the pure altruism model by Barro (1974) and Becker (1974) is a particularly important model of outcome-based social preferences. In the pure altruism model, arguments of an individual's utility function are the levels of other individuals' utilities. For example, a typical application of the pure altruism model is an intergenerational altruism model of a parent toward his child. Let the parent's utility function be U, the child's utility function be V, the parent's consumption be C_0, the child's consumption be C_1 and

$$U(C_0, V(C_1))$$

be the parent's utility function.[7]

Here, let us see if the pure altruism model can explain the experimental results described in this textbook if we apply it to the altruism of a participant in an experiment toward a stranger rather than toward his own child. Let the participant's utility function be U, the stranger's (who happens to be the partner in the experiment) be V, the participant's payoff be C_0,the stranger's payoff be C_1, and

$$U(C_0, V(C_1))$$

be the participant's utility function. This model can explain the altruistic behavior of many participants in the dictator game but cannot explain the behavior of many responders to reject offers in the ultimatum game.

A model of outcome-based social preferences that is closely related to the pure altruism model is the *warm glow model* of Andreoni (1989, 1990). In this model, an individual feels utility not only from other individuals' utilities as in the pure altruism model, but also from his own act of giving money per se. A casual look may give an impression that this model is not very different from the pure altruism model, but there are various important differences. An example is the Ricardian equivalence proposition, which is important for thinking about policies on government debt as explained in Chap. 11 below. This equivalence proposition holds in the pure altruism model, but does not hold in the warm glow model.

An outcome-based model that can simultaneously explain the results of dictator and ultimatum games and the results of games with competition that have been explained in this chapter is the *inequality aversion model* by Fehr and Schmidt (1999) and Bolton and Ockenfels (2000). There are important differences such as that Fehr and Schmidt use a linear utility function and Bolton and Ockenfels use a nonlinear utility function. In most applications, however, both theories yield similar results. For this reason, we will mainly explain the simpler theory of Fehr and Schmidt (FS, hereafter).

The purpose of the FS model is to give a unified explanation of various experimental results by introducing the idea of self-centered inequality aversion. Inequality aversion means that an individual's utility decreases when there is inequality in outcomes. Inequality aversion is self-centered if people are interested

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[7]In this model, if an argument of the child's utility function is the child's utility, then by thinking of the parent and all his descendants, one can derive the infinite-horizon utility function that is often used in macroeconomics.

only in the inequality of their own payoffs relative to the payoffs of others rather than inequality per se that exists among other people.

Let N be the number of participants in a game of an experiment and x_i be the payoff obtained by player i. The utility of player i depends not only on x_i but the payoffs obtained by the other players. Let the vector of the payoffs obtained by the other players be

$$x_{-i} = (x_1, x_2, \ldots, x_{i-1}, x_{i+1}, \ldots, x_N),$$

and the utility function of player i be[8]

$$\begin{aligned} U_i(x_i, x_{-i}) = x_i - \alpha_i \frac{1}{N-1} \sum_{j=1}^{N} max\{x_j - x_i, 0\} - \\ \beta_i \frac{1}{N-1} \sum_{j=1}^{N} max\{x_i - x_j, 0\} \end{aligned} \tag{8.1}$$

where parameters of the utility function, β_i and α_i satisfy the conditions

$$\beta_i \leq \alpha_i,\ 0 \leq \beta_i \leq 1.$$

In order to explain this FS model, we first consider the case of a game with two players ($N = 2$). In this case, the utility function is

$$U_i(x_i, x_{-i}) = x_i - \alpha_i max\{x_j - x_i, 0\} - \beta_i max\{x_j - x_i, 0\}. \tag{8.2}$$

In the case where there is disadvantageous inequality against player 1 ($x_2 > x_1$), his utility function is

$$U_1(x_1, x_2) = x_1 - \alpha_1(x_2 - x_1). \tag{8.3}$$

The first term on the right-hand side is the utility he obtains from his own payoff irrespective of inequality. The second term on the right-hand side measures the utility loss from disadvantageous inequality. A typical source of this loss is displeasure from envy. If x_2 is constant and x_1 increases, then the utility of player 1 increases not only from the increase of his own payoff but also from a decrease in disadvantageous inequality. If x_1 is constant and if x_2 increases by one unit, then the utility of player 1 decreases by α_1 units from an increase in disadvantageous inequality. Hence the value of α_1 measures the degree of player 1's displeasure for disadvantageous inequality. If α_1 is zero, then he does not feel any utility loss even in the presence of disadvantageous inequality. When the value of α_1 is large, then

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[8] *max{a,b}* is the larger number among the two numbers *a* and *b*.

the utility loss from disadvantageous inequality is large. It is conceivable that α_1 is larger than 1 for some people.

In the case where there is advantageous inequality against player 1 ($x_1 > x_2$), his utility function is

$$U_1(x_1, x_2) = x_1 - \beta_1(x_1 - x_2). \tag{8.4}$$

The first term on the right-hand side is the utility he obtains from his own payoff irrespective of inequality just as before. The second term on the right-hand side measures the utility loss from advantageous inequality. A typical source of this loss is guilt. If x_2 is constant and x_1 increases, then the utility of player 1 increases from the increase of his own payoff but decreases from a increase in disadvantageous inequality. If x_1 is constant and if x_2 increases by one unit, then the utility of player 1 increases by $(1 - \beta_1)$ units as the utility increases by one unit from an increase in his own payoff but decreases by β_1 units from an increase in advantageous inequality. Hence the value of β_1 measures the degree of player 1's displeasure at advantageous inequality. Because this is a model of inequality aversion, $\beta_1 \geq 0$ is assumed. If β_1 is 0, then he does not feel any utility loss even in the presence of advantageous inequality. When the value of β_1 is large, then the utility loss from advantageous inequality is large. If $\beta_1 > 1$, then his overall utility decreases as his own payoff increases. Because this is unlikely to happen, $\beta_1 \leq 1$ is imposed in the model as a condition. Because is it unlikely that anyone feels more displeasure from advantageous inequality than from disadvantageous inequality, it is assumed that $\beta_1 \leq \alpha_1$.

If $N > 2$, then both disadvantageous and advantageous inequalities can exist at the same time. If disadvantageous inequality exists for player i, then the parameter α_i is multiplied with the ratio of the total sum of the differences between the payoffs of the other players who have higher payoffs and his payoff to $(N - 1)$. If advantageous inequality exists for player i, then the parameter β_i is multiplied with the ratio of the total sum of the differences between his payoff and the payoffs of other players who have lower payoffs to $(N - 1)$. Because this is a model of inequality aversion, $\beta_i \geq 0$ is assumed. It is assumed that $\beta_i \leq 1$, so that player i's utility increases when his own payoff increases. Because is it unlikely that anyone feels more displeasure from advantageous inequality than from disadvantageous inequality, it is assumed that $\beta_i \leq \alpha_i$.

By assuming that different people have different values of the preference parameters α_i and β_i i, the FS model can provide a unified explanation to various behaviors observed in the experiments explained in this chapter. For an individual who offers zero payoff as the dictator to the recipient in the dictator game and makes zero contribution in the public goods game, we can assume that his utility function as player i satisfies $\alpha_i = \beta_i = 0$ so that he has a selfish economic man's utility function that does not show any concerns about other players' payoffs. In contrast, for an individual who chooses to give an equal payoff to the recipient in the dictator game, we can assume that she has a high value of β_i such as $\beta_i = 1$ so that she has strong aversion to advantageous inequality. Many people can be assumed to have intermediate values, $0 < \beta_i < 1$ and to dislike disadvantageous inequality at least as much as they dislike advantageous inequality. As a result, the FS model predicts they will reject unfair offers against them as responders.

Using the FS model, we can understand why people's behaviors do not reflect their inequality aversion when competition is introduced. Individuals whose preferences have inequality aversion may behave to decrease inequality if their individual behaviors affect the inequality. They, however, behave to maximize their own payoffs if their individual behaviors have no or little effect on the inequality (see Appendix 2 to this chapter).

Bolton and Ockenfels (2000) constructed their inequality aversion model around the same time as the FS model. Their model also explains various experimental results with and without competition. In their model, player *i*'s utility function is given by $x_j \geq 0$ ($j = 1, \ldots, N$)

$$\mathrm{v_i}(x_i, \sigma_i(x_i, x_{i-1}, N)) \tag{8.5}$$

$$\sigma_i = \begin{cases} \frac{x_i}{\sum_{j=1}^{N} x_i} & if \sum_{j=1}^{N} x_i > 0 \\ \frac{1}{N} & if \sum_{j=1}^{N} x_i = 0 \end{cases} \tag{8.6}$$

where σ_i is the share of the payoff of player *i* of the payoffs of all players. Here the utility function v_i is assumed to satisfy the following two conditions: given x_i, the utility is assumed to be maximized when $\sigma_i = 1/N$, and given σ_i, the utility increases or stays the same as x_i increases. The idea is that, for the case in which player *i* is obtaining a positive payoff, his utility is the highest when his payoff share is equal to $1/N$, which is the share he gets when every player receives an equal payoff. When his payoff deviates from $1/N$, his utility decreases.

Both the model of Bolton and Ockenfels (2000) and the FS model are models of outcome-based preferences with inequality aversion. These two models have similar theoretical predictions for most experiments. The essential difference between these two models is that player *i* compares his payoff with that of each of the other players in the FS model while player *i* compares his payoff with the average payoff of the group in Bolton and Ockenfels' model.[9]

8.5 Neuroeconomics on Social Preferences

In recent years, many studies have investigated the neural mechanism of social preferences. This field is one of the big pillars of neuroeconomics with subfields to study time preferences and decisions under uncertainty.

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[9]Falk et al. (2005) did a study that tested this difference of the two models.

8.5.1 Betrayal and Reward System in Trust Game

We first introduce the study on the neural mechanism at the time of betrayal in a trust game (de Quervain et al. 2004). In the experiment, volunteers play 7 games with 7 opponents through a display screen respectively. Because all 7 opponents are collaborators with the researchers, 3 of the 7 return the money to the volunteers, and the remaining 4 do not return the money at all, or steal the money. After the each match, the participants are interviewed about how much the opponents were fair or punishing. The brain activities of the participants are measured during the interviews by positron emission tomography (PET).

When punishing the opponents, the participants are given two kinds of additional information: Whether the opponents betrayed intentionally or not, and whether the punishment requires a cost or not. The brain activity was compared with these two conditions. Results showed that the striatum was activated strongly when they gave a real punishment to the intentional betrayal. Moreover, the striatum activities were significantly and positively correlated to the amount of real punishment. This shows that the bigger punishment the participants give, the stronger the activities of the striatum are. Since the striatum is a central component of the brain reward system, the experimental result suggests that giving punishment is similar to a reward. In contrast, the decision of punishment with payment involved the activities of the ventromedial prefrontal cortex (VMPFC), a part of the frontal lobe. Because this brain area is considered to relate to goal-directed behaviors, these experiments can lead to a conclusion that the VMPFC involves the trade-off between minus utility of punishing costs and positive utility of giving punishment.

8.5.2 Ultimatum Game and Unfairness

In an ultimatum game, we can get a profit by accepting any requests, even if they are the most ultimate and illogical requests. Therefore, rejects are considered to happen when minus utilities with unfair requests from the opponents exceed the positive utility with the profits. If so, what is going on in the brain?

Sanfey et al. measured brain activities by fMRI when the opponents made an unfair request and found that specifically the insular cortex and the dorsolateral prefrontal cortex (DLPFC) were activated strongly (Sanfey et al. 2003). The insular cortex (see Fig. 2.3 in Chap. 2) is known to involve minus attributes, such as loss and punishment, and can be understood to reflect the minus utility of unfair requests. In fact, the activity of the insular cortex is bigger at the time of rejection than the time of acceptance of unfair request. Contrastively, there was no difference in activities in the area of the DLPFC on this matter. This can be interpreted that the DLPFC might be trading off the minus utility caused by accepting the unfair request of the opponents to the positive utility gaining from one's own profit in order to accomplish the goal to gain more profit.

To examine the works of DLPFC during the ultimatum game, Fehr et al. at the University of Zurich use the method of repetitive transcranial magnetic stimulation, rTMS, with which the device causes a magnetic sphere and lowers the activities of DLPFC artificially. The experts then observe the reaction of participants to the unfair requests (Knoch et al. 2006). As a result, suppression of the right DLPFC activity significantly increased the portion of accepting the most unfair request compared to the suppression of the other parts of the brain. At that time, among the people who received the right DLPFC suppression, a phenomenon to accept the unfairness happened even if they understood its unfairness when they were asked the degree of unfairness. From this observation, it should be possible to determine that the neural suppression by rTMS oppressed control of the DLPFC for the egoism to require only the utility from one's own profit.

8.5.3 Neuroeconomics on Unfairness

Tricomi et al. clarify the positive utility coming from the feeling that the people in worse circumstance can gain a better environment (Tricomi et al. 2010). In the experiment each of two participants receives 30 dollars at first. After a lottery, if one draws "rich," he can gain 50 dollars. The income gap is 50 dollars; one has 30 dollars, and the other 80 dollars. Under this condition, brain activities were tested by fMRI when one or the other got 30 dollars by lottery. The result shows that the striatum of the participants, who drew "rich", was activated on both occasions when they gained an additional 30 dollars and the partner gained the same additional income. Contrastively, when the participants who did not draw "rich" saw that the partner gained additional income, their striatum was not activated. Considering a previous study that shows the involvement of the striatum to rewards, we can interpret this result that the decrease of income gap by others' gaining profit tends to increase the utility.

Haruno et al. demonstrated the correlation between brain activities and individual preferences on the different gains during the distribution of the profit with the participants and the partners in a game (Haruno and Frith 2010). Three different cases were presented: (1) the difference of owning money between one and the other is minimum, and the sum of the owning money of both became maximum, (2) one's income became maximum, (3) the difference between one and the other became maximum. They defined those who consistently chose the first case as the pro-social, those who chose the second case as the individualistic, and those who chose the last one as the competitive. In short, in the case of the pro-social participants, the bigger the difference of distribution was, the stronger the amygdala was activated. Contrastively, there was no correlation between the brain part and the distribution among the individualists. Thus, we can conclude that the pro-social tend to judge the income difference, or the degree of unfairness, with activities of the amygdala. In this experiment, among the participants, mostly undergraduate students, their social preferences were 65% pro-social, 34% individualistic, and 1% competitive.

8.5.4 Neuroeconomics About Social Affection

For decision making in a social setting, social affection, such as reputation from others and jealousy toward others, can be critical factors to process the information as well as physical and financial rewards like food and money. More experimental results have been reported, indicating that all of these feelings are processed as a reward in one's brain. For instance, Izuma et al. examined the correlation of this social reward and monetary reward by fMRI (Izuma et al. 2008). They requested that participants read aloud the sentences in which others evaluated them, measuring their brain activities. When they were reading a positive evaluation, "you are trustworthy," the striatum was activated. The more the evaluation was praising, the stronger the striatum activation was. This result indicates that the social reward like the evaluation from others is processed in the same system of monetary reward. Takahashi et al. also examined how jealousy is processed in one's brain by fMRI (Takahashi et al. 2009). At first, each participant read a short story of a fictitious person. In the story, the researchers intentionally included a target person of jealousy as a similar but better person who has various common points with each participant: the same gender, similar social circumstances, the same life goal, and the same hobbies, but with better intelligence and with a better car. They reported that the striatum of the participant was activated when this target person of jealousy failed in the script. In this way, the research of brain function on the decision making involving sociability is called "social neuroscience," and this attracts many neuro-economists.

8.6 Summary and Further Reading

There are many experiment results indicating that it is necessary to consider social preferences models such as the inequality aversion model. The experiments in this category include public goods games and the trust game introduced in this chapter as well as the ultimatum and dictator games that were explained in Chap. 1. There are also many experiment results that can be explained very well with the models with selfish economic men when competition is introduced. The experiments in this category include market experiments when double auction is used and versions of ultimatum games with competition. The inequality aversion model explains results of both of these categories of the experiments. When a person with inequality aversion feels that her actions have little or no consequence on inequality, her concerns for inequality will have little or no effect on her actions. If a government, a nonprofit organization, or a for-profit business firm interested in corporate social responsibility wishes to evoke social preferences of people for their altruistic behavior, it is important to make sure that they can feel the differences they make. For example, they can use the Internet to show how donations of people are making differences.

For further reading, Cooper and Kagel (2016) give a survey of an enormous amount of experimental research on social preferences since 1995. Levitt and List (2007) point out that laboratory experiments on social preferences have special difficulties for external validities of experimental results because participants' behavior can be affected by scrutiny given to them in laboratories, for example. They conclude that the use of field experiments (experiments conducted outside laboratories in natural settings) can serve as a bridge between lab-generated data and non-experimental data from natural settings. Falk and Heckman (2009) explain that external validity is a common problem in social sciences, and that conducting more laboratory experiments to understand various aspects of the problem can be a solution.

8.7 Questions and Problems

8.7.1 Multiple-Choice Problems

1. Assume that in a public goods game of four people, each participant initially receives 20 tokens and the private rate of return of contributing to the public good is 0.4 for an individual. What will be the theoretical prediction and typical results in real experiments of this standard public goods game where each participant cannot punish other members? Choose the most appropriate answer.

   (A) Under the Nash equilibrium, if all participants behave as selfish economic men, we can expect that they all contribute 20 tokens and gain 32 tokens.
   (B) Under the Nash equilibrium, if all participants behave as selfish economic men, they have an incentive to free-ride, so nobody will contribute.
   (C) In a single-shot game experiment, the typical result is that no participant makes any contribution.
   (D) In a single-shot game experiment, participants typically contribute at levels much more than the free-riding level.
   (E) In a repeated game experiment, where the game is repeated for 10 times, the contribution rate gradually declines toward the free-riding level.
   (F) In a repeated game experiment, where the game is repeated for 10 times, the contribution rate gradually increases.
   (G) A, C, and E
   (H) A, C, and F
   (I) A, D, and E

(J) A, D, and F
(K) B, C, and E
(L) B, C, and F
(M) B, D, and E
(N) B, D, and F

2. Assume that in a public goods game of four people, each participant initially receives 20 tokens and the private rate of return of contributing to the public good is 0.4 for an individual. For the standard public goods game where subjects cannot punish other members, choose the most appropriate answer for the learning hypothesis.

   (A) According to the learning hypothesis, because participants do not understand the structure of the game in the beginning, they will contribute at a higher rate than what selfish economic men would do. However, as they learn the structure of the game by repetition, the contribution rate will converge to zero.
   (B) According to the learning hypothesis, because participants do not understand the structure of the game in the beginning, they will contribute at a lower rate than what selfish economic men would do. But as they learn the structure of the game by repetition, the contribution rate will increase.
   (C) Imagine that, after one round of repeating the game for 10 times, the second round of an additional 10 games is conducted. If the initial rate of contribution in the second round is high, then it is evidence against the learning hypothesis.
   (D) Imagine that, after one round of repeating the game for 10 times, the second round of additional 10 more games are conducted. If the initial rate of contribution in the second round is approximately at the free-riding level, then it is evidence against the learning hypothesis.
   (E) A and C
   (F) A and D
   (G) B and C
   (H) B and D

3. In an experiment of the public goods game by Fehr and Gächter (2000), all players are given an option to punish other players by reducing their payoff. Punishment is costly because the punisher's payoff is proportionately reduced. In this public goods game with punishment, what will be the theoretical prediction of the outcome if all participants are selfish economic men? Choose one most appropriate answer.

   (A) The players who free-ride will be punished by other players.
   (B) The players who free-ride will *not* be punished by other players.
   (C) The contribution rate will be increased compared with the public goods game without punishment.

(D) A and C
(E) B and C

4. Assume that, in the standard trust game, player A receives a certain amount of money (say 10 dollars), and he will decide how much of the money he will send to player B. The amount of the shared money will be tripled and given to player B. Player B will then decide how much of the money he has received will be returned to player A. Choose the most appropriate answer regarding the theoretical prediction of this experiment.

(A) If player B behaves as a selfish economic man, player B will return 50% of the total amount he has received to player A.
(B) If player B behaves as a selfish economic man, player B will not return anything to player A.
(C) If player A thinks that player B will behave as a selfish economic man, player A will send the entire 10 dollars to player B, because together players A and B will be able to obtain the largest amount (30 dollars).
(D) If player A thinks that player B will behave as a selfish economic man, player A will send 5 dollars out of 10 dollars to player B.
(E) If player A thinks that player B will behave as a selfish economic man, player A will not send any money to player B.
(F) A and C
(G) A and D
(H) A and E
(I) B and C
(J) B and D
(K) B and E

5. Continuing the standard trust game experiment in the previous problem, choose the most appropriate answer for the typical results of actual experiments.

(A) Many participants as player A send some amounts of money to player B.
(B) No participant as player A sends any amount from 10 dollars because he does not expect player B to return any money.
(C) No player B will return any money to player A.
(D) Most players B who received the money from players A return some money.
(E) A and C
(F) A and D
(G) B and C
(H) B and D

6. Choose the most appropriate answer regarding Smith's (1964) experimental study of market analysis.

(A) When a double auction is used for market transactions, the outcome that is essentially consistent with market equilibrium under the assumption of selfish economic man was obtained after several rounds.

(B) When a double auction is used for market transactions, the outcome that is essentially consistent with market equilibrium under the assumption of selfish economic man was obtained in the first round.

(C) When a double auction is used for market transactions, the outcome was very different from market equilibrium under the assumption of selfish economic man even after several rounds.

8.7.2 Short Answer/Essay Problems

1. In a market experiment with an imaginary good, assume a case where seven buyers have values of 10, 20, 30, 40, 50, and 60 cents, respectively, and seven sellers have costs of 10, 20, 30, 40, 50, and 60 cents, respectively. Assume that each buyer can buy only one unit and that each seller can sell only one unit. Draw a diagram with demand and supply curves, and find the market equilibrium price and quantity. Explain your diagram.
2. In a market experiment with an imaginary good, suppose the following market experiment: all buyers have the same value (2 dollars) and all sellers have the same cost (1 dollar). Assume that each buyer can buy only one unit and that each seller can sell only one unit. Answer the following two questions:

(A) Find the market equilibrium price and quantity when there are 10 buyers and 30 sellers, by drawing a diagram with demand and supply curves. Explain your diagram.

(B) Find the market equilibrium price and quantity when there are 30 buyers and 10 sellers, by drawing a diagram with demand and supply curves. Explain your diagram.

Appendix 1

Using the experimental setting of Smith (1964)—which we introduced in this chapter,—we can analyze market equilibrium under the perfect competition assumption where neither individual seller nor buyer can affect the price by drawing supply and demand curves. For example, assume the following: Each of 7 sellers receives different costs (10, 20, 30, 40, 50, 60, and 70 cents), and each of 7 buyers receives different values (10, 20, 30, 40, 50, 60, and 70 cents). First we consider the demand curve. If the price exceeds 70 cents, there is no buyer who wants to buy, so the market demand is zero. When the price is 70 cents, for the buyer with the value of 70 cents, the payoff of buying 0 and 1 unit will be equal. Hence the demand curve will be a flat line between zero and one. As long as the price is lower than 70 cents but higher than 60 cents, only the buyer whose value is 70 cents will buy 1 unit and obtain a positive payoff, so the market demand will be one unit. When the price is 60 cents, the buyer whose value is 60 cents will choose either 0 or 1 unit, as the payoff from the two options is the same. Because there is a buyer whose value is 70 cents, the market demand will be either 1 or 2 when the price is 60 cents. When the price is lower than 60 cents and higher than 50 cents, the market demand will be 2 units because two buyers with a value of 70 cents or 60 cents will buy one unit each as they receive a positive payoff from the transaction. In this manner, as the price declines, the experimental demand curve will increase as price decreases in a stepwise manner.

Next let us consider the supply curve. If the price is lower than 10 cents, there will be no seller, so the market supply will be 0. When the price is 10 cents, the seller with the cost that equals 10 cents will face the same payoff between selling nothing and selling one unit, so the supply curve will be flat between 0 and 1. When the price is higher than 10 cents but lower than 20 cents, a seller with the production cost of 10 cents will sell one unit and receive a positive payoff, so market supply will be 1. When the price is 20 cents, the seller with the production cost of 20 cents will either sell nothing or sell one unit, because the payoff will be the same between the two options. With the supply from the seller with the production cost of 10 cents, the market supply will be either 1 or 2. If the price is higher than 20 cents but lower than 30 cents, the sellers with production costs of 10 cents and 20 cents will gain from selling one unit each, so the market supply will be 2. Thus, the market supply curve will increase as the price increases in a stepwise manner.

As shown in Fig. 8.3, the demand and supply curves will meet when the price is 40 cents, which means the participants who have a 40-cent card are indifferent between selling and buying. Therefore, there are two market equilibria: the price equals 40 cents, and the quantity traded under the equilibrium is either 3 or 4 units.

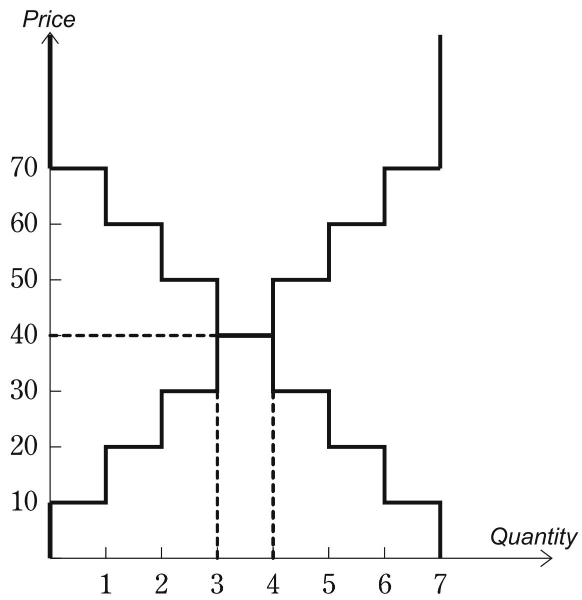

Fig. 8.3 Stepwise demand and supply curves in an experiment

Appendix 2: Inequality Aversion Model and Competition

According to Fehr and Schmidt's (1999) analysis, when players have preferences for inequality aversion as in the FS model, the difference in the sub-game perfect equilibrium under no competition and that under competition is explained as follows:

In a standard ultimatum game with two players, assume that the proposer (player 1) has a preference parameter of (α_1, β_1), and the responder (player 2)'s preference parameter is (α_2, β_2). Under disadvantageous inequality for player 1 ($x_2 > x_1$), his or her utility will be:

$$U_1(x_1, x_2) = x_1 - \alpha_1(x_2 - x_1)$$

Under an advantageous inequality condition for player 1 : $(x_1 > x_2)$

$$U_1(x_1, x_2) = x_1 - \beta_1(x_1 - x_2)$$

Similar logic applies to player 2.

Under the ultimatum game, the utility of each player depends on the share ratio s, which is player 2's share of the total payoffs because we can standardize the utility functions by dividing them by the fixed endowment without changing the preferences they represent. If $s \geq 0.5$ is accepted, then

$$U_1(s) = (1 - s) - \alpha_1(2s - 1)$$
$$U_2(s) = s - \beta_2(2s - 1)$$

If s < 0.5 is accepted, then

$$U_1(s) = (1 - s) - \beta_1(1 - 2s)$$
$$U_2(s) = s - \alpha_2(1 - 2s)$$

If responder rejects s, then $U_1 = U_2 = 0$.

The optimum response of a responder is as follows. If s $\geq$ 0.5, the U_2 (s) is always positive (because $\beta_2 \leq 1$), so player 2 will accept the proposal. In this case, the inequality is advantageous to the player 2, so he prefers accepting the proposal which gives him a positive payoff rather than rejecting the proposal which both players will end up with zero payoff. On the other hand, when s < 0.5, the responder will accept the proposal if

$$U_2(s) = s - \alpha_2(1 - 2s)$$

is satisfied. If $U_2(s) < 0$. player 2 will reject the proposal. In sum, the responder will accept the offer if $s \geq \alpha_2/(1 + 2\alpha_2)$, and reject it if $s < \alpha_2/(1 + 2\alpha_2)$.

In order to examine the subgame perfect equilibrium outcome in this game, consider the behavior of the proposer who predicts the behavior of the responder. Compared with $s > 0.5$, the proposer's payoff will increase by offering $s = 0.5$ (because his offer will be accepted and the proposer will receive more payoff). So the equilibrium can be pursued for the range of $s \leq 0.5$. When $\beta_1 > 0.5$, as long as $s \leq 0.5$, the increase in s will increase the proposer's utility: thus, if $\beta_1 > 0.5$, the equilibrium can only be achieved when the proposer offers $s = 0.5$ and the responder accepts the offer. If the proposer's inequality aversion is strong (i.e., $\beta_1 > 0.5$,), the proposer will offer $s = 0.5$ (equal payoff), which will be accepted by the responder. If $\beta_1 < 0.5$, the proposer's utility will decrease when s increases. The proposer's inequality aversion is weak, the proposer will prefer to choose the minimum s that he can offer. However, if s is too small, the responder will reject the offer. Thus, the proposer will offer the lowest acceptable proposal for s, i.e., $s = \alpha_2/(1 + 2\alpha_2)$. If $\beta_1 < 0.5$, the only subgame perfect equilibrium is when the proposer offers $s = \alpha_2/(1 + 2\alpha_2)$ and the responder accepts the offer. If $\beta_1 = 0.5$, as long as $s \leq 0.5$, the utility of the proposer will not change even if s changes. The proposer therefore will pick any s, which satisfies $\alpha_2/(1 + 2\alpha_2) \leq \mathrm{s} \leq 0.5$, and if the responder accepts the offer the subgame perfect equilibrium will be achieved. In the last case, there are many possible equilibria.

In summary, as long as $\beta_1 > 0.5$, the proposer will offer $s = 0.5$ and the responder will accept the offer. If $\beta_1 < 0.5$, the proposer will offer $s = \alpha_2/(1 + 2\alpha_2)$, and the responder will accept the offer. Finally, if $\beta_1 = 0.5$, the proposer will choose any s which satisfies $\alpha_2/(1 + 2\alpha_2) \leq \mathrm{s} \leq 0.5$, and the responder will accept the offer. As such, the typical results of the experiments of ultimatum game can be explained by the inequality aversion of FS model.

Next, we introduce competition to the ultimatum game model as in Roth et al. (1991), which we discussed in the main text. Consider the case where there are multiple proposers who compete among themselves. There are N players, where N-1 players are the proposers. The proposer i will offer the share ratio s_i ($0 \leq s_i \leq 1$ where $i = 1, \ldots, N - 1$). The responder ($i = N$) makes a decision whether or not to accept the highest offer $s_{max} = \max(s_i)$. Any offer s_i that is lower than s_{max} will be automatically rejected. If there are multiple proposers who offer s_{max}, only one proposer's offer will be picked randomly. If the responder rejects the offer s_{max}, the payoff of all the participants will be zero. If the responder accepts the offer s_{max}, his pay-off will be $(1 - s_{max})$. Note that if the gain is $Y\, s_{max}$, the FS utility functions can be standardized by dividing by Y, then they end up with the same result. Each player has FS utility function, and we assume that if he is not certain that he can receive a payoff, he will act in such a way as to maximize the game in order to maximize the expected value of the FS utility function.

In what follows, we show that there will be an equilibrium if there are more than one proposers who offer $s_{max} = 1$. Because the responder will gain nonnegative utility if he accepts $s_{max} \geq 0.5$, the offer will be accepted with certainty. To confirm this, see that the following condition holds:

$$s_{max} - \frac{1}{N-1}\beta_N(2s_{max} - 1) - \frac{N-2}{N-1}\beta_N(s_{max} - 0) \geq 0. \tag{8.7}$$

The necessary and sufficient conditions for (8.7) to hold is

$$(N-1)s_{max} \geq \beta_N(Ns_{max} - 1) \tag{8.8}$$

because $\beta_N \leq 1$, (8.8) will hold as long as

$$(N-1)s_{max} \geq (Ns_{max} - 1)$$

Because $s_{max} \leq 1$, the responder will accept the offer of $s_{max} = 1$ and (8.8) will hold. Here, one of the proposers who offers $s_{max} = 1$ will obtain 0 profit, which is an unfavorable inequality compared to that of the responder who accepted the offer; however, because there are other proposers (i.e., competitors), the proposer's payoff cannot increase by offering less, both in terms of profit and inequality. In short, if more than one proposer offer $s_{max} = 1$, the offer will be accepted and an equilibrium is achieved.

To confirm that there is no other equilibrium, consider the case where $s_{max} < 0.5$ is rejected. Consider the behavior of one proposer. Given the strategy of other proposers and rejection of the responder, if the proposer offers s = 0.5, The offer will always be accepted by the responder. Then the proposer's payoff will be positive. Therefore, at the equilibrium, the offer will always be accepted.

Assume there is an equilibrium under $s_{max} < 1$. If there is a proposer who makes a lower offer than s_{max}, this proposer can have his own expected utility without changing the inequality situation. If all the proposers are making the same offer, a proposer can increase his expected utility by slightly increasing his offer. This is also contracdictory.

As such, using the FS model, we can explain why the effects of preference for inequality aversion will disappear from observed behavior when we introduce competition.

References

Andreoni, J. (1988). Why free ride? Strategies and learning in public goods experiments. *Journal of Public Economics, 37*(3), 291–304.

Andreoni, J. (1989). Giving with impure altruism: Applications to charity and Ricardian equivalence. *Journal of Political Economy, 97*(6), 1447–1458.

Andreoni, J. (1990). Impure altruism and donations to public goods: A theory of warm-glow giving. *Economic Journal, 100*(401), 464–477.

Barro, R. J. (1974). Are government bonds net wealth? *Journal of Political Economy, 82*(6), 1095–1117.

Becker, G. (1974). Theory of social interactions. *Journal of Political Economy, 82*(6), 1063–1093.

Berg, J. E., Dickhaut, J., & McCabe, K. (1995). Trust and reciprocity, and social history. *Games and Economic Behavior, 10*(1), 122–142.

Bolton, G. E., & Ockenfels, A. (2000). ERC: A theory of equity, reciprocity and competition. *American Economic Review, 90*(1), 166–193.

Chamberlin, E. H. (1948). An experimental imperfect market. *Journal of Political Economy, 56*(2), 95–108.

Cooper, D. J., & Kagel, J. H. (2016). Other regarding preferences; a selective survey of experimental results. In J. H. Kagel & A. E. Roth (Eds.), *The Handbook of Experimental Economics* (vol. 2). Princeton, NJ: Princeton University Press.

de Quervain, D. J., Fischbacher, U., Treyer, V., Schellhammer, M., Schnyder, U., Buck, A., et al. (2004). The neural basis of altruistic punishment. *Science, 305*(5688), 1254–1258.

Falk, A., & Heckman, J. J. (2009). Lab experiments are a major source of knowledge in the social sciences. *Science, 326*(5952), 535–538.

Falk, A., Fehr, E., & Fischbacher, U. (2005). Driving forces behind informal sanctions. *Econometrica, 73*(6), 2017–2030.

Fehr, E., & Gächter, S. (2000). Cooperation and punishment in public goods experiments. *American Economic Review, 90*(4), 980–994.

Fehr, E., & Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics, 114*(3), 817–868.

Güth, W., Marchand, N., & Rulliere, J. L. (1997). *On the reliability of reciprocal fairness—An experimental study*. Discussion Paper: Humboldt University of Berlin.

Haruno, M., & Frith, C. D. (2010). Activity in the amygdala elicited by unfair divisions predicts social value orientation. *Nature Neuroscience, 13*(2), 160–161.

Holt, C. A., Langan, L. W., & Villamil, A. P. (1986). Market power in oral double auctions. *Economic Inquiry, 24*(1), 107–123.

Izuma, K., Saito, D. N., & Sadato, N. (2008). Processing of social and monetary rewards in the human striatum. *Neuron, 58*(2), 284–294.

Knoch, D., Pascual-Leone, A., Meyer, K., Treyer, V., & Fehr, E. (2006). Diminishing reciprocal fairness by disrupting the right prefrontal cortex. *Science, 314*(5800), 829–832.

Levine, D. K. (1998). Modeling altruism and spitefulness in eperiments. *Review of Economics, 1*(3), 593–622.

Levitt, S. D., & List, J. A. (2007). What do laboratory experiments measuring social preferences reveal about real world? *Journal of Economic Perspectives, 21*(2), 153–174.

Ogaki, M., & Tanaka, S. (2014). *Koudu keizaigaku*. Tokyo: Yuhikaku.

Plott, C. R. (1982). Industrial organization theory and experimental economics. *Journal of Economic Literature, 20*(4), 1485–1527.

Rabin, M. (1993). Incorporating fairness into game theory and economics. *American Economic Review, 83*(5), 1281–1302.

Roth, A. E., Prasnikar, V., Okuno-Fujiwara, M., & Zamir, S. (1991). Bargaining and market behavior in Jerusalem, Ljubljana, Pittsburgh, and Tokyo: An experimental study. *American Economic Review, 81*(5), 1068–1095.

Sanfey, A. G., Rilling, J. K., Aronson, J. A., Nystrom, L. E., & Cohen, J. D. (2003). The neural basis of economic decision-making in the Ultimatum Game. *Science, 300*(5626), 1755–1758.

Smith, V. (1962). An experimental study of competitive market behavior. *Journal of Political Economy, 70*(2), 111–137.

Smith, V. (1964). Effects of market organization on competitive equilibrium. *Quarterly Journal of Economics, 78*(2), 78–202.

Takahashi, H., Kato, M., Matsuura, M., Mobbs, D., Suhara, T., & Okubo, Y. (2009). When your gain is my pain and your pain is my gain: Neural correlates of envy and schadenfreude. *Science, 323*(5916), 937–939.

Tricomi, E., Rangel, A., Camerer, C. F., & O'Doherty, J. P. (2010). Neural evidence for inequality-averse social preferences. *Nature, 463*(7284), 1089–1091.

Part IV
Frontiers of Behavioral Economics

Chapter 9
Culture and Identity

Abstract This chapter examines how culture and identity affect economic behaviors and outcomes. Cultural differences in economic behavior have been found in survey data and experiment data. Differences in norms and worldviews have been used to empirically and theoretically study these cultural differences.

Keywords Cultural economics · Identity economics · Norm · Worldview

Cultural economics and identity economics are not branches of behavioral economics, but are closely related to it. In this chapter, we examine how culture and identity would affect economic behaviors (including altruistic economic behavior we examined in the context of social preferences in the previous chapter) and economic outcomes.

9.1 Cultural Economics

Cultural Economics has been one of the rapidly developing branches of economics since the 1990s. The progress is concentrated on the effect of culture on economic phenomena. One example of a large difference among countries in the saving rates and economic growth can be attributed to cultural differences among different countries. However, until the 1990s, many economists tended to avoid such an approach, probably because of two reasons.

First, in traditional economics, the main focus of empirical research is on behavior rather than on the decision-making process behind the behavior. Therefore, economists tend to hesitate to use subjective answers to questions that are often asked in psychology such as "What do you think?" Second, the notion of "culture" is too broad to derive refutable hypotheses from theory.

As behavioral economics developed, however, many empirical studies found that in order to understand economic behavior, bounded rationality, learning, temptation, and psychology in the decision-making process are also important, and theoretical

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models to explain them were also constructed.[1] As a result, economic discipline also uses subjective variables in their empirical analyses. In addition, as the research on empirical research on subjective variables on culture progressed, a new approach which made it easier to conduct empirical and theoretical research by using a narrower definition of culture emerged. For example, Guiso et al. (2006) define culture as "those customary beliefs and values that ethnic, religious, and social groups transmit fairly unchanged from generation to generation." As we discuss later, analyzing the culture from the worldview behind it is also an effective approach.

In the history of economics, economists such as Adam Smith and John Stuart Mill in the eighteenth and nineteenth centuries claimed that cultures affect economic phenomenon. Karl Marx in the nineteenth century, however, claimed that the substructure (e.g., economic relations for production) completely determines the superstructure (e.g., culture), and denied the opposite causality direction. At the beginning of the twentieth century, Max Weber opposed the idea of Marx claiming that the Protestant ethic had a great influence on capitalism. Mainstream economics after World War II has ignored culture for a long period of time; however, in the 1990s, the impact of trust on economic performance has gained attention, which has acted as a catalyst for the impact of culture on the economy that has rapidly developed since then.

9.2 Survey Data of Cultural Economics and Empirical Analysis

Two major survey datasets that have been used in many empirical studies in cultural economics are (1) the European Values Survey (EVS), which was conducted four times between 1981 and 2008 for European countries; and (2) the World Values Survey (WVS), conducted in cooperation with EVS.[2]

In these research projects, many social scientists from different countries cooperated to survey issues such as values, beliefs, and cultural change. The survey was done to make the core questions as consistent as possible across different countries. Inglehart (2000) proposed two major instruments to measure cultural values: the secular–traditional measures and the self-expression survival measures. Inglehart and Welzel (2010) applied these measures on EVS/WVS, and created the WVS cultural map of the world.[3] Based on the WVS survey conducted between 2005 and 2009, they divided countries into 9 cultural zones: English Speking, Protestant Europe, Catholic Europe, Islamic, etc.

[1]The examples include the model of temptation and self-control (Chap. 3), the level-k model (Chap. 5), and models of learning (Chap. 7).

[2]The latest data can be found at: http://www.worldvaluessurvey.org/.

[3]This and other versions of the WVS cultural map can be found in http://www.worldvaluessurvey.org/WVSNewsShow.jsp?ID=192.

In cultural economics, some researchers use Inglehart's measure and some use the answers to questionnaires. For example, Guiso et al. (2003) used the data of the WVS and tested how religions affect economic outcomes. One of the many attitudes that were analyzed was thriftiness. The attitude of thriftiness is important because it affects the saving rate, which in turn affects economic growth. In order to measure thriftiness, they used a WSV question: "Here is a list of qualities that children can be encouraged to learn at home. Which, if any, do you consider to be especially important?" One of the respondents listed as important "Thrift, saving money, and things". Guiso et al. (2003) find based on their regression analysis that the more religious a respondent is, the more she or he believes these values to be important. However, the question remains whether the attitude is reflected in their action. i.e. more savings. Because of this, Guiso et al. (2006) used the savings rate data of both developing and developed countries combined with the data on the measure of thriftness. Their results show that a country that places importance on teaching thriftiness to children has a high savings rate.

Other data that is often used in empirical studies in culture economics is explained in Hofstede (1984, 1991) and various editions of his book. In the initial study, they used the survey data of IBM employees in around 40 countries. Various statistical methods were applied to different questions, and various indexes such as the individualism vs. collectivism index and the power distance index, have been constructed. One example of using Hofstede's index in the context of cultural economics is Gorodnichenko and Roland (2017). They found that countries with a more individualistic culture are likely to give a social reward to technological progress, so individualistic culture promotes technological progress and economic growth. They also used an extended version (covering 80 countries) of Hofstede's index and found the empirical result to be consistent with the argument.

9.3 Cultural Economics and Experiments

One way to examine the influence of culture on economic behavior using experiments is a *meta-analysis*, which analyzes the results from numerous studies done by various researchers. Another method is to use a unified empirical method for cultural comparison. In this section, we review the literature using these methods.

9.3.1 Dictator Game

Engel (2011) conducted a meta-analysis of experimental results of 129 papers published between 1992 and 2010. The regional coverage spans not only Western and developing countries, but also primal societies. The average giving rate of the dictators (calculated from all reported or constructed means per 616 treatments) was 28.35%. The distribution of the giving rates, however, was not normally distributed:

36.11% of the participants gave nothing to the recipient; 16.74% split it evenly; 5.44% gave everything to the recipient. Among the possible giving rates of the dictator, 0, 50, and 100% made up 60% of all samples. However, this distribution of giving differed depending on the region. The distributions of study results were fairly similar in Western countries. However, in primal societies and developing countries, giving more than 50% was rare; in primal societies, the equal split consisted of 30% (higher than in Western countries), and giving nothing was 5% (less than Western countries). Developing countries were in the middle. Giving nothing was much less frequent than in Western societies, but much more frequent than in primal societies. In developing countries, the equal split was 25%, and giving nothing was a little less than 20%; thus, their results stood in between developed and primal societies. These results suggest that culture plays an important role in the dictator game.

9.3.2 Ultimatum Game

Oosterbeek et al. (2004) conducted a meta-analysis of experimental studies on the ultimatum game in many countries with different cultural backgrounds. Oosterbeek et al. (2004) analyzed 37 papers with 75 results from ultimatum game experiments. They found the mean of proposers' offered percentage share was 40.41%, with a standard deviation of 5.85%.

In comparing the averages offered percentage share across different countries, Peru had the lowest (26%) and Paraguay had the highest (51%) share. The average rejection rate was 16.2%, with a standard deviation of 10.74%. Cross-country comparison showed that Bolivia and Paraguay had the lowest (0%) rejection rate, whereas France had the highest (39.78%). As such, there was a wide range both in average offered and average rejection share across countries, The difference was most pronounced in the average rejection rate.

Meta-analysis has an advantage in that it allows us to compare many different experimental results; however, when different results were obtained for different countries, there are some potential factors aside from cultural and/or regional differences that might significantly alter the outcome of the experiments:

1. Experimenter effect: factors that an experimenter is unaware of, such as subtle verbal (e.g., tone of voice) and non-verbal cues, gestures, social distances between the experimenter and the participants, etc.
2. Language effect: countries with different cultures often have different languages. Therefore, there would be a subtle difference in nuances for the same instruction.
3. Currency effect: countries with different cultures often use different currencies.
4. Experimental procedure effect: a small and subtle difference in experimental procedures.

In order to make sure that the difference in experimental outcome comes from cultural differences, these effects described above must be eliminated as much as possible. Roth et al. (1991), which we discussed in Chap. 9, tested the cultural difference of Israel, Japan, and Yugoslavia (a former Eastern European country which existed between 1929 and 2003) using the ultimatum game. In order to control for the experimenter effect, all four experimenters conducted experiments in Pittsburgh (USA), making sure that every detail of experimental procedure was identical.

In the experiments of Herrmann et al. (2008) and others, one experimenter supervised the experiments of all countries, and participants did not know one another, and also an experimenter used the same experimental software in compartmentalized laboratories. No verbal explanations were given by the experimenter, but the participant would read the explanation of the experiment and the experimenter answered only when participants had questions. To control for the language effect, Roth et al. (1991) took an approach that, since the authors came from different cultural backgrounds but they all had lived in the USA, the author who had a good understanding of both cultures and languages translated the explanations for the experiment from English into the language of his country. Another often-used method includes *back translation*, which is a procedure for checking the translation by translating back to the orignial language. For example, a document is translated from English to Japanese. Then a second translator who has not seen the original language would translate from Japanese into English. A researcher would compare the original document and the back translated dcoument, and ask for necessary corrections for the translation. This process is repeated as necessary. To control for the currency effect in the ultimatum game, it is necessary to use the same values of the initial endowment. When a nominal exchange rate is used, this does take the purchasing power (the value of currency divided by the price of typical consumption basket) into account, which may create a substantial difference in outcomes. The experiment of Roth et al. (1991) used 10–30 dollars as an initial endowment as the baseline. In other countries, they adjusted the initial endowment by purchasing power (10 dollars or more). Considering the difference in currency unit, they used tokens (the initial endowment was 1000 tokens, which could be offered in increments of 5 tokens). They found little statistically significant results for different countries in both the normal and market setting versions (see Chap. 8 for the marekt setting version) of the ultimatum game. From the experimental outcome we explained so far, we cannot rule out the possibility that results of the meta-analysis are due to the experimenter effect or languager effect rather than cultural difference.

Whether the regional differences in experiment outcome is due to cultural difference can be checked by another method, which is to see if the difference across the experiments can be explained by some sort of measurement of cultures. When they can, then there is a high chance that the regional differences are due to cultural differences.

As such, Oosterbeek et al. (2004) used, as a part of meta-analysis, Hofstede's individualistic index and the power distance index, and Inglehart's "secular–rational versus traditional", as well as two questions drawn from the World Values Survey: The percentage of a country's population saying that most people can be trusted ("trust"), and the average score of a country on a 1–10 scale on the statement that competition is good (“competition”) in addition to other explanatory variables such as the size of the initial endowment. However, in a regression model where the offered share is the dependent variable, the respect for authority was statistically significant at the 5% level, but other cultural variables were not statistically significant at the 10% level. For the regression model with an average rejection rate as the dependent variable, no cultural variables were statistically significant at the 10% level.

The meta-analysis of Oosterbeek et al. (2004) also includes the result of the ultimatum game in Henrich et al. (2005) in which an experiment was conducted in 15 primal societies. However, since the study was conducted by field researchers, the experimental procedure differed by region. In a regression model where the average share ratio was the dependent variable, payoffs to cooperative activities (as opposed to solitary family-based productive activities was the dependent variable), based on rankings they constructed on the basis of their own and others’ ethnographic investigations, was statistically significant at the 5% level. The positive coefficient denoted that the societies with higher payoffs to cooperative activities tended to have higher share ratio. To sum up, at least in primal societies where the cultural gap can be substantial, there was a high probability of the impact of culture on the ultimatum game experiment outcome.

9.3.3 Public Goods Game

Herrmann et al. (2008, henceforth HTG) clearly show that cultural difference has an impact on economic behavior using uniform experiments of the public goods game with a punishment rule (Fehr and Gächter 2000, in Chap. 9) conducted in 16 regions around the world. Only Zurich and St. Gallen were in the same country, Switzerland, and the other 14 regions were in different countries. The 15 countries that HTG selected covered all the 9 cultural zones of WVS described earlier to maximize cross-cultural differences. In the public goods game where the private rate of return is α, if every player contributes y tokens, then every player in the group would receive αy tokens. In the experiment of HTG, $\alpha = 0.4$, and each group would consist of four members. The participants of their research were students in order to control for sociodemographic differences. In addition, they took various measures to control for experimenter effects, language effects, and currency effects. In conducting the experiment, they used the same software called z-tree[4] to control for the experimental procedure effects. In each country, groups of four students were selected randomly from the pool of about 20 participants. First, the public goods game without punishment (the N experiment)[5] was conducted for 10 rounds and

[4]The software and its description is available at http://www.iew.uzh.ch/ztree/index.php.

[5]For an explanation of the public goods game with and without punishment, see Sect. 9.1.3 in Chap. 9 above.

then with punishment (the P experiment) for 10 rounds.[6] Each member could decide, out of an endowment of 20 tokens they received at the beginning of the round, how many tokens to contribute to a group. For N experiment (without punishment), among 16 regions, the average contribution was the minimum in Melbourne, Australia (4.9 tokens), and the maximum was in Copenhagen, Denmark (11.5 tokens). The difference across the region was statistically significant. However, in all regions, the average contribution to the public good tended to decline over the period. In the P experiment setting, they observed even wider regional difference in the average contribution—the minimum was 5.7 and maximum was 18 tokens. The difference in average contribution across all 16 regions was statistically significant. During the last five periods, the average contribution was stable for all regions except Seoul, Korea, where the average contribution gradually increased over the period. For the difference in average contribution between the P experiment and N experiment throughout the period, 16 regions could be divided into three groups: (1) the difference was positive and statistically significant at 1% (9 regions); (2) the difference was positive and statistically significant at 10% but not at the 1% level (2 regions: Samara in Russia and Minsk in Belarus); (3) the difference was not statistically significant [5 regions: Athens (Greece), Istanbul (Turkey), Riyadh (Saudi Arabia), Muscat (Oman), and Dnipropetrovsk (Ukraine)]. For the average contribution in the P experiment, five regions in the third group had a minimum contribution (from Athens' 5.7 tokens to Dnipropetrovsk's 10.9 tokens). The second group had a larger contribution than the third (11.7 tokens and 12.9 tokens) but smaller than China's Chengdu (13.9 tokens) whose average contribution is the smallest in the first group. The region with the largest average contribution in the P experiment was Boston in the USA (18 tokens).

As this study demonstrates, there exist wide regional differences in terms of the average contribution to the public goods under the punishment setting as well as the effect of punishment on the average contribution as measured by its difference in N and P conditions. One possible explanation for this regional disparity is the regional difference in punishment behavior. HTG labelled the punishment when the punisher punishes the member with a lower contribution as "punishment of free riding"; whereas they labelled the punisher punishes a member with similar or higher contribution as "antisocial punishment." The mean punishment expenditure for antisocial punishment was highest in Muscat, followed by Athens, Riyadh, Samara, Minsk, Istanbul, Seoul, and Dnipropetrovsk. Except for Seoul, all these locations belong to the second or the third groups. HTG constructed two variables, norms of civic cooperation and the rule of law to explain the regional differences in these behaviors. The indicator of norms of civic cooperation was constructed from questions such as how much they can justify tax evasion and not paying transportation fares: when the citizens are more averse to these behaviors, the norms of civil cooperation were stronger (index value

[6]In order to see how the order of experiments (N to P experiments) change the outcome, they also repeated the same experiment with the reversed order (P to N experiments) in three regions: Samara, Minsk, and St. Gallen. There was no statistically significant difference in the ordering.

was higher). The rule of law indicator is constructed based on the confidence in and abidance by the rules of the society, and higher values indicate the higher rule of law. The regression analysis shows that the norms of civil cooperation indicator and the rule of law have a negative effect on antisocial punishment with 5% statistical significance. Another interesting finding is that most of the countries in the second and third were in either Islamic or Orthodox zones in the WVS cultural map.

Funaki et al. (2013) conducted an experiment, using the same experimental procedures as HTG in Waseda University and Osaka University in Japan. They show that the average contribution in P-condition, as well as the difference between P and N conditions, were lower than HTG's result, and the average contribution was close to the second group. However, antisocial punishment was relatively weak, close to the first group. From the point of view of the norms of civic cooperation and the rule of law, and also from the point of view of the cultural map of WVS (Japan is part of Confucian culture as is China and Korea), the natural guess is that Japan will be in the first group; thus, the result is puzzling. However, if they applied the different punishment rule used in Yamagishi (1988) where only the member with the smallest contribution will be punished, the contribution under P condition increased significantly.

Depending on the setting of the public goods game, Japanese contribute less to increase the benefit of others compared to Korean and Chinese, which is consistent with Chun et al. (2011). In a standard public goods game, α (private return from one unit of contribution) is between 0 and 1 ($0 < \alpha < 1$), so the individual payoff maximization of individuals does not maximize the group's total payoff. However, the study of Chun et al. (2011) set α to be smaller than 1 as normal (L experiment) and larger than 1 ($\alpha > 1$, H experiment), and there was not a punishment rule. In H experiment, contributing all initial endowments maximized the payoffs of both individual and group. However, Saijo and Nakamura (1995), who also conducted H experiment ($\alpha > 1$), found that many Japanese participants did not make the full contribution of an initial endowment, despite the fact that it was the dominant strategy that maximizes pay-outs of individuals as well as the group. A possible explanation is the existence of spiteful participants, who care primarily about the ranking among participants rather than individual payoffs. They labeled such acts as "spite". Chun et al. (2011) found that Japanese participants tended to "spite" more than Korean and Chinese participants.

As we have seen above, various experiments using the public goods game give us enough evidence based on experiments to believe that culture affects economic behavior. However, it is yet uncertain if the existing cultural measure is sufficient to explain these effects; we need to look more closely at *how* culture affects economic behavior.

9.4 Norms and Identity Economics

Akerlof and Kranton (2005) defined "norm" as "how people think that they and others should behave," and they constructed a model with the utility function where a person feels disutility from diverging from the norm. In economics, the definition of "norm" varies, and various models exist. In this book, we use Akerlof and Kranton's (2005) definition of the norm and the utility function based on this definition.[7] According to the definition of Akerlof and Kranton (2005, 2010), norms are for behavior and not the outcome, and the norms depend on a social context (when, where, how and with whom). Because culture is a social context, the norm can be considered as one element that explains the difference in behavior due to cultural difference. A social context is a social category such as gender, race, and place of origin. In the next section of this chapter, we first explain the case in which norms are not related to the social category. Then in the following section, we explain identity economics in which norms are related to the social category.

9.4.1 Norms and Economics

Pareto (1920 [1980]) stated that utility depends not only on what economists normally think of as tastes, but also on norms. Based on this conception, we can model utility function where utility also depends on norms; Akerlof's (1982) model of gift exchange is one such example. In this chapter, we explain the model of Krupka and Weber (2013). They defined $A = \{a_1, a_2, \ldots, a_k\}$ as a set of K actions available to an individual. Norms $N(a_i)$ are numerical scores of action $a_i(-1 < a_i < 1)$, and describes the appropriateness of behavior a_i. If a behavior is appropriate, $N(a_i) > 0$, and the more appropriate the behavior is, $N(a_i)$ approaches 1. If the behavior is inappropriate, $N(a_i) < 0$, more inappropriate behavior will make $N(a_i)$ closer to -1. If a behavior is "very socially inappropriate," the rating is -1. In a certain social context for which $N(a_i)$ is the norm, the utility of an individual who takes action a_i is assumed to be

$$u(a_i) = V(\pi(a_i)) + \gamma N(a_i) \tag{9.1}$$

where $\pi(a_i)$ represents (monetary) payoff by the action, and the function $V(\cdot)$ represents the values of the individual places on the monetary payoff, which is an increasing function of $\pi(a_i)$. The parameter $\gamma \geq 0$ represents the degree to which the individual places values on social norms. When $\gamma = 0$, the individual has zero concerns with norms (he is an economic man), so he is interested only in payoff from his behavior and takes actions according to the payoff-maximizing rule. On the other hand, if $\gamma > 0$, an individual derives positive utility from selecting actions that are socially appropriate; thus his behavior may change according to the social conditions and norms.

In an actual experiment, Krupka and Weber (2013) used two variations of the dictator game. In a "standard" dictator game, one individual (the dictator) initially

[7] For other definitions of norms and models with norms, see, e.g., Elster (1989) and the models mentioned in the Appendix 1.

receives 10 dollars while another (the recipient) receives 0 dollar. The individual with 10 dollars can then decide how much of the 10 dollars, in 1 dollar increments, to share with the other person. In a "bully" variation of the game, two people receive 5 dollars, and the dictator can take/give any amount up to 5 dollars from the "recipient", again in the increment of 1 dollar. As a result, for both versions of the dictator game, wealth allocation (dictator's payoff and recipienty's payoff) would offer 11 choices, e.g., (10, 0), (9, 1), …, (0, 10). Therefore, if the dictator is an economic man, or has an outcome-based social preference as discussed in Chap. 8, then the dictator is predicted to take exactly the same actions in the two versions of this dictator game. If the dictator is a selfish economic man, then in the "standard" dictator game, he will not share anything, while in the "bully" version, he will take everything from the other so the payoff would be (10, 0). The theoretical prediction is that, if an individual has outcome-based social preferences, he will choose different actions based on his preferences, but versions of the dictator game should not matter for the outcome. On the other hand, if we take norms into account, the social context differs in two experimental settings: "Sharing" is socially appropriate, and "depriving" is socially inappropriate, so an individual with utility function with $\gamma > 0$ will take different actions in different versions of the experiment.

Krupka and Weber (2013) conducted two experiments. In Experiment 1, the participants were 199 students from Carnegie Mellon, the University of Pittsburgh, and the University of Michigan. They presented the participants with a description of a choice of possible actions they could take, and asked them to rate the social appropriateness of each action by choosing one of the four ratings: "very socially appropriate," "somewhat socially appropriate," "somewhat socially inappropriate," and "very socially inappropriate." Each participant got an additional payment when his answer was equal to the one that was chosen by the most participants (the mode). This additional payment was announced before the participants started to fill in their ratings. Therefore, they were given an incentive to fill in the rating that they believed to be the mode.

In Experiment 1, a participant was given explanations of one of the two versions (standard or bully) and of another version of the dictator game conducted by other researchers. Then the participant was asked to rate actions in the two versions whose explanations were given. Krupka and Weber converted their answers into numerical scores. A rating of "very socially appropriate" received a score of 1, "somewhat socially appropriate" a score of 1/3, "somewhat socially inappropriate" a score of −1/3, "very socially inappropriate" a score of −1. We list the mean rating scores in Table 9.1. Krupka and Weber used the mean rating scores for an action in this table as an estimate of the values of the norm $N(a_i)$ for the action. Both the action of "Give $ 0" in the standard version and that of "Take 5 dollars" in the bully version resulted in the same monopolizing outcome ($10, $0). For each of these actions, $N(a_i)$ took a negative value, indicating it was socially inappropriate. When we compare their absolute values, however, the value in the bully version is greater. Both the action of "Give 5 dollars" in the standard version and that of "Give $0/Take $0" in the bully version resulted in the same outcome ($5, $5) with equal payoffs. For each of these actions, $N(a_i)$ takes a positive value, indicating it is socially appropriate. When we compare their values, however, the value in the bully version is greater. The participants in Experiment 1 only rated these actions and did not participate in the dictator game in Experiment 2 and had not participated in any dictator game.

The participants in Experiment 2 were students of Carnegie Mellon University, and took part in either the standard version or the bully version. In order to think about theoretical predictions for Experiment 2 based on the results of norms in Experiment 1, assume that $V(\pi(a_i)) = \beta\pi(a_i) + \varepsilon$, that β, γ, $N(a_i)$ are common to all participants, and that ε is normally distributed with mean 0. A participant with high values of ε obtains a high utility from the monetary payoff compared with the utility from conforming to the norm, so tends to behave to increase his monetary payoff. There are two theoretical predictions from the model. First, more participants in the bully version will take the action which results in the (5 dollars, 5 dollars) outcome than those in the standard version will take the action which results in the same outcome. This is because $N(a_i)$ in Table 9.1 for the action in the bully version which results in ($5, $5) is higher than that in the standard version which results in the same outcome. Second, if we restrict our attention to those dictators who take the action that results in higher monetary payoff for them than recipients, then more participants in the bully version will take the action which results in the ($10, $0) outcome than those in the standard version will take the action which results in the same outcome. The reason for this prediction is also based on $N(a_i)$ in Table 9.1 and is explained in Appendix B to this chapter.

The results of Experiment 2 were consistent with these two predictions. In order to examine the first prediction, Krupka and Weber first removed a small fraction of the dictators who took actions that resulted in allocations with a lower payoff to the dictator than a payoff to the recipient. Then in the bully version, 18 dictators out of 49 (37%) chose the action of "Give 0 dollar/Take 0 dollar." In the standard version, 8 dictators out of 48 (17%) chose the action of giving 5 dollars. The difference was statistically significant at the 1% level. For the second prediction, 31 dictators took

Table 9.1 Elicited norms for fully versus standard dictator environments (Krupka and Weber 2013)

	Standard		Bully	
Outcomes	Action	Mean	Action	Mean
($10, $0)	Give $0	−0.80	Take $5	−0.90
($9, $1)	Give $1	−0.64	Take $4	−0.83
($8, $2)	Give $2	−0.44	Take $3	−0.67
($7, $3)	Give $3	−0.16	Take $2	−0.38
($6, $4)	Give $4	0.14	Take $1	−0.09
($5, $5)	Give $5	0.87	Give $0/ Take $0	0.93
($4, $6)	Give $6	0.57	Give $1	0.48
($3, $7)	Give $7	0.42	Give $2	0.31
($2, $8)	Give $8	0.32	Give $3	0.20
($1, $9)	Give $9	0.22	Give $4	0.10
($0, $10)	Give $10	0.18	Give $5	0.04

1 dollar or more from recipients, and 16 (52%) of them took 5 dollars in the bully version. In contrast, 40 dictators gave 4 dollars or less and 16 (40%) of them gave 0 dollars in the standard version. The difference was statistically significant at the 5% level.

The participants in Krupka and Weber's Experiment 1 also rated actions in terms of norms of other versions of the dictator game conducted by other researchers. The theoretical predictions from these norms were also consistent with the experimental results of the other researchers.

9.4.2 Identity Economics

We have seen that norms can affect economic behavior. Given this, an important observation is that norms can be related to groups such as societies, peoples, religions, and business firms. A group can have different norms from other groups, and different norms cause different behaviors. Therefore, one reason for differences in behaviors across cultures is differences in norms. Norms can vary depending on social contexts, and identity economics proposed by Akerlof and Kranton (2005, 2010) focus on the social context based on social categories such as gender, race, and religion.[8] Identity is a self-image that an individual belongs to a social category. Akerlof and Kranton present various models, but we will consider a model of a utility function by introducing the social category and identity into Eq. (9.1):

$$u(a_i) = V(\pi(a_i)) + \gamma(s)N(a_i) \tag{9.2}$$

where s is the degree of the strength of the self-image (identity) of the individual i's belonging to the social category, and $\gamma(s)$ is an increasing function in s. As an example, consider a social category of gender. Suppose that society has developed norms that some jobs are for men and others are for women. In this situation, if individual i is female and if she takes action to engage in a "man's job", then the norm $N(a_\mathrm{i})$ takes a negative value; if she takes action to engage in a "woman's job", then the norm $N(a_\mathrm{i})$ takes a positive value. If she is talented in a particular "man's job" and even if she can gain a high monetary payoff by engaging in that job, she may not choose that job.

Up to now, we have only considered cases in which one individual belongs to one social category. Many people in the modern world, however, belong to multiple social categories. For example, a Japanese economist belongs to two social categories, "Japanese" and "economists." As a Japanese with a culture of shame, he might feel shame not to make a donation when he is asked to make some. As an

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[8]We will focus on utility of an individual related to identity and behavior in this textbook. Akerlof and Kranton (2010), however, also explain utility felt by an individual related to norms regarding identity of other members of a group. For example, an individual' utility may depend on how other members of his group behave relative to its norms.

economist with a culture of emphasizing economic efficiency, he might feel that he should investigate the most efficient charity before making a donation. Thus, if one individual belongs to multiple social categories, multiple sets of norms affect his behavior. Moreover, if he has just read a book on economics, his identity as an economist may become more salient and may affect his behavior more than his identity as a Japanese. Thus, one identity may be more salient than others, depending on the situation he is exposed to just before making a decision.

An experimental method that can be used in identity economics is *priming* used in psychology. In this method, a task that a participant does just before another task unconsciously affects the behavior in the subsequent task. In order to see how priming is used in economics, we will explain how Benjamin et al. (2010, 2016) used this method. The former paper studied economic effects of ethnic, racial, and gender identities, and the latter paper studied religious identities.

These papers use the following model of identity economics. An individual belongs to a social category c (an Asian American, for example) with strength $s \geq 0$. Let x_0 be the action chosen when the identity is not considered, while x_c be the action which is ideal according to the norm of the social category. An individual who belongs to multiple social categories maximizes

$$U = -(1 - w(s))(x - x_o)^2 - w(s)(x - x_c)^2,$$

where $(x - x_c)^2$ is the utility loss from deviating from the norm's ideal of the social category c, and $(x - x_0)^2$ is the utility loss from taking the action that is affected by norms such as the monetary loss. Here, $0 \leq w(s) \leq 1$ is the weight placed on social category c in the individual's decision, which satisfies

$$w(0) = 0, w' > 0\cdot$$

Namely, if the strength of belonging to a social category increases (if s increases), then the utility cost of deviating from the norm of that category increases and the individual's decision will be more strongly affected by the norm in this model.

Compared with Caucasian Americans, Asian Americans tend to accumulate more human capital and are more likely to participate in tax-deferred savings accounts. Motivated by this observation, Benjamin et al. (2010) tested a research hypothesis that Asian Americans have a norm that values patience more than Caucasian Americans do. For the priming method in the experiment for Caucasian and Asian Americans, the participants answered questionnaires. For one randomly chosen group, the questionnaire included questions about language spoken at home and how many generations their families have lived in the United States. These questions have ethnic meanings, and have an effect of making their ethnic identities more salient. Hence this is called the ethnicity-salience condition. For the randomly chosen other group, the questionnaire did not include any question with ethnic meanings. After answering these questionnaires, they participated in the experiment to measure their time and risk preferences. The Asian American group who received the ethnicity-salience condition displayed a statistically significant tendency to show more patient time preferences than the other group. There is no such tendency for Caucasian Americans. For both ethnic groups, there were no statistically significant differences in the degree of risk aversion. These results are consistent with their research hypothesis that norms of Asian Americans include a norm for patience. Interpretation in terms of the model is that the social category is either Caucasian or Asian ethnicity, and when the priming method increases s, the choice becomes closer to what the norm prescribes. The reason for using the priming method in this type of study is to examine the effect of norms. For example, it is possible that Asian Americans are more patient than Caucasian Americans for a reason unrelated to identity such as heredity. In such a case, the priming method will not yield changes in patient behavior. The fact that the priming method had an effect supports the hypothesis that Asian American identity includes a norm for patience.

9.5 Culture and Worldview

Identity economics introduces important aspects of culture that there are social categories and that people have self-recognition of belonging to social categories into economics. Culture, however, has various other aspects. A relatively new approach to introducing such aspects into theoretical and empirical analyses in economics is to study a culture by the *worldview* behind it.[9] The word "worldview" has been used with many different meanings depending on fields and scholars, but the meaning in anthropology seems especially useful for applications in economics. In anthropology, the concept of worldview includes not only the cognitive aspect such as the origin and the end of the world but also affective aspect (what is viewed as beautiful and *kawaii*, etc.) and evaluative aspects (ethical views and values). Hiebert (2008, pp. 25–26) defines "worldview" in anthropological terms as "the foundational cognitive, affective, and evaluative assumptions and frameworks a group of people makes about the nature of reality which they use to order their lives." Religions greatly affect worldviews, but people belonging to the same religion often have very different parts in their worldviews and people belonging to different religions often have common parts in their worldviews. Because human experiences are given certain formats though our sense organs and brains, we do not recognize all truth. Every person is considered to have a pair of "glasses" to see the world. Every person's worldview glasses are somewhat different from another's, but if one group of people have important common parts in their worldviews, then we can define a culture from the worldview consisting of the common parts.

In order to think about the relationship between a culture and its worldview, we distinguish three parts of culture as in Fig. 9.1, which modifies Hiebert's (2008)

[9]It is said that the word "worldview" was first used by the philosopher Immanuel Kant.

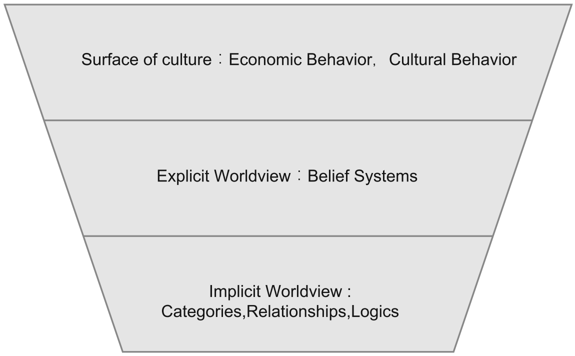


Fig. 9.1 Culture and worldview

Fig. 2.1. On the surface of culture, we have economic behavior and cultural behavior (such as organizing or participating in marriage and funerals). Here we consider everything behind these as the worldview. The worldview is divided into the explicit worldview consisting of belief systems and the implicit worldview, which is the core of the worldview that is usually unconscious. Belief systems are mainly about the conscious cognitive aspect such as whether or not an afterlife exists, or whether or not God or Buddha exists. The deeper core of the worldview includes the cognitive aspect such as whether categories or relationships are emphasized when we recognize things and carry out logic, the affective aspect of what we view as beautiful, and the evaluative aspect of norms, ethics, and values.

In order to collect data about the implicit worldview, we can adapt methods in anthropology into economics. For example, Lee et al. (2013) used the question "Which figure does not belong with the other three figures?" (see Fig. 9.2) in nationwide surveys in Japan, Korea, and the USA. This question is about how people carry out logic. With Western rationalism, a respondent will choose the third one. The basis of Western rationalism is the set theory in which it is important to be able to tell whether or not something belongs to a category. Therefore. the third one is chosen because it is the only smaller figure. As in Fig. 9.3, most Japanese and Koreans chose the third figure, but the fraction of people who chose the third figure in each of these countries was smaller than that in the USA. In Japan, 8% of people chose the first one, and in Korea, 10% of them chose the first one. These people are likely to view the

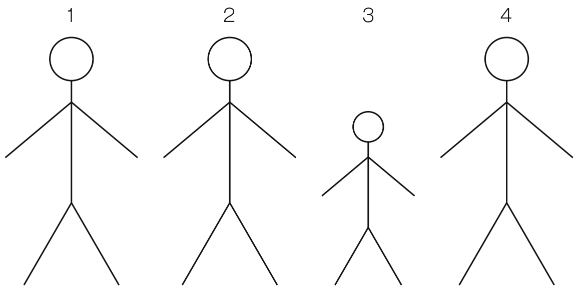


Fig. 9.2 Implicit worldview (*source* Lee et al. 2013)

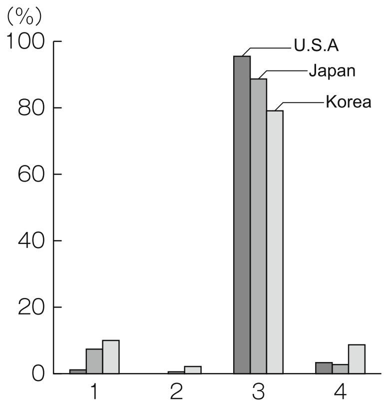


Fig. 9.3 Distributions of answers in Japan, Korea, and USA (*source* Lee et al. 2013)

second, third, and fourth figures as a family. This way to carrying out logic with an emphasis on relationships is called the *relational logic* (Hiebert 2008).[10] In Korea, 9% of people choose the fourth one. This may be because of the strong bond felt between a husband and a wife in the context of interpretation of considering the first, the second, and the third ones as a family. People who chose the second figure were less than 1% in the USA and Japan, but approximately 2% in Korea. One plausible explanation is that the fourth figure was considered as a mother, the third one as a child, and the first figure as a father. Although the connection between a mother and a child is strong, the second figure is a father or mother's mother, and there is some distance between a father and a child plus a mother.

In order to examine how the implicit worldviews are influencing economic behavior, Lee et al. (2013) asked a hypothetical question "If your child is in financial trouble, how much percentage of your income are you willing to give up for him or her?" In Korea, those who choose no. 2 in Fig. 9.2 had a higher (statistically significant) likelihood to answer, "I will not help him or her" than people who choose no. 3. As we have seen so far, implicit worldview has an influence on economic behavior. In the next section, we will examine the empirical analysis on how explicit belief systems would influence economic activities.

9.6 Models of Cultural Transmission

In theoretical research in cultural economics, one of the most important areas is the cultural transmission model, which deals with the transmission of preferences, beliefs, and norms. Bisin and Verdier (2011) present a survey of theoretical as well

[10] R. Nisbett, a social psychologist, captures a similar difference as the difference in the Western and Eastern worlds in the way of cognition when people classify using either categories or relations as in Nisbett (2003, pp. 144–147).

as empirical literature on cultural transmission. The theoretical model of cultural transmission has been in existence since the 1980s. However, Bisin and Verdier's (2000, 2001) seminal analysis includes a general model including decision making of cultural transmission from parents to children, which has been developed by many economists into models applicable to various economic problems. This book puts a particular emphasis on the model of *cultural transmission of preferences*. In this area, a child's preferences are not exogenous but endogenously determined in the model. A parent's choice influences a child's preference development via a certain mechanism. This is related to the research by Guiso et al. (2003) which we discussed earlier. The *tough love model* of Bhatt and Ogaki (2012), which is related to virtue as an important element to consider policies in behavioral economics (Chap. 11), will also be discussed.[11]

9.6.1 Tough Love Model

In the tough love model, a child's patience is endogenously determined. If parents spoil their child by buying snacks and toys when a child is still very young (childhood age), the child would be less patient. The parents wish their child to be persistent so they want to raise the child with discipline ("tough love"), but at the same time, they face temptations to spoil their child. In the framework of traditional economics, a discount factor is exogenously determined genetically, not by upbringing. This hypothesis can be tested by applying the method of behavioral genetic study,[12] comparing identical twins' (with identical genes) and non-identical twins' (with non-identical genes) time discount factors.

In the study of Hirata et al. (2010) conducted at Osaka University using data of twins, 20–25% of the variations of individual discount factors can be explained by genes, and the upper limit of 95% confidence interval is 40%, indicating that upbringing has a substantial influence.

Let us analyze this situation using a three-period model (t = 1: childhood; t = 2: working-age, t = 3: after retirement) of the child. The parent is alive only t = 1 when they transfer the income to the children. Children's consumption in t = 1 is C_1, transfer of income is T, and the child will consume the transferred income, thus:

$$C_1 = T$$

The lifetime utility of the child is expressed as:

$$u(C_1) + \beta(C_1)u(C_2) + \beta(C_1)u(C_3)$$

[11]In this model, for ease of understanding, we simplify the original version. Please refer to Appendix C for the background of the model.

[12]See, e.g., Plomin et al. (2013) for an overview of behavioral genetics.

$u(C_t)$ is a utility function of the child derived from consumption in period t, and $\beta(C_1)$ is a discount factor, which is a decreasing function of consumption of the child in t= 1. In other words, we assume that, the more the parent gives to the child to consume during his childhood (t = 1), the less patient the child will become (the discount factor will be smaller and the future utility becomes less important). The parent's consumption is denoted as C_p, thus the parent's utility function is defined as:

$$u(C_p) + \theta\{u(C_1) + \beta_p u(C_2) + \beta_p^2 u(C_3)\}$$

Under this assumption, θ is a positive real number, which is a parameter to express altruism to the child. The larger θ denotes higher altruism. β_p is a discount factor applied when the parent evaluates lifetime utility of the child and is a reflection of values of the parents. For example, in a classical paper on the theory of saving, Ramsey (1928) argued that it is not ethical to discount future utility. Hence Ramsey set the discount factor to be 1 when analyzing how much of its income should a nation save. If the parent holds the same ethical view as Ramsey, then β_p = 1. In this case, the parent puts equal value on his or her child's present and future selves. In the framework of the tough love model, the discount factor of the parent (β_p) with tough love is 1 or close to it.

First, we consider the decision making of the child. The consumption of the child is defined as:

$$C_3 = (1 + r)(y_2 - C_2)$$

where r is the interest rate and y_2 is an income earning in t = 2 (working-age period). After retirement (t = 3), the child would consume from the savings he or she built up during t = 2. The child will determine C_2 in order to maximize $u(C_2) + \beta(C_1)u((1 + r)(y_2 - C_2))$. For the child, C_1 is exogenous (determined by the parent), so he or she takes $\beta(C_1)$ as given. Accordingly, the child would make the decision over his or her savings in the same manner as the two-period model we discussed in Chap. 6.

Under the standard intergenerational altruism model discussed in Chap. 8, $\beta(C_1)$ is an exogenous and fixed variable, β, which does not depend on C_1, and $\beta_p = \beta$. In other words, compared with the standard model, β in the tough love model differs in two ways: first, the discount factor of the child is endogenously determined; second, the discount factor that the parent used to evaluate the lifetime utility of the child differs from the discount factor that the child uses to evaluate her own lifetime utility. We can interpret β_p as a measure of how patient the parent thinks the child should grow to be. The parent can achieve his goal based on his values by income transfer so that $\beta(C_1) = \beta_p$. At the same time, however, the parent is facing the temptation to spoil the child.[13]

[13]In the tough love model, the temptation is expressed by a trade-off between the parent's values for patience and rises in his utility when the child' consumption rises. This is a different way of expressing temptation than in Gul and Pesendorfer (2001) in Chap. 3.

Let us consider a hypothetical situation: a child goes to a high school where she befriends peers with low patience and as a result, the child also becomes less patient. A child with less patience stops studying and starts engaging in undesirable activities such as spending more time with impatient peers, smoking, and drinking. A strict patient will take some disciplinary actions such as less allowance for the child. In order for the model to be consistent with this kind of change in the parent's behavior, when $\beta(C_1)$ becomes smaller for an exogenous reason, a theoretical result that the parent reduces T needs to hold.

Under the standard model framework, the parent is unable to affect the consumption of the child in $t = 2$ and that in $t = 3$ because he can only make a transfer in $t = 1$ in this model setting. Therefore, the parent only maximizes the weighted sum of his utility and the child's utility in period 1. If β declines for an exogenous reason, the discount factor has an effect only in $t = 2$ and $t = 3$. This is because the parent is unable to affect the consumption of the child if $t \geq 2$. Therefore, the parent only maximizes utilities of him- or herself and the child if $t = 1$. This means that, under the standard model framework, even if β declines T remains unchanged. In other words, even the child becomes less patient because of exogenous factors, the parent does not take any disciplinary actions.

On the contrary, in the tough love model, assume $\beta(C_1)$ declines at each level of C_1 [i.e., the downward shift of the $\beta(C_1)$ function]. Then a parent with high β_p puts high value on making the child patient, so the decline in $\beta(C_1)$ will make the disutility from the deviation from this value larger, which in turn reduces the impact of temptation to spoil the child. Thus, the parent reduces T to improve the condition. In other words, under the tough love model, if the value of β_p is high enough, the parent will take disciplinary action (the reduction of T) against the child in whom patience became weaker because of exogenous reasons.

As we have seen, the tough love model can explain the disciplinary behavior of a parent which cannot be explained in the standard model. In the context of cultural transmission of preferences, the tough model expresses how the values related to the patience of the parent can affect the formation of the child's preference via the change in income transfer (T) during the child's childhood ($t = 1$). A parent with a high β_p thinks that it is better to constrain the child's consumption during childhood to make the child more patient, but also faces the temptation to spoil the child by increasing the child's consumption (the parent wants to increase his own utility by increasing $u(C_1)$. As we will discuss in Chap. 11, this model allows analyzing the policy to promote the virtue of patience.

9.6.2 Tough Love and Cultural Difference

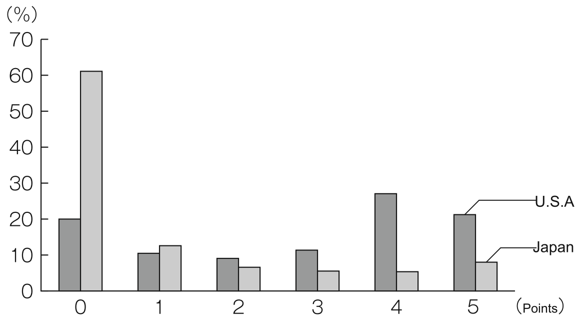
In what follows, as an empirical analysis of the tough love model, we consider the influence of the belief system part of worldview on economic behavior. In today's globalized world, many people from all over the world not only through short-period visits to foreign countries but also thorough various economic transactions have many opportunities to be familiar with different worldviews of different countries and regions. As a result, in modern society, many people can be thought to assign subjective probabilities to various beliefs in different belief systems. This subjective probability can be quantified and numerized. For example, Kubota et al. (2013) used nationwide survey data in Japan and the USA. In these surveys, the respondents were asked to select the value from 1 (You totally agree) to 5 (You totally disagree) for a question "Do you agree with the following ideas?" for ideas such as "Life after death exists." They were also asked to select the value from 1 (It is particularly true for you) to 5 (It doesn't hold true at all for you) same scale was applied to answer the question "Do the following statements hold true for you" for statements such as "I will never be robbed" "I always keep my promise," etc.

Kubota et al. (2013) used the following five spiritual statements: "Spirits and Ghosts exist," "Heaven exists," "Life after death exists," "God or gods exist," and "God knows about all wrong we've done." If the answer is 1 (completely agree) or 5 (completely disagree), then each answer is assigned the score of 1, and otherwise 0. They then calculated the degree of confidence about spiritual worldview beliefs by summing up values from these five questions. As in Fig. 9.4, they find a large difference in the degree of confidence in Japan and the USA. In the USA, the mode (the answer that appears most) of the respondents was 4. The mode in Japan was 0.

They also used questions about six other, non-spiritual statements in order to calculate the degree of confidence about non-spiritual worldview beliefs: (1) What is written in science textbooks is true; (2) Human beings evolved from other living things; (3) I will never be robbed; (4) I always keep my promises; (5) I know a lot about politics; and (6) I have a good memory. Again, when a subject answered 1 or 5, then each answer was assigned a score of 1, and otherwise 0, and they were summed up over the six statements. In Fig. 9.5, the distribution of the score is shown. Once again, the mode in Japan was 0, and was smaller than the mode in the USA of 1.

They added scores from a set of spiritual questions and a set of non-spiritual questions. Figure 9.6 shows the distribution of the summed scores, which they interpret as "degree of confidence". The mode for the USA subjects was 6 and 0 for Japanese respondents. This expresses the cultural difference between the USA and Japan in the degree of conviction in worldview beliefs.

Fig. 9.4 Distribution of "Confidence About Spiritual Worldview Beliefs" (*source* Kubota et al. 2013)



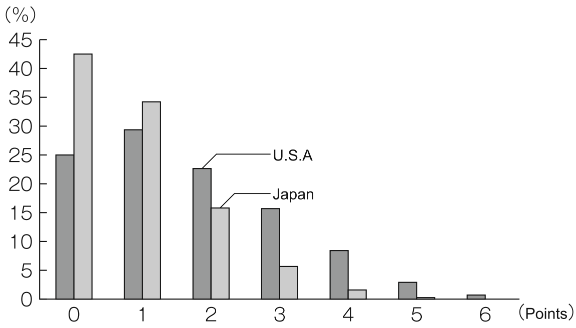


Fig. 9.5 Distribution of "Confidence About Non-Spiritual Worldview Beliefs" (*source* Kubota et al. 2013)

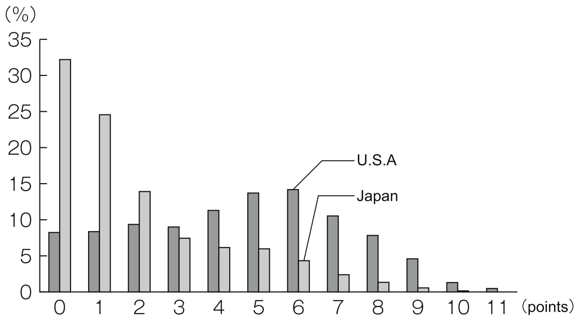


Fig. 9.6 Distribution of "Confidence About Worldview Beliefs" (*source* Kubota et al. 2013)

Kubota et al. (2013) used a hypothetical question ("fever question") from the surveys on the parent's attitude of giving medicines to their children to measure the altruism based on the tough love model described above. The question was

Imagine that you have a 5-year-old child that has a high fever and is in pain. The child's doctor tells you that both the fever and pain are harmless. He can give you a medicine that cures the sickness but slightly weakens the child's immune system when the child becomes 50 years old. What would you do? (Select one).

(1) I would give the medicine to the child if the sickness is known to last for one day.
(2) I would give the medicine to the child if the sickness is known to last for two days.
(3) I would give the medicine to the child if the sickness is known to last for one week.
(4) I would give the medicine to the child if the sickness is known to last for one month.
(5) I would not give the medicine to the child.

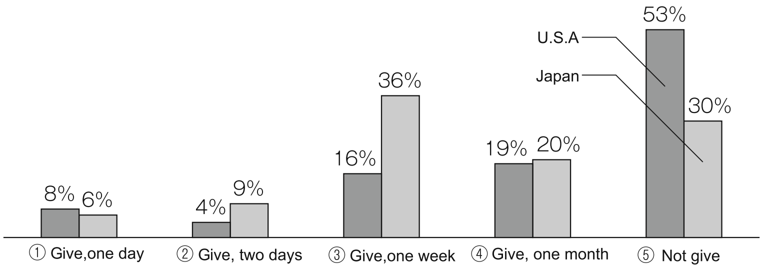


Fig. 9.7 Distribution of "Fever" (*source* Kubota et al., 2013)

Their interpretation of the five answers is as follows. The side effect on the immune system that it becomes weaker when the child becomes an adult is a serious problem in the long-run, so the tough love behavior is (5). People who choose answer (1) must have a conviction that the child should not suffer no matter what. On the other hand, hose who choose (2), (3), and (4) think that it is better not to give the medicine, but yield to the temptation that they do not want to see the child under painful conditions for a long time.

When we compare the answer to this "fever question" between the USA and Japan, American parents are more likely to choose tough love behavior. As Fig. 9.7 shows, in the USA, 53% of parents answered they would not administer the medication to their child, whereas in Japan, only 30% of parents answered as such. This can be interpreted as a cultural difference between the USA and Japan in attitudes towards tough love behavior.

According to the statistical analysis of Kubota et al. (2013), on the individual level, the higher the confidence in his or her worldview beliefs, the higher likelihood that he or she will choose tough love-based behavior. On the country level, people in general have stronger confidence about worldview beliefs in the USA than Japan, which can explain a large part of the behavioral difference between Japan and the USA.

This analysis based on worldview is one example of empirical analysis of the cultural transmission model of preferences where preferences are endogenously formed. As we see in Chap. 11, models with endogenous preference can be useful for policy evaluations in behavioral economics.

9.7 Concluding Remarks

Based on the various theoretical, empirical, and experimental analyses introduced in this chapter, we would like to draw readers' attention to leadership and community when considering the relationship between culture and economics. One of the most striking differences clearly shown in experiments is punishing behavior in public goods game in Herrmann et al. (2008). When high contributors to public goods punish free-riders even when it is costly for them, such punishing is a leadership behavior. So this suggests important cultural differences in leadership behavior. In the tough love model, in a family as a community, behaviors of a parent as a leader of the community influence the utility function of a child. A parent's values on patience and spoiling influence the utility function of a child. An implication of this is that parents, as leaders of communities, have an obligation to ponder seriously and to discuss with other people about their own behavior and values.

Leadership and community have drawn very little attention in the framework of traditional economics. Development of economic theory regarding leadership and its cultural difference is needed for better understanding of why and how people differ in altruistic behavior such as contributing to public goods and of how policies should be shaped, depending on cultural differences.

9.8 Summary and Further Reading

Cultural differences in economic behavior have been found in survey data and experiment data. Differences in norms and worldviews have been used to empirically and theoretically study these cultural differences.

For further reading, Guiso et al. (2006) give a survey of cultural economics. Akerlof and Kranton (2010) give an introduction of identity economics for general readers. Bisin and Verdier (2011) give a survey of the theoretical and empirical literature of cultural transmission and socialization. A recent paper in this literature, Doepke and Zilibotti (2014), studies parenting styles by developing an economic model of parenting and using it to guide their empirical research. Their model focuses on effects of parenting on the child's patience, which is a noncognitive ability. In the field of economics of education, more attention has been paid to noncognitive abilities as in Heckman (2013).

9.9 Questions and Problems

9.9.1 Multiple-Choice Problems

1. Choose the most appropriate answer about two versions (standard and bully) of Krupka and Weber's (2013) dictator game.

   (A) According to the norm data in Experiment 1, we can make a theoretical prediction that the proportion of dictators who shared 10 dollars equally (i.e., 5 dollars, 5 dollars) is higher under the standard version than the bully version.

(B) According to the norm data in Experiment 1, we can make a theoretical prediction that the proportion of dictators who shared 10 dollars equally (i.e., 5 dollars, 5 dollars) is lower under the standard version than the bully version.
(C) In Experiment 2, the proportion of dictators who shared 10 dollars equally (i.e., 5 dollars, 5 dollars) was higher under the standard version than the bully version.
(D) In Experiment 2, the proportion of distributors who shared 10 dollars equally (i.e., 5 dollars, 5 dollars) was lower under the standard version than the bully version.
(E) In Experiment 2, there was no statistically significant difference (at the 5% significance level) between the standard version than the bully version in the proportion of dictators who shared 10 dollars equally (i.e., 5 dollars, 5 dollars).
(F) A and C
(G) A and D
(H) A and E
(I) B and C
(J) B and D
(K) B and E

2. Choose the most appropriate description of regional difference in the outcome of Herrmann et al. (2008) experiment of public goods under N condition (without punishment) and P condition (with punishment).

(A) There was no statistically significant regional difference under both N condition and P condition.
(B) There was statistically significant regional difference under both N condition and P condition, but the regional difference was larger under P condition.
(C) The mean punishment expenditures for anti-social punishment tend to be larger in the region where the mean contribution to the public good is larger.
(D) The mean punishment expenditures for anti-social punishment tends to be larger in the region where the mean contribution to the public good is smaller.
(E) A and C
(F) A and D
(G) B and C
(H) B and D

9.9.2 Short Answer/Essay Problems

1. Define worldview and provide one example where worldview can influence economic behavior.
2. Comment on whether or not the statement "the act of donation for poor people by an economic agent is not rational economic behavior" is true in the following three cases, and explain your answer.
   (A) When the economic agent is a selfish economic man.
   (B) When the economic agent has social preferences.
   (C) When the economic agent has preferences that solely depend on his own consumption in the present and future times, but has a worldview that the probability of more consumption in heaven in the future increases when he makes donation.
3. Explain (using mathematical equations are preferred) the theory of how priming in an experiment to measure time preferences in Benjamin et al. (2010) will influence the choice, via social identity and norms, between two outcomes: one is to receive 3 dollars today and the other is to receive X dollars (X > 3) one week later. Explain the results obtained in the experiment in Benjamin et al. (2010) regarding the influence of priming on the choice of Caucasian Americans and Asian Americans, and discuss how these results are interpreted by the theory you explained.

Appendix 1: Institution and Culture as Equilibria

In this chapter, we discussed an approach where institutions and norms are taken to be exogenous. There is also another approach where how norms and institutions are endogenously determined in economic systems. In this approach, norms and institutions are determined by repeated game, evolutionary game, or one of multiple equilibria as a general equilibrium model of market transactions. In these models, culture is considered to be a part of an institution and treated as an endogenous factor. Examples are Aoki's (2001) Comparative Institutional Analysis; Greif's (2006) Historical and Comparative Institutional Analysis; Cole et al.'s (1992) model of norms; and Alesina and Angeletos' (2005) and Bénabou and Tirole's (2006) models where preferences for income redistribution are endogenously determined. In many of these models, the assumption of selfish economic man is maintained, but an economic man behaves altruistically because of sanctions against behaviors that violate norms that are endogenously determined. Such models are categorized as those in traditional economics. When a model assumes social preferences, or norms to influence endogenous preferences for altruism, it is categorized as one in behavioral economics. Making a distinction between behavioral economics and traditional economics, however, is not important. How to analyze norms, culture, and altruism for what purpose *is* important. In this chapter, we discussed models in which norms are given and exogenous, but an interpretation may be how an individual might act with given norms when the norms are endogenously determined.

Appendix 2: Theoretical Prediction of Krupka and Weber's (2013) Experiments on the Dictator Game

In the text of this chapter, we introduced a theoretical prediction by Krupka and Weber (2013) that, if we restrict our attention to those dictators who take the action that results in higher monetary payoff for them than recipients, then more participants in the bully version will take the action that results in the (10 dollars, 0 dollar) outcome than those in the standard version will take the action which results in the same outcome. In this Appendix, we will explain the reason for this theoretical prediction.

The reason for this prediction can be explained using Table 9.1. In the table, we can see that the cases when the distributor's payoff will be larger are not only (\$10, \$0), but also (\$9s, \$1), (\$8, \$2), (\$7, 3), and (\$6, \$4). If we compare $N(a_i)$ of the action which leads to the last four outcomes and $N(a_i)$ of the action which leads to the first outcome, the absolute value of each of the difference will be smaller under the bully version. In other words, in the bully version, the evaluation for an action which brings an outcome (\$10, \$0) is relatively higher than that in the standard version (i.e., it is easier to take such action). For example, if we compare the difference in $N(a_i)$ between (\$10, \$0) and (\$6, \$4), under the bully version, it is $-0.9 - (-0.09) = 0.81$ whereas in the standard version it is $-0.8 - 0.14 = 0.94$.

Appendix 3: The Background of the Tough Love Model

Because this chapter and Chap. 11 use the tough love model of Bhatt and Ogaki (2012) as an important example, in this Appendix we will explain its background for the deeper understanding of the model. The first author of this book came up with the idea of the model around 2005 and started building a model with Vipul Bhatt, who was a graduate student then. The author spent more than 20 years in the USA and often felt that children in Japan are less disciplined than the ones in the USA, especially when a child is in the pre-school age. For example, in Japan, even when a child is running around in a store and being a nuisance, his or her parent does not say anything, or just say "You will hurt yourself if you are running around" or "You will be scolded by that old man." In comparison, in the USA, parents typically reprimand their child clearly saying, "That is bad" even in a public place with other people around. These observations prompted the author to think that in Japan, people may be thinking that love means accepting everything in a gentle manner; else, parents lack confidence in ethical judgement when they reprimand their children.

According to Nobuta (2009), the term "tough love" originates back in the 1950s, as the wisdom of a self-help group called Al-Anon for wives with alcoholic spouses based on members' tough experiences dealing with their partners' alcoholism. Various efforts of wives to stop their spouse's binge drinking failed. From this experience, wives admit that what they can do is limited. What they did was detachment with love: they cuorageouly let their spouses make decisions to hurt themselves while still kept on watching over them. Thus the concept of tough love came into existence. This is different from the common perception of loving family, i.e., stay close and devote themselves to each other. Many people may think alcoholism is an extreme example and not relevant to them. However, sometimes an extreme example may reveal the universal truth without being bounded by common sense. We believe that the concept of tough love will provide a hint when thinking about the family relationship, especially whether or how to discipline a child.

References

Akerlof, G. A. (1982). Labor contracts as partial gift exchange. *Quarterly Journal of Economics, 97*(4), 543–569.

Akerlof, G. A., & Kranton, R. E. (2005). Identity and the economics of organizations. *Journal of Economic Perspectives, 19*(1), 9–32.

Akerlof, G. A., & R. E. Kranton. (2010). *Identity economics: How our identities shape our work, wages, and well-being*. Princeton: Princeton University Press.

Alesina, A., & Angeletos, G.-M. (2005). Fairness and redistribution. *American Economic Review, 95*(4), 960–980.

Aoki, M. (2001). *Towards a comparative institutional analysis*. Cambridge: MIT Press.

Bénabou, R., & Tirole, J. (2006). Belief in a just world and redistribution policies. *Quarterly Journal of Economics, 121*(2), 699–746.

Benjamin, D. J., Choi, J. J., & Strickland, A. J. (2010). Social identity and preferences. *American Economic Review, 100*(4), 1913–1928.

Benjamin, D. J., Choi, J. J., & Fisher, G. (2016). Religious identity and economic behavior. *Review of Economics and Statistics, 98,* 617–637.

Bisin, A., & Verdier, T. (2000). Beyond the melting pot: Cultural transmission, marriage and the evolution of ethnic and religious traits. *Quarterly Journal of Economics, 115*(3), 955–988.

Bisin, A., & Verdier, T. (2001). The economics of cultural transmission and the dynamics of preferences. *Journal of Economic Theory, 97*(2), 298–319.

Bisin, A., & Verdier, T. (2011). The economics of cultural transmission and socialization. In J. Benhabib, A. Bisin, & M. O. Jackson (Eds.), *Handbook of social economics* (Vol. 1A, pp. 339–416). The Netherlands: North Holland.

Bhatt, V., & Ogaki, M. (2012). Tough love and intergenerational altruism. *International Economic Review, 53*(3), 791–814.

Chun, Y., Kim, J., & Saijo, Y. (2011). The spite dilemma experiment in Korea. *Seoul Journal of Economics, 24*(1), 87–98.

Cole, H. L., Mailath, G. J., & Postlewaite, A. (1992). Social norms, saving behavior, and growth. *Journal of Political Economy, 100*(6), 1092–1115.

Doepke, M., & Zilibotti, F. (2014). Parenting with style: Altruism and Paternalism in intergenerational preference transmission. *NBER Working Paper* 20214.

Elster, J. (1989). Social norms and economic theory. *Journal of Economic Perspectives, 3*(4), 99–117.

Engel, C. (2011). Dictator games: A meta study. *Experimental Economics, 14*(4), 583–610.

Fehr, E., & Gächter, S. (2000). Cooperation and punishment in public goods experiments. *American Economic Review, 90*(4), 980–994.

Funaki, Y., Gächter, S., Ogaki, M., Ohtake, F., & Veszteg, R. (2013). *Punishment in public good games in Japan*. Paper Presented at the Thirteenth International Meeting of the Association for Public Economic Theory.

Gorodnichenko, Y., & Roland, G. (2017). Culture, institutions and the wealth of nations. *Review of Economics and Statistics, 99*(3), 402–416.

Greif, A. (2006) *Institutions and the path to the modern world*. Cambidge: Cambidge University Press.

Guiso, L., Sapienza, P., & Zingales, L. (2003). People's opium? Religion and economic attitudes. *Journal of Monetary Economics, 50*(1), 225–282.

Guiso, L., Sapienza, P., & Zingales, L. (2006). Does Culture affect economic outcomes? *Journal of Economic Perspectives, 20*(2), 23–48.

Gul, F., & Pesendorfer, W. (2001). Temptation and self-control. *Econometrica, 69*(6), 1403–1435.

Heckman, J. (2013). *Giving kids a fair chance*. Cambridge, MA: The MIT Press.

Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H., et al. (2005). Economic man in cross-cultural perspective: behavioral experiments in 15 small-scale societies. *Behavioral and Brain Sciences, 28*(6), 795–815.

Herrmann, B., Thöni, C., & Gächter, S. (2008). Antisocial punishment across societies. *Science, 319*(5868), 1362–1367.

Hiebert, P. G. (2008). *Transforming worldviews: An anthropological understanding of how people change*. Grand Rapids: Baker Academic.

Hirata, K., Iiboshi, H., Hayakawa, K., Ikeda, S., Tsutsui, Y., & Ohtake, F. (2010). *Genetic inheritance of time-discounting behavior: A Bayesian approach using Markov Chain Monte Carlo Method*. Paper Presented at the 2010 Spring Meeting of the Japanese Economic Association.

Hofstede, G. (1984). *Culture's consequences: International differences in work-related values.* Beverly Hills: Sage.

Hofstede, G. (1991). *Cultures and organizations: Software of the mind*. New York: McGraw-Hill.

Inglehart, R. (2000). *Culture and democracy*. In L.E. Harrison & S.P. Huntington (Eds.), *Culture matters: How values shape human progress.* London: Basic Books.

Inglehart, R., & Welzel, C. (2010). Changing mass priorities: The link between modernization and democracy. *Perspectives on Politics, 8*(2), 551–567.

Krupka, E. L., & Weber, R. A. (2013). Identifying social norms using coordination games: Why does dictator game sharing vary? *Journal of European Economic Association, 11*(3), 495–524.

Kubota, K., Kamesaka, A., Ogaki, M., & Ohtake, F. (2013). Cultures, worldviews, and intergenerational altruism. Paper Presented at the European Regional Science Association 2013 Congress.

Lee, S. Y., Kim, B.-Y., Kwon, H. U., Hyoung-Seok, L., Ogaki, M., & Ohtake, F. (2013). Altruistic economic behavior and implicit worldviews. Paper Presented at the 7th Annual Meeting of Association of Behavioral Economics and Finance.

Nisbett, R. E. (2003). *The geography of thought: How asians and westerners think differently… and why*. NY: Free Press.

Nobuta, S. (2009). *Tafu labu to iu kaitou*. Tokyo: Goto Shoin.

Oosterbeek, H., Sloop, R., & Van de Kuilen, G. (2004). Cultural differences in ultimatum game experiments: Evidence from a meta-analysis. *Experimental Economics, 7*(2), 171–188.

Pareto, V. (1980). *Compendium of general sociology*. (Abridged in Italian by Giulio Farina, 1920, from *Tratatto di sociologia generale*. Abbott, E. trans.). Minneapolis: University of Minnesota Press.

Plomin, R., DeFries, J. C., Knopnik, V. S., & Neidertheiser, J. (2013). *Behavioral genetics* (6th ed.). New York: Worth Publisher.

Ramsey, F. P. (1928). A mathematical theory of saving. *The Economic Journal, 38*(152), 543–559.

Roth, A. E., Prasnikar, V., Okuno-Fujiwara, M., & Zamir, S. (1991). Bargaining and market behavior in Jerusalem, Ljubljana, Pittsburgh, and Tokyo: An experimental study. *American Economic Review, 81*(5), 1068–1095.

Saijo, T., & Nakamura, H. (1995). The Spite dilemma in voluntary contribution mechanism experiments. *Journal of Conflict Resolution, 39*(3), 535–560.

Yamagishi, T. (1988). The provision of a sanctioning system in the United States and Japan. *Social Psychology Quarterly, 51*(3), 265–271.

Chapter 10
The Economics of Happiness

Abstract In the economics of happiness, three different concepts of happiness have been used: emotional happiness, life satisfaction, and eudaimonia. Many economists outside this field are concerned about whether or not meaningful interpersonal comparisons of happiness are possible. When we compare results from empirical research with and without interpersonal comparisons, many results are robust while some results are not. Unless we think that all robust results across two types of research are coincidental, the robustness suggests that interpersonal comparisons must be possible at least under some conditions.

Keywords Subjective well-being · Emotional happiness · Life satisfaction Eudaimonia

The economics of happiness is not a branch of behavioral economics but is closely related to it just like identity economics and cultural economics. The economics of happiness is a study of economics that uses measures of subjective well-being. In order to measure subjective well-being, researchers use answers to questions such as "In general, how happy are you?", or "How well are you satisfied with your daily life?" For the answers, different scales are used. For example, the answer can range from 1 to 4: from (1) very happy, (2) a little happy, (3) not very happy, and (4) not happy at all, or can range from 0 to10—from 0 (not satisfied at all) to 10 (very satisfied).

Psychology has a long literature on subjective well-being, but in economics, it is only recently that many economists started analyzing the data of subjective well-being. In 2008, then French President Nicolas Sarkozy established the Commission on the Measurement of Economic Performance and Social Progress. The Commission was chaired by Nobel Prize Laureate Joseph Stiglitz and Amartya Sen, and under their supervision, its aim was to identify the limits of Gross Domestic Product (GDP) as an indicator of economic performance and social progress. The Committee's recommended complementing objective measures such as GDP with some measures of subjective well-being. The OECD (2013) published a very detailed methodological guideline on how to measure subjective well-being. It explains the various concepts of subjective well-being, the method of design questionnaires to

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create subjective well-being measures that are internationally comparable as much as possible. In the future, more data based on questions on subjective well-being would be compiled and analyzed, contributing to the literature of economics of happiness.

In economics, subjective well-being used to be largely ignored, and there are two main reasons. First, traditional economics is based on revealed preference theory, which assumes that preferences would be observed in people's behavior. As such, economists focused on data on behavior, which is an outcome of subjective well-being, and subjective data including subjective well-being was not considered to be very useful for their analysis. On the contrary, behavioral economists use theories that are often inconsistent with revealed preference theory—such as a model where preferences change endogenously (see Chap. 4 for a change in reference point in Prospect theory, and the cultural transmission theory discussed in the previous chapter). For this reason, data on subjective well-being has been actively used by many behavioral economists, including Kahneman. Even among economists who had made a substantial contribution to traditional economics, there is an increasing number of economists such as Nobel Prize Laureate Angus Deaton (e.g., Kehneman and Deaton 2010) who actively use subjective well-being data for the research, and do not adhere to revealed preference theory,

Another reason that traditional economics has not paid attention to subjective well-being is that is it not very clear whether we can meaningfully conduct interpersonal comparisons of subjective well-being. For example, assume that person A answered "very satisfied" and person B answered "a little satisfied". If this answer is to be considered as "utility" in traditional economics, a researcher will face a fundamental problem of whether the interpersonal comparison of utility is possible to begin with. However, Nobel Prize Laureate Harsanyi showed in (1955) that, under certain axioms, it is possible to compare individual utility theoretically. However, even if we follow his axioms and compare individual utility, it is impossible to know whether the utility of person A is truly higher than person B, or whether it is just a matter of individual character or cultural background that person A tends to answer more assertively than person B. As such, we do not have a clear theoretical answer yet to conduct interpersonal comparisons of subjective well-being. For this reason, in this chapter we first introduce studies that do not include interpersonal comparisons, and after more examination, we introduce studies that include interpersonal comparisons.

10.1 Three Concepts of Well-Being

In the economics of happiness, the term "well-being" is used more broadly than in traditional economics, and covers three different concepts: (1) *emotional happiness*, (2) *life satisfaction*, and (3) *eudaimonia*.[1] Emotional happiness refers to the

[1]These are from Frey's (2008, p. 5) concepts of happiness. However, the OECD (2013, Chap. 1) uses the concept of "life evaluation" rather than "life satisfaction"; but these two concepts are essentially identical.

emotional state related to the frequency and the degree of comfort or discomfort related to momentary and/or temporary joy, sadness, and anger. The second one, life satisfaction, is considered relevant to traditional economics' concept of "utility," where evaluating consumption and leisure stands at the center of well-being. The third one, eudaimonia, is a concept that was first proposed by Aristotle, and it essentially translates into "living well" "have good conduct". Eudaimonia is fulfillment a person feels in growing by acquiring virtues and abilities and contributing to a community. In order to achieve eudaimonia, one has to cultivate virtues by practicing them, make it a habit, and live according to virtues (Aristotle 1925, Book II.1; Sandel 2009, Chap. 8).

One way to measure emotional happiness is the experience sampling method (ESM). Specifically, the subject is asked to document comfort and discomfort several times a day, either randomly or at the fixed time. This puts a big burden on the subject. The second method, which puts less burden on the subject, is the Day Reconstruction Method (DRM). This method asks subjects to make a diary of how they spent their time the day before. The results derived by ESM and DRM are consistent (OECD 2013, p. 31). While ESM and DRM measure momentary emotion, some surveys ask questions that are more general and longer-term emotional states, such concerning the previous day, or recent comfort and discomfort.

The second one, life satisfaction, takes a method of asking questions such as "How happy you are with your life?" to gauge the overall life satisfaction, and questions asking specific aspects of their life, such as about job and health. The Self-Anchoring Striving Scale method,[2] which was invented by Henry Cantril, asks the subject to imagine a ladder in steps numbered from 0 at the bottom and 10 at the top, and rate the top of the ladder as being the best possible life and the bottom the worst possible one. And then the respondent is asked which step of the ladder they feel they stand on. Among these three concepts of happiness described above, this concept of life satisfaction is closest to the utility in traditional economics.

More recently, the third definition of happiness, eudaimonia, is attracting attention as a concept of well-being; however, there is no clear consensus on how the question should be formulated to measure this kind of happiness. Huppert et al. (2009) explain a framework that had been used in the third round of the European Social Survey (ESS). Eudaimonia contains various elements, such as interest in learning, goal orientation, a sense of purpose, etc., so questions are asked about those elements. For example, questions on a clear sense of purpose are formulated as "Generally I feel that what I am doing in my life is worthwhile and rewarding", or question-based on the oriented element of goal orientation is "For almost every day of my life, I feel a sense of achievement," etc. The panel survey conducted at Osaka University asks if the respondent has a sense of fulfillment. Kamesaka et al. (2010) use this as a measurement of fulfillment. This can be interpreted as one aspect of eudaimonia.

[2]It is formally called the Self-Anchoring Striving Scale Method.

Kahneman and Deaton (2010) analyzed the first concept (emotional happiness) and the second concept (life satisfaction). Regarding emotional happiness, they measured the respondents' answers such as joy, anger, sadness, stress, and anxiety that they experienced the day before. Regarding life satisfaction (2), they uses Cantril's Self-Anchoring Striving Scale, using a sample of US residents. According to a survey by Gallup, high-income people's marginal emotional happiness would be 0 after income reaches a certain threshold; however, life satisfaction keeps increasing even for high-income people as the income (logarithmic form) increases.

10.2 Research Without Interpersonal Comparisons of Subjective Well-Being

In the economics of happiness, research without interpersonal comparisons of subject well-being has been done by comparing subjective well-being at two or more points in time of one person. In this section, we introduce studies that used panel datasets collected by (1) asking questions to the individual subject at more than two points in time, and (2) the *retrospective evaluation* where the subject is asked to answer the change of subjective well-being from a certain point in the past to the present. Because psychologists are not as skeptical as economists are on interpersonal comparisons of well-being, a large number of studies on objective well-being include interpersonal comparisons. From now on, as panel datasets improve over time, we hope that there will be more studies that compare results with interpersonal comparisons and results without interpersonal comparisons. If some results are robust with and without interpersonal comparisons, then it would be powerful rebutting evidence against the claim that interpersonal comparisons of well-being is meaningless.

In addition, if it becomes clearer when and where the empirical results with and without interpersonal comparisons are consistent with each other, then it will provide a clue for a theoretical study on the interpersonal comparisons of well-being. From this perspective, it is important that the empirical results of the analysis determinants of happiness using cross-section (across-individual) well-being data have been fairly consistent regardless of the stage of economic development of a country.

For example, Graham (2011, pp. 13–14) finds that, regardless of how developed the country a person lives in, losing a job, a divorce, and an unstable personal economic situation would have a negative impact on the degree of happiness, and a stable marriage relationship, sufficient income, and good health would have a positive impact. It is crucial to find out if tests without individual comparison would yield similar results. In what follows, we review studies using panel data on the effect of unemployment, marriage, and divorce on happiness.

10.2.1 How Life Events Influence Happiness

Clark (2003) used a panel data of residents of England. His dataset included emotional happiness and examined how social norms against unemployment affects happiness. Using an empirical technique called the fixed effect model of panel data (see Appendix), he controlled for individual differences.[3] If a person loses a job, it becomes more likely for the degree of happiness to decline. Notably, for a male, the degree of decline becomes smaller when his region has a high unemployment rate, his spouse is also unemployed, and when the "others' unemployment rate" (the unemployment of all the adult members of his household after excluding him) is higher. The result was the same when he did not use the fixed effect model and conducted interpersonal comparisons. Clark interpreted these results by considering a social norm which we discussed in the last chapter, namely, that people should be employed, and if more people around the person are unemployed, the utility declines from deviating from this norm would be smaller.

Clark, Diener, Georgellis, and Lucas (2008) used panel data in Germany over a period of 20 years and examined how life events such as unemployment, marriage, and divorce would affect people's happiness. In the literature, even if a person experiences a big life event that should affect the degree of happiness, *adaptation* where the degree of happiness reverts back to the long-term level is often observed. In their data, there was a question "Taking everything into consideration, how satisfied are you with your current life?" and asked the respondents to rank life satisfaction on a 0–10 scale. They used the fixed effect model for the estimation.[4] The key findings are as follows: first, regarding the effect of unemployment, life satisfaction declines even *before* losing a job, and declines again after losing a job, both with statistical significance. For male respondents, the decline in life satisfaction starts 4 years[5] before losing a job, but for female respondents, it starts when they lose a job. The decline in the life satisfaction after losing a job lasts as long as 5 years for males, but 3 years for females, after which time the decline was not statistically significant. Possible explanations for the decline in life satisfaction before losing a job include the possibility that they foresaw their job loss or they were not satisfied with their job. The adaptation was not observed after losing a job for male respondents.

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[3]See Clark's (2003) Table 4.

[4]The main results reported in this paper treat life satisfaction not as an ordinal number (e.g., 1 is better than 0), but as a cardinal number (not only the order, but the difference such as between 0 and 1 and 9 and 10 also matters). This means that even controlling for individual differences using fixed effects, interpersonal comparisons of life satisfaction are not completely removed. This is because cardinal differences must have the same meaning across persons in regressions. However, they report that even if they treat the life satisfaction as an ordinal number, they obtain similar results.

[5]Because of the nature of the data, "4 years before losing a job" includes "3 years before." For a more detailed explanation, see Table 3 of Clark, Diener, Georgellis, and Lucas (2008) and their explanations in the text for it. In what follows, we use the same definition when we use "before" and "after" a certain event.

Second, regarding the effect of marriage, the statistically significant positive effect on life satisfaction before and after the marriage for both male and female respondents was observed; however, the effect is not persistent. Two years after the marriage, the effect is no longer significant for both male and female respondents, which is an indication that adaptation is taking place. The positive effect of marriage on life satisfaction is statistically significant 3 years before the marriage for males and 1 year for females.

Last, regarding the effect of divorce, life satisfaction declines with statistical significance for both males and females *prior* to the divorce. Again, the negative effect lasts longer for males—statistically significant for 4 years prior to the divorce—but only 2 years for females. However, effects *after* the divorce from the panel data were very different from the robust results from the cross-section data with interpersonal comparisons that the effects of divorce on life satisfaction are negative. Results from the panel data showed positive effects some years after the divorce for both male and female respondents: The life satisfaction statistically significantly *increases* 2, 4, and 5 years after the divorce for male respondents, and 4 and 5 years after the divorce for female respondents. The statistically significant decline in life satisfaction was not observed after the divorce. One interpretation is the reverse causality—i.e., the negative effect of divorce on happiness in cross-section analysis is that people with a lower degree of happiness are more likely to get divorced. This needs further examination.

10.2.2 The Impact of Great East Japan Earthquake on Happiness

The Great East Japan Earthquake in 2011 is still causing damage in various forms—not only direct human and physical damage, but also the aftermath effect of the tsunami and radioactivity. The Great Earthquake shook many Japanese people's worldviews in many aspects such as what really is happiness and how important people around us are in our lives.

Ishio et al. (2014) studied the effect of happiness of the Great Earthquake in March 2011 from data consisting of responses from over 4000 people all over Japan. They analyzed changes in people's happiness before and after the earthquake. They found that a larger number of Japanese people reported an *increase* in happiness than the number who reported a drop in happiness. This counterintuitive result given how devastating the earthquake was may be explained by a large increase in charitable donations which increased by 850% in March 2011 compared to 1 year earlier if we think that reported happiness at least partly reflects eudaimonia. So a possible research hypothesis is that many Japanese people became more altruistic after the earthquake, inducing them to make charitable donations, which in turn made them happier. Ishino et al. (2014) found that data support this research hypothesis.

They used data based on the first Great East Japan Earthquake Special Survey (GEES), Keio Household Panel Survey (KHPS), and Japan Household Panel Survey (JHPS) conducted by the Panel Data Research Center at Keio University. GEES was conducted in June 2011, and the respondents were from those of KHPS and JHPS, two panel data surveys that had existed before the earthquake. For individual happiness, respondents of GEES were asked whether “In general, I think I am happy.” For altruism, they were asked whether “I put other people’s needs before my own”. Each respondent answered using an 11-point scale method (0 indicated “completely disagree”). For each question, the respondents were asked to put their retrospective answer for February in 2011 and when the survey was conducted on the same page (before and after the earthquake), so that they could consciously notice the change between the two periods.

In this study, each variable is categorized as “increased,” “unchanged,” and “declined,” and by using these methods, they avoided using the level of variable and interpersonal comparisons of the change of the level. Using an econometric method called two-stage logit analysis, they found statistically significant evidence for the hypothesis above after allowing for reverse causality.[6]

When a significant event such as a natural disaster occurs, using retrospective survey data measuring the change in happiness and one’s view of the world from before and after the event has pros and cons. Pros include the ease of collecting data other than panel dataset. In the case of an unexpected event, unless one had collected the panel data right before the unexpected event took place purely by chance, a panel data before and after the event took place cannot be collected. Another pro is the change in recognition of happiness and how the worldview of respondents changed would be reflected in the retrospective survey data. For example, assume that the degree of happiness has not changed before and after the event. If we assume that happiness contains a measurement error at two points of the panel data survey, the change in happiness is merely a reflection of measurement error at two data points. On the other hand, if we use retrospective survey data, we will not have a similar problem. One of the cons of retrospective survey data is “retrospection error” when evaluating the past when the survey takes place. How important this problem is can be examined if we have both retrospective survey data and panel data. Because the annual survey of KHPS and JHPS were conducted in January 2011, this was the situation. The main results of Ishino et al. were robust in both retrospective and real-time data. Given this robustness, there seems a large scope for future study on collecting retrospective data after a major event.

[6]The reverse causality is the causality direction that is the opposite from the research hypothesis, e.g., the happier people feel, the more likely they donate. It is possible to remove the bias from this reverse causality by econometric methods such as instrumental variables and two-stage regression methods.

10.2.3 Altruistic Behavior and Happiness

The finding of Dunn et al. (2008) is consistent with the assumption that the act of donation increases the sense of happiness discussed in the last section. Dunn et al. (2008) conducted an experiment to test the hypothesis that happiness would increase when one uses his or her money for others. They surveyed 46 participating students of the University of British Columbia. In the morning, each participant was given either 5 or 20 dollars, and was instructed to use it by 5:00 p.m. on the same day. The participants were randomly divided into two groups: one group was instructed to spend the money on themselves while the other group was instructed to use the money on others (a gift for someone else or a charitable donation). Twice a day— in the morning before the recipients were given the money and after 5:00 p.m. when they had used the money—they were asked to answer questions to rate their happiness. The result showed that happiness statistically significantly increased for the group that spent the money on others. Whether they received 5 or 20 dollars did not make a significant difference. To a different set of 109 students of the same university, they showed this experiment's four conditions (spend 5 or 20 dollars on themselves or on others), and asked the participants to select the condition that would make them happiest. The students' guess was wrong on two grounds. More respondents guessed that they would feel happier when they spent money on themselves rather than on others, and 20 dollars would make them happier than 5 dollars. In other words, students tended to incorrectly think that they would become happier if they spent money on themselves, but they would actually become happier if they spent money on others.

10.3 Research with Interpersonal Comparisons of Subjective Well-Being

Before we introduce the empirical studies that include the cross-individual comparison of well-being, additional factors need to be taken into consideration. In traditional economics, the concept of well-being is utility, and the concept of Pareto optimality, which is widely used in traditional economics, avoids interpersonal comparisons of utility. In the first section, we mentioned that, Harsanyi (1955) showed that, under certain axioms, it is possible to make interpersonal comparisons of utility. However, Diamond (1967) objected to one of the axioms from an ethical perspective. Also, as we have seen in Sect. 10.2, the various indicators of subjective well-being are not designed to capture utility as used in traditional economics. With this in mind, there are three theoretical problems regarding the possibility of interpersonal comparison of well-being. First, whether or not we should accept the axioms of Harsanyi (1955); second, if we cannot accept it, whether or not there is any alternative set of axioms that make it possible to make interpersonal comparisons; third, when the concept of well-being other than utility is used for their research, there is a theoretical problem of whether or not there are interpersonal comparisons of that concept of well-being. This begs for further theoretical research; however, because we know that it is possible to make interpersonal comparisons of one concept of well-being (utility) at least under certain conditions, we cannot simply rule out the possibility of empirical research of comparing well-being across different individuals.

Also, Harsanyi (1955) explains why it is difficult to measure well-being that is comparable across different individuals even if his axioms are satisfied. For example, when a person says that his or her level of life satisfaction is higher than that of other people, we cannot tell if the satisfaction level is indeed higher, or he or she has a psychological tendency to answer those questions more assertively than others. Unfortunately, we do not yet have a convincing enough theoretical answer to the problem. As we discussed in the third section, one of the tasks of empirical research is to compare results involving across-individual well-being comparison and results without such comparison to obtain some clues to such theoretical research.

The Easterlin Paradox, which is well-known in the economics of happiness, involves interpersonal comparisons of well-being. Easterlin (1974) used answers to a three-point rating scale question which asks "Generally speaking, how happy are you?" to construct the indicator of subjective happiness. His cross-section research in the USA found a tendency that people with higher income are likely to have a higher degree of happiness; however, when he conducted time-series analysis, the average degree of happiness did not change even when the income per capita of the country increased over time. This is called the Easterlin Paradox. Easterlin (1974) used only the US data for time-series analysis, but many studies in other countries at different points in time yield similar results as showin in Easterlin (1995) and a survey by Clark, Frijters, and Shields (2008).[7] For Japan, Ohtake et al. (2010, pp. 270–271) found that, despite the six-fold increase in Japan's real GDP between 1958 and 1998, there was no clear increase in life satisfaction.

Easterlin (1974) also showed that there is no clear indication that countries with higher per capita income have a higher average degree of happiness. In many studies that followed, researchers found that the degree of happiness would increase up to a certain income level, but after reaching the level, the degree of happiness did not increase (Graham 2011, pp. 16–17). However, Deaton (2008) used the Gallup world survey on life satisfaction and found a positive and stable relationship between income (in the natural log) and life satisfaction even for high-income countries.

10.4 Summary and Further Reading

In the economics of happiness, three different concepts of happiness have been used: emotional happiness, life satisfaction, and eudaimonia. Many economists outside this field are concerned about whether or not meaningful interpersonal

[7]However, there are some studies which show that the Easterlin Paradox does not hold (e.g., Veenhoven and Hagerty 2006). Life satisfaction has a stronger tendency to increase in response to an increase in income more than subjective happiness does.

comparisons of happiness are possible. When we compare results from research with and without interpersonal comparisons, many results are robust while some results are not. Unless we think that all robust results across two types of research are coincidence, the robustness suggests that interpersonal comparisons must be possible at least under some conditions. More empirical and theoretical research will be fruitful to search for conditions under which interpersonal comparisons of well-bine are possible.

For further reading, Frey (2008) gives a survey of many empirical results about life satisfaction, given this concept of happiness is most closely related to utility in traditional economics. Graham (2011) gives a survey of the empirical literature, and also gives a discussion of how the concept of eudaimonia may be useful for making policy recommendations. This is closely related to what we will discuss in Chap. 11
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10.5 Questions and Problems

10.5.1 Multiple-Choice Problems

1. What is eudaimonia? Choose the most appropriate answer.
   (A) The emotional quality which is strongly associated with instantaneous or temporary positive emotions such as joy, and negative emotions such as sadness, and anger.
   (B) The happiness to live well, by using obtained virtue.
   (C) The degree of overall happiness.
   (D) The concept of happiness corresponding to Kant's Deontology.

2. Choose the most accurate description of the research by Clark, Diener, Georgellis, and Lucas (2008) which used panel data to examine life satisfaction.
   (A) There was a statistically significant positive effect on life satisfaction before and after marriage.
   (B) There was a statistically significant negative effect on life satisfaction before and after marriage.
   (C) Life satisfaction declined before marriage, with no statistically significant effect on marriage.
   (D) The change in life satisfaction was persistent, and the statistical significance lasted 5 years.
   (E) The change in life satisfaction was not persistent, and the statistical significance was lost after 2 years.
   (F) A and D
   (G) A and E
   (H) B and D

(I) B and E
(J) C and D
(K) C and E

3. Choose the most appropriate answer about the experiment of Dunn et al. (2008) with four conditions (spend 5 or 20 dollars on themselves or on others).

(A) Happiness increased for those who spent the money on others rather than in those who spent the money on themselves.
(B) Happiness increased for those who spent the money on themselves rather than in those who spent the money on others.
(C) A significant majority of the participants who were asked to select the condition that would make them happiest selected 20 dollars for themselves.
(D) A significant majority of the participants who were asked to select the condition that would make them happiest selected 20 dollars for others.
(E) A and C
(F) A and D
(G) B and C
(H) B and D

10.5.2 Short Answer/Essay Problems

As described in the text, a larger number of Japanese people experienced an *increase* in happiness than the number who experienced a drop in happiness when they compared their happiness 1 month before the Great East Japan Earthquake and 3 months after the earthquake. State a hypothesis that can explain this result.

Appendix: Fixed-Effect Model

Let us assume that we have a panel data of N number of individuals (or households, countries, or any groups) over period T. In regression analysis, our dependent variable is Y_{it} ($i = 1,\ldots,N$, $t = 1,\ldots,T$) and X_{it} is explanatory variable(s) of k dimensional vectors, β is vectors of coefficients, and u_{it} is error terms. Then we construct a regression model as follows:

$$Y_{it} = \beta' X_{it} + \alpha_i + u_{it}$$

In this specification, α_i is a fixed variable assigned for individual i which does not change over time. In a fixed-effect model, α_i does not have to be orthogonal to X_{it} (i.e., it can be correlated). On the other hand, in a random effect model, α_i and X_{it} should be orthogonal (no correlation).

References

Aristotle (1925) *Ethica Nicomaohea*. Translated by W. D. Ross. Oxford University Press.

Clark, A. (2003). Unemployment as a social norm: Psychological evidence from panel data. *Journal of Labor Economics, 21*(2), 323–351.

Clark, A., Diener, E., Georgellis, Y., & Lucas, R. L. (2008). Lags and leads in life satisfaction: A test of the baseline hypothesis. *The Economic Journal, 118*(529), F222–F243.

Clark, A. E., Frijters, P., & Shields, M.A. (2008). Relative income, happiness, and utility: an explanations for the Easterlin paradox and other puzzles. Journal of Economic Literature, 46 (1), 95–144.

Deaton, A. (2008). Income, health, and well-being around the world: Evidence from the Gallup World Poll. *Journal of Economic Perspectives, 22*(2), 53–72.

Diamond, P. A. (1967). Cardinal welfare, individualistic ethics, and interpersonal comparison of utility: Comment. *Journal of Political Economy, 75*(5), 765–766.

Dunn, E. W., Aknin, L. B., & Norton, M. I. (2008). Spending money on others promotes happiness. *Science, 319*(5870), 1687–1688.

Easterlin, R. (1974). Does economic growth improve the human lot ? Some empirical evidence. In P. A. David Reder, M. W. (Eds.), *Nations and households in economic growth: In honor of moses abramovitz*. Academic Press.

Easterlin, R. (1995). Will raising the incomes of all increase the happiness all? *Journal of Economic Behavior & Organaization, 27*(1), 35–47.

Frey, B. S. (2008). *Happiness; A revolution in economics*. US: MIT Press.

Graham, C. (2011). *The pursuit of happiness; an economy of well-being*. US: The Brooking Institution.

Harsanyi, J. C. (1955). Cardinal welfare, individualistic ethics, and interpersonal comparisons of utility. *Journal of Political Economy, 63*(4), 309–321.

Huppert, F. A., Marks, N. A., Clark, J., Slegrist, A., Stutzer, J., Vittersϕ, & Wahrendorf, M. (2009). Measuring well-being across Europe: Description of the ESS well-being module and preliminary findings. *Social Indicators Research, 91*(3), 301–315.

Ishino, T., Kamesaka, A., Murai, T., & Ogaki, M. (2014). Effects of the Great East Japan Earthquake on subjective well-being. *Rochester Center for Economic Research Working Paper* No. 588. Rochester, NY.: University of Rochester.

Kahneman, D., & Deaton, A. (2010). High income improves evaluation of life but not emotional well-being. *Proceedings of the National Academy of Science, 107*(38), 16489–16493.

Kamesaka, A., Yoshida, K., & Ohtake, F. (2010). Laifu suteiji no henka to danjo no kouhukudo. *Journal of Behavioral Economic and Finance, 3,* 183–186.

OECD. (2013). OECD guidelines on measuring subjective well-being: OECD Publishing, http://dx.doi.org/10.1787/978926419165-en.

Ohtake, F., Shiraishi, S., & Tsutsui, Y. (2010). *Nihon no koufuku-do*. Tokyo: Nippon Hyouron sha.

Sandel, M. (2009). *Justice: What's right thing to do?* Farrar Straus & Giroux.

Veenhoven, R., & Hagerty, M. (2006). Rising happiness in Nations 1946–2004: A reply to Easterlin. *Social Indicators Research, 79*(3), 421–436.

Chapter 11
Normative Behavioral Economics

Abstract In normative behavioral economics, we study how the public sector and private sector should behave. Based on libertarian paternalism, we can use the idea of nudging people in better directions without forcing them. In order to evaluate resource allocation to judge how this nudge tool and other public policies should be used when preferences are endogenous, relying exclusively on welfarism may not be satisfactory in many cases because some preferences may be thought to be better than others. Introducing one of the three major approaches in normative ethics, virtue ethics, into a formal analytical framework of normative economics seems a possible solution to this problem.

Keywords Libertarian paternalism · Nudge · Welfarism · Virtue ethics

Economics has two aspects. One is *positive economics*, which uses the scientific method to analyze neutrally (without any ethical judgment) how scarce resources are allocated. The second one is *normative economics*, which deals with questions that require ethical judgment such as "how we *should* allocate resources," thus cannot be neutral to values.[1] Behavioral economics, as one branch of economics, also has two aspects: *positive behavioral economics* and *normative behavioral economics*. What we have discussed in the previous chapters belong to positive behavioral economics. In this chapter, we are going to overview the literature of normative behavioral economics. Building upon what we already know from the literature, I would like to discuss the future prospect of normative behavioral economics.

In examining where normative behavioral economics are heading, there are two important issues. One issue is what kind of ethical views we are going to use. When we consider how it "should" be, then we need to introduce ethical views in our

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[1]Here it should be noted that positive economics includes theoretical economics. The distinction between empirical analysis (which uses experimental and nonexperimental data) and theoretical analysis is fundamentally different from the distinction between positive economics and normative economics. Also, "norm" in normative economics has a much wider connotation than the norm about the behavior that was explained in Chap. 9.

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argument one way or the other. *The Pareto criterion* is based on values that Pareto improvement is desirable for the overall society without making interpersonal comparisons of utility. In traditional economics, researchers have, in general, used values in the Pareto criterion to conduct research on normative economics. This chapter explains why it is natural to also consider other ethical views in models with endogenous preferences which are often used in behavioral economics. Conventionally in economics, ethical views in the Pareto criterion are considered to be very weak; however, as we will explain, if we compare them with different ethical views, then the Pareto criterion is not necessarily weak.

The other issue is whether or not recommendations of normative economics should be addressed only to the public sector. In traditional economics, an assumption is that the private sector is the set of economic men; consumers selfishly maximize their own utility, and firms maximize their profit. Economic men will not change their behavior even when normative economics makes recommendations to them. As such, the main objects of analysis in normative economics are government and/or public sectors. Normative economists examine how public sectors such as government create collective decision-making mechanisms such as voting and what kind of public policy should be done by government and the public sector. In comparison, in normative behavioral economics, recommendations from normative economics as to how different agents *should* follow can affect economic behavior of not only public sectors but also (1) private sectors such as non-governmental organizations (NGOs) and non-profit organizations (NPOs); (2) corporations pursuing corporate social responsibility (CSR)—some corporations are not only maximizing their profit but also trying to fulfill their social responsibilities; and (3) consumers who have social preferences, prefer to act following norms, or have worldviews that value ethically good behavior.

In this chapter, we first introduce the idea of libertarian paternalism which is behind the various policy methods in behavioral economics, and then we explain the limitation of the Pareto criterion that has been used in the traditional economics. Lastly, we explain virtue ethics that can be introduced into behavioral economics.[2]

11.1 Libertarian Paternalism

The idea of libertarianism takes liberty as the highest value. Among traditional economists, those who emphasize market efficiency are often sympathetic to libertarianism, thus tend to support public policy that respects an individual's freedom of choice. Paternalism is the principle that people with more information should guide people with less information just as a father dealing benevolently and often

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[2]Although we are not going to discuss them in detail in this chapter, results of analyses of how public policies affect resource allocation are very different between models based on behavioral economics and ones based on traditional economics. Please see Appendix 1.

intrusively with his children. Among traditional economists, those who focus on market failure are often sympathetic to paternalism, thus tend to support more intervention by government and central banks which have better knowledge and more information to deal with problems such as unemployment.

In behavioral economics, Sunstein and Thaler (2003) proposed the idea of *libertarian paternalism*. It had been considered that libertarianism and paternalism are incompatible concepts. They, however, were able to integrate these two concepts. In their book for the general audience, Thaler and Sunstein (2008), explained their idea and presented various examples where public policies in which libertarian paternalism can be applied. The libertarian aspect of libertarian paternalism claims that “In general, people should be allowed to do whatever they wish, but if they want to reject an undesirable rule, they should be given the right to opt out (choice to reject) from the rule.” The paternalism aspect emphasizes “It is natural that the government try to adjust individual behavior so that people can live longer, healthier, and better.”

The most important method to implement a policy based on libertarian paternalism is to use “nudge,” which is also the title of their book. The definition of “nudge” in everyday language is to “gently touch people’s side or push gently to obtain his or her attention”. The definition of “nudge” based on libertarian paternalism is to guide people without forcing them.

For example, their book explains the policies that are based on nudge, which influences social norms. The social norm is what is done, should be done, or is allowed to be done in societies and communities they belong to. They focus on the possibility of misperceptions from bounded rationality. For example, alcohol abuse stands out, so it will inflate the perceptions on the number of people who drink alcohol than actually do, which might form a basis of a social norm. The State of Montana in the USA adopted a large-scale educational campaign which is based on the norm using a nudge. By attempting to correct misconceptions that the large majority of college students engage in alcohol abuse, they advertised that “Most (81 percent) of Montana college students have four or fewer alcohol drinks each week.” They also used a similar approach in an advertisement targeted at teenagers. The advertisement claimed that “Most (70 percent) of Montana teens are tobacco free.” This strategy is to influence a norm by correcting misperceptions by surveying the actual behavior of certain groups and publicly announcing the results of surveys. Statistics shows that smoking significantly decreased as a result of this campaign.

Banerjee and Duflo (2011) explain various policies based on libertarian paternalism that are designed for various specific circumstances of low-income countries. They claim that governments (or NGOs and NPOs) should give people freedom of choice; however, they should at the same time promote the policies that they think are the best for as many people as possible. Banerjee and Duflo (2011) point out as an example that diarrhea from polluted water in low-income countries is a serious problem. People should remember to keep disinfecting water; before drinking water, they need to add a few drops of disinfectants to the drinking. Researchers equipped a free chlorine dispenser called “one turn” near the well where villagers come to obtain water, so that when they twist the knob of the equipment, they get the right quantity of chlorine. It has been proven scientifically that this is an effective way to prevent diarrhea.

As we have discussed, in libertarian paternalism, the method of "nudge" is used based on a major premise such as "smoking in unfavorable". When asked "Why is smoking unfavorable?", the answer will be "Because better health is desirable". This should be a strong enough basis for evaluating policies related to smoking of minors. However, when the problem becomes more complicated with conflicting interests—such as a rapidly aging population with low birthrate and the government budget problem associated with it—we need a theoretical framework to evaluate resource allocation resulting from alternative policies, and should be able to explain clearly why a particular policy is desirable.

11.2 The Limitations of Traditional Economics' Framework of Evaluating Resource Allocation

In traditional economics, the standard analytical framework of evaluating resource allocation consists of two parts. Both parts of the framework are based on revealed preference theory, which shows that we can find out actual preferences of people from observing their choice behavior under a set of standard assumptions in traditional economics. Because the framework is based on individual utilities, it can be called the standard framework of welfare economics.

One part of the standard framework evaluates resource allocation in terms of economic efficiency based on the *Pareto criterion*, which states that an allocation is better if one person is strictly better off and no one else is worse off. A formal definition is,

> The Pareto Criterion: Given two allocations x and y, if one person strictly prefers x to y, and if each of all others prefers x to y, then x should be evaluated to be better than y.

If a new allocation is better than the original allocation in terms of the Pareto criterion (say, because of a policy change), then the change is a *Pareto improvement*. An allocation is *Pareto efficient* if there is no possibility for any Pareto improvement. The very important theoretical result in this framework is *the first theorem of welfare economics*. This theorem states that under the assumption of perfect competition (an individual consumer or company cannot influence the market price) and no externalities (an individual's consumption and a company's production does not affect another consumer's or company's utility or production), the resource allocation in general equilibrium (demand equals supply in all markets) is Pareto efficient. One advantage of this approach is that it avoids interpersonal comparisons of utility, which was discussed in Chap. 10.

The other part of the standard framework can incorporate considerations other than economic efficiency such as income inequality based on the *social welfare function* (SWF). In an economy with N number of consumers, let the individual i's utility function under a certain resource allocation be u_i, (i = 1…N). In this framework, an allocation with a higher value of the SWF, $W(u_1, u_2, \ldots, u_N)$, is evaluated to be socially more desirable. For example, if we adopt J. Bentham's utilitarianism whose ethical basis is "the greatest happiness of the greatest number," then the social welfare function is

$$W(u_1, u_2, \ldots, u_N) = u_1 + u_2 + \cdots + u_N$$

This utilitarian SWF assumes that interpersonal comparisons of utility are possible. A SWF that does not require interpersonal comparisons of utility is the Nash SWF:

$$W(u_1, u_2, \ldots, u_N) = (u_1 - \overline{u_1})(u_2 - \overline{u_2})\ldots(u_N - \overline{u_N})$$

where $\overline{u_i}$ is the utility of i in one of the worst cases for all individuals such as a world nuclear war in which everyone dies. This does not require interpersonal comparisons in the sense that a positive linear transformation of any individual utility does not change the evaluation ranking based on this SWF.[3] Another example is the maxmin (or maximin) SWF:

$$W(u_1, u_2, \ldots, u_N) = Min\{u_1, u_2, \ldots, u_N\}$$

When this SWF is maximized, the utility of the least fortunate person is maximized. So it represents an egalitarian view.

Many SWFs such as the utilitarian and Nash SWFs satisfy the Pareto criterion and evaluate resource allocation based solely on individual consumer's utility: the ethical view incorporated by these SWFs is called *welfarism*. On the other hand, the maxmin SWF does not satisfy the Pareto criterion because even if one person's utility strictly increases in a new allocation more than the original allocation, the value of the maxmin SWF does not change unless the utility of the least fortunate changes. As we will see in the next section, the maxmin SWF, which does not satisfy the Pareto criterion, can be viewed as a way of expressing an ethical view that is different from welfarism. The maxmin SWF, however, still satisfies a weaker version of the Pareto criterion:

> The Weak Pareto Criterion: Given two allocations x and y, if everyone strictly prefers x to y, then x should be evaluated to be better than y.

[3] Kaneko and Nakamura (1979) proposed the Nash SWF.

The SWF is required to satisfy this weak Pareto criterion.

If we can directly apply this framework to behavioral economics without any modification, then we do not have to build a new framework. Unfortunately, however, the literature points out various problems in directly applying the framework (for example, Beshears et al. 2008 and Kőszegi and Rabin 2008). One cause of problems is bounded rationality: if we consider bounded rationality, the data on selection behavior is influenced by factors such as selectors' misconceptions, so we cannot precisely find out his or her preference. Another cause of problems is that preferences are not viewed as exogenous and stable in behavioral economics as we emphasized in Chap. 1. In Prospect theory, the reference point is endogenously determined for example by each period's initial endowment, which is endogenously determined in dynamic economic theory. Thus, prospect theory is one example of a model with endogenous preferences. The cultural transmission of preference model (Chap. 9) is another example of the model with endogenous preferences.

Bhatt et al. (2017) point out that there are two main issues in applying the framework in traditional economics to models with endogenous preferences. First, preferences that change with endogenous economic variables cannot be used as a yardstick for evaluation of allocation. For example, a change in tax policy can cause a change in consumption of addictive goods such as tobacco, and a change in consumption in turn can change preferences for addictive goods. Then we cannot use changing preferences to evaluate whether or not a change in tax policy is good for society. Second, many people seem to have an ethical view that some preferences are better than others in moral terms. For example, preferences without addiction may be considered better than preferences with addiction. Preferences with more patience and more altruism may be considered better than preferences with less patience and less altruism. If so, a role of normative economics is to provide an analytical framework to incorporate such a view, so that economists can advise those people with such a view how to promote better preferences based on theoretical and empirical insights obtained from models with endogenous preferences.

As for the first issue with endogenous preferences, a good solution was found a long time ago by Pollak (1978). Pollak examined a *habit formation model* as an example of a model with endogenous preferences (see Appendix 2). In a model with endogenous preferences, when an individual's given state variable (e.g., the reference point in the habit formation model) changes, his preferences change. The preference ordering which takes the state variables as given is termed *conditional preferences*, whereas the preference ordering which takes changes in state variables into consideration is termed *unconditional preference*s. In Pollak's approach, unconditional preferences are employed in the traditional economics' frameworks of Pareto efficiency and SWF.

An example is Becker and Murphy's (1988) rational addiction model. We consider a simplified version of the model with two periods ($t = 0, 1$). There are two goods: an addictive good (a_t) and a non-addictive good (c_t). The utility function in each period is

$$u_t = u(c_t, a_t, S_t) \tag{11.1}$$

where S_t is the stock of past consumption with the depreciation rate of d:

$$S_t = (1 - d)S_t + a_t. \tag{11.2}$$

Here the marginal utility of the addictive good is assumed to increase with this stock. The consumer maximizes the discounted lifetime utility $u_0 + \beta u_1$. Assume $S_0 = 0$ for simplicity, so that $S_1 = a_0$ is the state variable for period 1. Then the unconditional preference ordering can be represented by

$$U(c_0, a_0, c_1, a_1) = u(c_0, a_0, 0) + \beta u(c_1, a_1, a_0) \tag{11.3}$$

while the conditional preference ordering when S_1 takes a particular value Q can be represented by

$$U(c_0, a_0, c_1, a_1 | S_1 = Q) = u(c_0, a_0, 0) + \beta u(c_1, a_1, Q) \tag{11.4}$$

Thus, the unconditional preference ordering takes into consideration how a_0 affects not only the utility in period 0 but also the utility in period 1 through its effect on the stock in period 1. On the other hand, given the value of the stock in period 1 is Q, the conditional preference ordering is used to make optimal choices of consumption of the two goods in period 1.

As another example, in the tough love model that was introduced in Chap. 9, the parent's utility function can be described as:

$$U_p\left(C_p, C_1, C_2, C_3\right) = u\left(C_p\right) + \theta\left\{u(C_1) + \beta_p u(C_2) + \beta_p^2 u(C_3)\right\} \tag{11.5}$$

The parent's preference ordering is assumed to be exogenous. A utility function which represents the unconditional preference ordering of the child can be represented by:

$$U_k(C_1, C_2, C_3) = u(C_1) + \beta(C_1)u(C_2) + \beta(C_1)^2 u(C_3) \tag{11.6}$$

On the other hand, the conditional preference ordering of the child changes with T (income transfer from the parent, which is a given state variable for the child): the utility function that represents the conditional preference ordering is:

$$U_k(C_1, C_2, C_3 | T) = u(C_1) + \beta(T)u(C_2) + \beta(T)^2 u(C_3) \tag{11.7}$$

Thus, the unconditional preference ordering takes into consideration how childhood consumption C_1 affects not only the utility in period 1 (the childhood period) but also the discount factor for the utilities in period 2 (the work period) and period 3 (the retirement period). On the other hand, given the value of the parent's transfer in period 1 is *T*, the conditional preference ordering is used to make optimal choices of consumption in periods 2 and 3.

As Pollak (1978) has argued, the conditional endogenous preference ordering cannot be used for evaluating resource allocation in the standard framework of welfare economics because they change endogenously in the economic system. The unconditional preference ordering is exogenous and fixed, and we can apply the framework to this preference ordering.

The second issue remains, however. Many people may have an ethical view that some conditional preferences are better than others. For example, consider a problem of deciding the tax rate for the rational addiction model in the example above when the allocation is determined in perfect competition. When we apply the first fundamental welfare theorem to the model without any externality, we conclude that the optimum tax rate is zero. However, many people seem to argue that high tax rates for tobacco are desirable even when the externality is minimal through separation policies. This seems to suggest that many people have an ethical view that it is better not to form preferences with addiction. Similarly, many people may have an ethical view that it is better for the next generation to have patient preferences than impatient preferences in a situation described by the tough love model. This issue that some preferences may be evaluated to be morally better than others was discussed by Sen (1974) among others. When some preferences are preferred more than others, such preferences over preferences can be called *meta-preferences*.

11.3 Three Ethical Views

In order to consider further about our argument in the previous section that the issue of meta-preferences has been ignored in the standard framework of welfare economics, we will discuss the main approaches in normative ethics in this section. Normative ethics is the field to theorize many people's ethical views, so will be useful for our purpose.

In normative ethics, there exist three main approaches. One is *consequentialism*, which only evaluates consequences of actions of individuals. This approach includes utilitarianism and other forms of welfarism. The concept of well-being associated with welfarism in economics is utility. The second approach is *deontology*, which emphasizes moral duties. The third major approach is *virtue ethics*, which emphasizes the moral character of people and cultivation of virtues. The concept of well-being in virtue ethics is eudaimonia, discussed in the previous chapter.

The important aspects of the first two approaches have been investigated in economics, while virtue ethics has been largely ignored in economics. Utilitarianism and other forms of welfarism have been incorporated into the SWF as discussed in the last section. For deontology, Immanuel Kant is widely regarded as the most prominent contributor. Sandel (2009, Chap. 5) argues that Rawls' (1971) theory of justice develops a form of social contract of Kant's deontology. Some of the important aspects of Rawls' egalitarian view in his theory are incorporated in the maxmin SWF.[4]

The issue of meta-preferences is closely related to virtue ethics. It is virtuous to be pleased about what we should be pleased about. Many people's ethical views about meta-preferences such as preferences with less addiction and more patience can better be viewed as based on virtue ethics.

11.4 Introducing Virtue Ethics into Normative Economics

Given the need to incorporate meta-preferences and the close relationship between virtue ethics and meta-preferences discussed so far, one way to proceed is to introduce virtue ethics into normative economics. This section explains the framework of Bhatt et al. (2017), which consists of two parts.

11.4.1 Criteria for Virtue Ethics

In the first part, they propose to modify the weak Pareto criterion given that introducing virtue ethics means that welfare considerations in the weak Pareto criterion based on the unconditional preference orderings cannot always dominate the ethical consideration of virtue ethics:

> The Modified Weak Pareto Criterion: Given two allocations x and y, if everyone strictly prefers x to y, then x should be evaluated to be better than y for society as long as x is not evaluated to be worse than y in terms of other ethically relevant factors.

The conditional statement implied by "as long as" in this criterion allows for the possibility that other ethical considerations such as virtue ethics may outweigh the purely welfarist considerations. For example, even if everyone prefers the no government regulation for highly addictive drugs in terms of utilities, it may be morally better to regulate them if we think preferences with less addiction are morally better.

Bhatt et al. introduce virtue ethics through the idea of meta-preferences for the conditional preference orderings:

[4]Because the maxmin SWF satisfies the weak Pareto criterion, it is possible to classify it as welfarism. Here, we are emphasizing that the maxmin SWF does not satisfy the Pareto criterion and that it captures at least some important aspects of Rawls' egalitarian view.

The Criterion of Virtue Ethics: Given two allocations x and y, if at least one person's conditional preference ordering is strictly better in terms of virtue ethics and everyone else's conditional preference ordering is at least as good in terms of virtue ethics in x than in y, then x should be evaluated to be better than y for society.

Just as the pure welfarist view may imply extreme recommendations such as no regulation for highly addictive drugs, the pure virtue ethics may imply extreme recommendations that ignore utilities of people for the sake of cultivating virtues. Bhatt et al. modify the above criterion to allow for the possibility that the other ethically relevant factors such as welfarism may outweigh the considerations of virtue ethics:

The Modified Criterion of Virtue Ethics: Given two allocations x and y, if at least one person's conditional preference ordering is strictly better in terms of virtue ethics and everyone else's conditional preference ordering is at least as good in terms of virtue ethics in x than in y, then x should be evaluated to be better than y for society as long as x is not evaluated to be worse than y in terms of other ethically relevant factors.

11.4.2 Moral Evaluation Function and Social Objective Function

The second part of the framework of Bhatt et al. (2017) consists of two functions that supplement the SWF. Let x be an allocation of an economy with N individuals, $U_i(x)$ be the utility function of individual i, and $\varphi_i(x)$ be a function that expresses properties of the endogenous utility function of i. Let $W(U_1(x), U_2(x), \ldots, U_N(x))$ be the SWF. They define $M(\varphi_1(x), \varphi_2(x), \ldots, \varphi_N(x))$, the *moral evaluation function* (MEF), as a function that evaluates $(\varphi_1(x), \varphi_2(x), \ldots, \varphi_N(x))$ in terms of virtue ethics such as deviations of these properties from virtue. The MEF is required to satisfy the criterion of virtue ethics. They define $S(W(x), M(x))$, the *social objective function* (SOF), as a function that evaluates allocations by considering both virtue ethics and welfarism. The SOF is required to satisfy both the modified weak Pareto criterion and the modified criterion of virtue ethics.

For example, Bhatt et al. consider the rational addiction model in Sect. 11.2 in which there are N identical individuals in the economy. They define the SWF as

$$W(c_0, a_0, c_1, a_1) = u(c_0, a_0, 0) + \beta(u(c_1, a_1, a_0)), \tag{11.8}$$

from the utility function for the unconditional preference ordering in (11.5). In order to define the MEF, we need to specify the property of endogenous utility functions evaluated by the MEF and define virtue for that property. The relevant property in the model is addiction stock, and virtue of no addiction is obtained when the addiction stock is zero. Hence the MEF can be defined by

$$M(c_0, a_0, c_1, a_1) = f(a_0) \tag{11.9}$$

where $f(a_0)$ is a function that takes the unique maximum value at $a_0 = 0$. The shape of this function depends on meta-preferences of the evaluator (e.g., a voter or a government leader who is evaluating alternative policies).

As another example, Bhatt et al. consider the tough love model in Sect. 11.2, in which there are N identical parent–child pairs in the economy. For this model, the relevant property of endogenous utility functions evaluated by the MEF is the child's discount factor, and virtue of patience is obtained when the child's discount factor is exactly one: $\beta(C_1) = 1$. This condition is consistent with the argument by Ramsey (1928) and many other economists and philosophers that the time-discounting rate should be zero. Under this condition the child puts equal importance on her future self as on her present self. If $\beta(C_1) < 1$, she cannot imagine the future sufficiently, so she neglects her future, which would lead to insufficient patience. If $\beta(C_1) > 1$, she puts more importance on her future self than on today's self, which is excessive patience. Virtue is a mean between two extremes.

Bhatt et al. give examples of the MEF, SWF, and SOF for the model. Their MEF is

$$M(C_P, C_1, C_2, C_3) = -(\beta(C_1) - 1)^2. \tag{11.10}$$

Their SWF is a utilitarian one:

$$W(C_P, C_1, C_2, C_3) = U_1(C_P, C_1, C_2, C_3) + U_2(C_1, C_2, C_3). \tag{11.11}$$

Their SOF is

$$S(C_P, C_1, C_2, C_3) = (M(C_P, C_1, C_2, C_3) - \bar{M})^{\alpha}(W(C_1, C_2, C_3) - \bar{W})^{1-\alpha}, \tag{11.12}$$

where $\bar{M}$ and $\bar{W}$ are the value of the MEF and the value of the SWF in the worst case senario, respectively, and $0 \leqq \alpha \leqq 1$. If $\alpha = 0$, the SOF is identical to the SWF, and virtue ethics is ignored. If $\alpha = 1$, the SOF is identical to MEF, and unilateralism is ignored. A balanced view that combines moral virtue ethics and unilateralism can be expressed by an intermediate value of α ($0 < \alpha < 1$).

11.4.3 How Optimal Government Policies Change When Virtue Ethics Is Introduced

Bhatt et al. (2017) analyzed how optimal government polices change when virtue ethics is introduced for the rational addiction model and the tough love model in the last subsection. The rational addiction model gives an example in which introducing virtue ethics results in more government intervention. The tough love model gives an example in which introducing virtue ethics results in less government intervention. Thus, it is necessary to distinguish between whether virtue ethics should be taken into consideration and whether the government should intervene in preferences of people.

For the rational addiction model, Bhatt et al. show that the optimal tax rate for the addictive good is nonzero as long as the derivative of the SOF with respect to the MEF is nonzero unless the economy happens to satisfy specific conditions by chance.

In the tough love model, the government policy tool in their model is the bequest tax rate (see Appendix 3 for details of a simplified version of their model). In their model, the parent thinks that child should grow to be as patient as attaining his norm of β_p. For example, if the parent in the model thinks that his child should obtain the virtue of patience, his norm will be $\beta_p = 1$. Because the child's childhood consumption (C_1) is determined by his income transfer (T), he can choose the level of T, so that the child attains β_p. He is, however, tempted to spoil the child by giving more childhood consumption. Instead of giving much income transfer for childhood consumption, he can save the money to leave a larger bequest for the child's consumption after she grows up. When the bequest tax rate is high, he is more tempted to spoil the child.

In the model, the parent's utility is maximized when the bequest tax rate is zero. In the numerical example of Bhatt et al., the child prefers to be spoiled at this tax rate. As a result, the SWF that adds both parent's and child's utilities is maximized at a positive tax rate, so that the parent is more tempted to spoil the child. So the optimum tax rate is positive (20% in their example) when virtue ethics is ignored ($\alpha = 0$). When we introduce virtue ethics by putting a positive weight on the MEF by increasing α, the optimum tax rate that maximizes the SOF starts to decrease. In the numercal example of Bhatt et al., the optimum tax rate becomes zero when $\alpha = 0.05$.

11.5 The Principle of Learning to Unconditionally Love

Because virtue ethics is one of the three major approaches in normative ethics that has been largely ignored in economics, it is a natural task for normative economics to build an analytical framework to introduce virtue ethics as described in the last section. Because mathematical economic models can sometimes clarify various aspects of difficult philosophical problems in ways that are not possible by any other method, thinking about how the three major approaches can be integrated and whether virtue ethics should be considered for government policies is a possibly important task of normative economics.

Bhatt et al. (2015) tackled this ambitious task, using the framework to introduce virtue ethics developed in an earlier version of Bhatt et al. (2017). They propose the principle of learning to unconditionally love for the purpose of integrating the three major approaches in normative ethics. In this principle, the moral duty of unconditional love of any person is taken as the ideal from deontology, but anyone who cannot always unconditionally love any person is taken to be in a learning stage. During the learning stage, it is good for a person to learn to acquire virtues, but is also good to attain high enough utilities that the person can keep on learning. If so, it is good for the government policies to promote learning to unconditionally love, which means virtue ethics should be part of the ethical views that guide the evaluation of policies.

11.5.1 Unconditional Love and Virtues

Bhatt et al. start with the discussion in the previous section that one problem in models with endogenous preferences is that preferences do not give the perfect yardstick for evaluating resource allocation. The conditional preference orderings are endogenous and cannot serve as a fixed yardstick. The unconditional preference ordering is exogenous and fixed, and can serve as a yardstick. Given that some conditional preference orderings may prefer different allocations than the unconditional preference ordering, the unconditional preference ordering is a convenient yardstick but may not give the final answer to all ethical problems.

They propose unconditional love as an alternative yardstick for evaluating resource allocation. Unconditional love is not just an emotional feeling but a means to unconditionally will the good of another, regardless of the nature of the relationship. If everybody unconditionally loves other people, various economic problems such as environmental problems, budget problems and poverty, etc., will all be solved. For problems such as chains of hatred (e.g., terrorism and retaliation), rationally speaking, there is no real solution other than unconditional love, when people love even their enemies.

Unfortunately, however, the reality is far from such an idealistic situation (i.e., everybody unconditionally loving other people). Analyzing policies based on the idealistic situation is very unlikely to lead us to realistic and effective policy recommendations. As such, they propose the principle of learning to unconditionally love in order to evaluate policies, which will bring us closer to our ideal. If we take it as given that all of us (or at least most of us) cannot unconditionally love others, then we can evaluate policies to facilitate learning of unconditional love as good policies.

Even though many people may agree on a rational level that unconditional love is desirable, we as human beings are exposed to many tempting distractions. Thus, understanding the concept and its virtue is not enough; we must learn from the actual exercise of unconditional love.

In order to see how this works in an economic model, Bhatt et al. (2015) use an endogenous altruism model à la Mulligan's (1997) model. Mulligan proposed a model of endogenous altruism within and beyond the family where a decision maker invests in resources to become more altruistic. These resources are typically in terms of time and effort—for instance, time spent interacting with a child or doing volunteer work to help other people. A version of the model of Bhatt et al. is a case of three people, the parent, the child, and a stranger. The parents' social preferences are assumed to be:

$$u(C_P) + \theta_K(R_K)u(C_K) + \theta_S(R_S)u(C_S) \tag{11.13}$$

where C_P, C_K, and C_S, denote consumption of the parent, the child, and the stranger, respectively. Here $\theta_K(R_K)$ is a function of endogenous altruism of the parent for his child, and R_K represents the resource that the parent spends for the child such as time spent with the child. The virtue of family altruism in this model is defined as $\theta_K(R_K) = 1$. When this virtue is obtained, the parent regards the utility of the child as being equivalent to his own utility. Similarly, $\theta_S(R_S)$ is a function of endogenous altruism of the parent toward the stranger, and R_S represents a resource that the parent spends for the stranger, such as volunteer time. The virtue of altruism toward the stranger is defined as $\theta_S(R_S) = 1$. When this virtue is obtained, the parent regards the utility of the stranger as being equivalent to his own utility. Unconditional love by the parent in this model is defined as $\theta_K(R_K) = \theta_S(R_S) = 1$, when both virtues are obtained by the parent.

11.5.2 A Model of Work–Life Balance

Bhatt et al. (2015) use a special case of (11.13) without the stranger to analyze optimal policies for work–life balance. They consider a two-period economy with three agents: a representative parent, a representative child, and the government. The parent's utility is given by

$$u(C_P) + \theta_K(R_K)u(C_K) \tag{11.14}$$

In the first period, the parent's input of L generates an output which is denoted by Y:

$$Y = F(L) \tag{11.15}$$

where $F(L)$ is a production function. The time constraint for the parent is given by

$$R_K + L = 1 \tag{11.16}$$

where the total time available is normalized to be 1.

In the second period, the parent chooses to divide his income Y between his own consumption (C_P) and transfer to the child (T), which is assumed to be equal to the child's consumption (C_K). The government collects income tax at a rate of τ and provides a lump-sum subsidy of z. Hence the budget constraint of the parent is

$$(1-\tau)F(1-R_K) = C_P + T \tag{11.17}$$

They assume that the lump-sum subsidy is given such that the government budget is balanced. In the second period, the parent maximizes (11.14) the subject to (11.18) by choosing C_P and T given his choices of R_K and L in the first period and given τ. In the first period, the parent maximizes (11.14) the subject to (11.16) by choosing R_k and L given the function of optimum levels of C_P and T for each combination of R_k and L.

For their numerical example, Bhatt et al. define the SWF as

$$W(C_P, C_K, R_K, T) = u\left(C_p\right) + u(C_K) \tag{11.18}$$

which is a utilitarian SWF. Their MEF is

$$M(C_P, C_K, R_K, T) = -(\theta(R_K) - 1)^2, \tag{11.19}$$

such that the larger deviations from the virtue of altruism are evaluated to be morally undesirable. They define the SOF by

$$S(C_P, C_K, R_K, T) = (M(C_P, C_K, R_K, T) - \bar{M})^{\alpha}(W(C_P, C_K, R_K, T) - \bar{W})^{1-\alpha}, \tag{11.20}$$

where $\bar{M}$ and $\bar{W}$ are the value of the MEF and the value of the SWF in the worst-case scenario, respectively.

In their numerical example, the optimum income tax rate that maximizes the SOF is −20% when zero weight is placed on the MEF ($\alpha = 0$). This means that the government subsidizes production by the negative income tax rate. On the other hand, the optimum tax rate is 0% when $\alpha = 0.4$. The optimum income tax rate becomes positive when a higher weight is placed on the MEF.

Thus, when material satisfaction measured by utility is the only concern for the government, the government policy may encourage production at the cost of parents spending less time with their children and such a policy may have an effect of making parents less altruistic toward their children even if the policy does not have such intentions. When the government's evaluation of its policies includes concern about the family communities, this may imply less government intervention.

11.5.3 A Model of Volunteering

Another numerical example in Bhatt et al. (2015) uses (11.13) to analyze optimal policies when volunteering opportunities are added to the model in the last subsection. They consider a two-period economy with four agents: a representative parent, a representative child, a representative disabled stranger, and the government. The parent's utility is given by (11.13). In the first period, the time constraint for the parent is given by

$$R_K + R_S + L = 1 \tag{11.21}$$

where the total time available is normalized to be one. In the second period, the parent chooses to divide his income Y into his own consumption (C_P), transfer to the child (T), and donation to the stranger (D).

A similar analysis for optimal policies for this model as in the last subsection shows a tradeoff between encouraging production for material satisfaction versus promoting stronger bonds in the family community and the larger community including a non-family member.

This model may be useful for thinking about a trade-off between economic efficiency and community building. For example, Habitat for Humanity is a global nonprofit housing organization and one of its activities is to send volunteers from high-income countries to low-income countries in order to build houses. From the pure economic efficiency point of view, this does not make sense given that it is cheaper to send money to hire enough carpenters to build houses in low income countries. If we introduce the point of view of virtue ethics, this can promote deeper bonding of the global community by encouraging people in high-income countries to become more altruistic toward people in low-income countries.

11.6 Public Policies and Virtue Ethics

Theoretical considerations about virtue ethics and the principle of learning to unconditionally love suggest a new way to look at some existing policies. One example is marriage as a form of contract. The romantic feeling is emotion and fades away sooner or later. When there still is a romantic feeling between the two people, they make a contract of marriage to commit to unconditional love as an eternal love. From this perspective, a tax incentive to encourage marriage can be considered as a good policy.

Another example is to financially support low-income households, because extreme poverty hinders the learning process of unconditional love. Thus, policy to support low-income households is a good policy. Learning can include academic learning but the more important thing to learn is moral virtues.

One area in which empirical evidence as to how public policies affect people in terms of virtue ethics can be found is the economics of education. As Heckman (2013) explains, growing research in this area focuses on noncognitive abilities, that include altruism and patience that have been discussed in this chapter. If public policies that affect noncognitive abilities are evaluated by pure welfarism, then noncognitive abilities are evaluated to be good only when they lead to higher income. On the other hand, policies that promote altruism and patience are evaluated to be good by virtue ethics even when there is no evidence that they lead to higher income.

For the purpose of evaluating policies from virtue ethics, empirical research that focuses on noncognitive abilities such as altruism and patience rather than the overall noncognitive ability is useful. An example is how education policies may affect altruism of people. For example, Ito et al. (2015) found from survey data of adults in Japan that people who had experienced participatory/cooperative learning (such as group learning) in their elementary schools in Japan tend to form more altruistic social preferences. On the other hand, people who experienced educational practices emphasizing anti-competitive practices (such as no footraces or no ranking of finishing order in footraces in sports day meetings) tend to form less altruistic preferences. This result may be counterintuitive, but suggest that people need to experience competition in more than one dimension given that Japanese students compete in the academic dimension. In order to grow to be more altruistic, children probably need to value different strong points of various people in different dimensions. These results suggest that educational practices that involve students' experiences in participating in group learning and in competing in more than one dimension. In contrast, Ito et al. found that instructions on leftist political thought and those on human rights and peace do not have any statistically significant impact on altruism. Just as virtue ethics emphasizes, learning virtues need practice.

Because virtue ethics has been largely ignored in economics, empirical there has been very little research on economic policies related to virtue ethics at this point. Theoretical considerations point to promising new areas of research. Models of cultural transmission explained in Chap. 9 and empirical research on noncognitive abilities suggest empirical research on how policies affect parenting will be useful.

11.7 Summary and Further Reading

In normative behavioral economics, we study how the public sector and private sector should behave. Based on libertarian paternalism, we can use the idea of nudging people for better directions without forcing them. In order to evaluate resource allocation to judge how this nudge tool and other public policies should be used when preferences are endogenous, relying exclusively on welfarism may not be satisfactory in many cases because some preferences may be thought to be better than others. Introducing one of the three major approaches in normative ethics, virtue ethics, into a formal analytical framework of normative economics seems a possible solution to this problem. Introducing virtue ethics may mean more government intervention or less government intervention, depending on particular cases. Hence more theoretical and empirical research in this area seems fruitful.

For further reading, Thaler and Sunstein (2008) explain libertarian paternalism and various examples of how nudge can be used. Sachs (2013) argues that promoting virtue ethics should form an important part of policy to increase happiness in a society. In his discussion, he provides arguments for incorporating virtue ethics in public education and promoting virtuous behavior through public policy. For different ethical views that can be used in behavioral economics, Sandel (2009) gives an introduction to various ethical views with many examples that are relevant to economics.

11.8 Questions and Problems

11.8.1 Multiple-Choice Problems

1. According to Bentham's utilitarianism approach, the purpose of a policy is:
   (A) the greatest happiness for the greatest number
   (B) to promote freedom of choice
   (C) to nurture ability and virtue
   (D) to build an egalitarian society
2. In deontology, the emphasis is on:
   (A) doing whatever you wish to do
   (B) moral duties
   (C) nurturing ability and virtue
3. In virtue ethics, the emphasis is on:
   (A) maximizing the utility of citizens
   (B) giving freedom of choice to citizens
   (C) nurturing ability and virtue
   (D) achieving an egalitarian society

11.8.2 Short Answer/Essay Problems

1. Explain what libertarian paternalism is.
2. Explain the method of "nudge" based on the idea of libertarian paternalism, and describe one example of how nudge can change people's behavior.

3. Why is a Pareto improvement not necessarily socially desirable in models with endogenous preferences, even when there is no unwanted outcome in income distribution such as widening inequality?

Appendix 1: Government's Budget Problem and Ricardian Equivalence

We review Ricardian equivalence theory to see the role behavioral economics can play in important policy evaluations. In this appendix, we use a simple two-generation, two-period model. Ricardian equivalence theory deals with the fiscal problem, i.e., when or on which generation the government should impose a tax.

In many countries, a lower birthrate and aging population are becoming serious problems, and pension payment for the elderly and increases in medical expenses are imposing a large fiscal burden. The problem will intensify in the future. This is especially relevant for countries with persistent fiscal deficit such as Japan, where gross government debt per GDP is higher than 200% (the highest in the world) against the backdrops of low birthrate and rapidly aging population.

First, we consider a pure altruistic model (the parent to the child). Parents divide their income into three: C_0 for their own consumption, C_1 for their children's consumption, and B for bequests. t_i is a fixed tax for generation i, y_i is an exogenous labor income of generation i (i = 0, 1), r is the interest rate. Thus, the bequest would be expressed as:

$$B = y_0 - t_0 - C_0 \tag{11.22}$$

The child's consumption would equal his own disposable income plus bequest and interest on the bequest, thus:

$$C_1 = y_1 - t_1 + (1 + r)B \tag{11.23}$$

Hence, the combined budget constraint of two generations of this household would be:

$$C_0 + \frac{C_1}{1 + r} = y_0 - t_0 + \frac{y_1 - t_1}{1 + r} \tag{11.24}$$

In other words, the present value of consumption is the explicit value of disposable income. The parent is altruistic, and chooses C_0 and C_1 in the manner that maximizes:

$$u(C_0) + \theta\, u(C_1) \tag{11.25}$$

under the budget constraint (11.24). In order to sustain this economy, expenditure for public goods G is necessary, and a fixed tax satisfies the government's budget constraint:

$$G_0 + \frac{G_1}{1+r} = t_0 + \frac{t_1}{1+r}$$

Initially, the government's budget is balanced, i.e., $G_{\mathrm{i}} = t_{\mathrm{i}}$ (i = 0,1). If the government reduces the tax by one unit, issue government bonds, and pays off the debt by increasing the tax of the child's generation, t_1 needs to increase by (1 + r) unit. However, the right-hand side of (11.24) indicates that such policy change does not change the budget constraint of the household. Therefore, the optimal consumption to maximize utility for the parent (C_0) and a child (C_1) do not change. The parent will transfer his or her disposable income to a bequest, so consumption of both generations do not change. This is the essence of Ricardian equivalence—i.e., the timing of taxation does not affect consumption.

If Ricardian equivalence holds in the real world, the large budget deficit as in Japan is not a problem, because the parent's generation would expect a tax increase in the future and act accordingly to increase the bequest. Traditional economics' standard macroeconomic model uses the infinite-horizon model (i.e., not the two-period model). The infinite-horizon model does not assume that an individual's life is infinite; instead, it assumes that generations are connected by pure altruism. Under such an assumption, Ricardian equivalence holds.[5]

Next, the warm glow model in Chap. 8 builds on the assumption that a parent derives utility from the act of bequest itself. Thus, the parent's utility function would be:

$$u(C_0, B) + \theta u(C_1) \tag{11.26}$$

In this model, the parent derives utility from B, so they choose C_0 and B to maximize their utility based on (11.26) under the budget constraint of (11.22) and (11.24). The tax cut of the parent's generation does not affect (11.24), but does affect budget constraint (11.22), so Ricardian equivalence does not hold.[6]

Lastly, in the bounded rationality model, there is a possibility that, even if the tax cut is done in the parent's generation, he or she does not consider the tax increase in

[5]In traditional economics, the overlapping generation model, which assumes no altruism of the parent to the child, is also often used. In this model, the Ricardian equivalence model does not hold. The point is that Ricardian equivalence holds for standard macroeconomic models.

[6]Andreoni (1989) uses the standard public goods model to prove that Ricardian equivalence does not hold. In the appendix of this model, C_1 is defined as public goods for parents–children, and B is the parent's contributions to public goods. This idea gives us a clear idea of the relationship of our model to Andreoni's proof. In Akerlof (2007), from the point of view of identity economics (Chap. 9), the reliance of the warm glow model's utility on B is considered as a normative influence on leaving a bequest. He further explains that, if the norm is considered as a motive for a bequest, Ricardian equivalence does not hold.

the future generation. In that case, Ricardian equivalence does not hold. Also, a person with hyperbolic discounting who is unable to fulfill the sophisticated individual commitment in the multiple-period model, disposable income and consumption would co-move, so an increase in disposable income by reducing the tax would simply lead to disposable income of the current generation, thus Ricardian equivalence does not hold.

Appendix 2: Conditional and Unconditional Preference Orderings in Models of Endogenous Preferences

In the habit-formation model, as in Prospect theory, utility function depends on the reference point. If the reference point is one's past consumption, it is called the endogenous habit formation model. On the other hand, if the reference point is average consumption of the overall economy such as other people's consumption, it is called the exogenous habit-formation model.[7] For example, a person with nicotine addiction from smoking can be considered as having the past smoking as the reference point which impacts on today's smoking pattern. The idea of dependency (habit) on the reference point is similar to the endogenous preference model in Prospect theory, so it is categorized as behavioral economics in this book. However, many studies assume that the consumption that is less than the reference point will not be selected (i.e., people will not reduce their consumption from the reference point), and habit formation was used in macroeconomics and the standard financial model in a way that is compatible with other definitions.

In order to explain the concept of conditional and unconditional preference ordering as in Pollak (1978), we consider a habit formation model as follows. In an economy, there are N consumers. Consumer i's reference point is the average of everybody else's consumption average. Then:

$$u_i(C_i - C_{ia}) \tag{11.27}$$

where C_i is consumer i's consumption, C_{ia} is the average of other people's (number of people is $N - 1$) consumption, then consumer i maximizes his or her utility under the normal assumption of $u_{\mathrm{i}}(\cdot)$ (monotonically increasing convex function) under the budget constraint. For consumer i, C_{ia} is given a state variable, and the preference ordering of C_i given the state variable is defined as *conditional preference ordering*. The utility function of this conditional preference ordering can be expressed by the utility function $U_i(C_i; C_{ia}) = u_i(C_i - C_{ia})$. On the other hand, for a policymaker, the state variable is not given. Without the assumption that C_{ia} is given, the utility of

[7]The external habit formation model is also called "catching up with the Joneses" model (Abel 1990), which is a social preference model where other people's consumption affects one's own utility.

consumer i $(C_1, \ldots, C_N)$ can be expressed as $u_i(C_\mathrm{i} - C_{ia})$, and the preference ordering can be expressed by the utility function $U_i(C_1, \ldots, C_N) = u_i(C_i - C_{ia})$. This ordering is defined as *unconditional preference ordering*.[8]

Pollak (1978) proposed that policy evaluation should be done using fixed unconditional preference ordering instead of variable conditional preferential ordering. As long as we use the utility function of unconditional preferential ordering, $U_1(C_1, \ldots, C_N)$, …, $U_N(C_1, \ldots, C_N)$, analysis based on Pareto improvement and social welfare functions can be used even in the models with endogenous preferences.

Appendix 3: Tough Love Model with Bequest

Bhatt et al. (2017) extend the tough love model of cultural transmission of preferences to analyze bequest and bequest tax. In this model, the parent divides his income into three: (1) own consumption, (2) future consumption for the child during his or her childhood (T), and (3) bequest after the child reaches the working age (B). The government decides the bequest tax rate τ and collects the bequest tax τB and gives a subsidy s to the child of working age. s is set to be fixed so that it will offset the decline in income from the bequest tax. This assumption is made so that we can analyze the effect of bequest tax with given income, by offsetting income decline from the bequest tax with a fixed amount of subsidy. Thus, the government's budget constraint will satisfy $\tau B = s$. Because the amount of the subsidy is fixed, the bequest tax only affects the decision of the parent on whether they give the money to his child while the child is still under the working age (T), or gives the bequest (B). Under this assumption, the extended model of consumption of the child after his or her retirement would be[9]:

$$C_3 = (1 + r)(y_2 + (1-\tau)B + s - C_2).$$

References

Abel, A. B. (1990). Asset prices under habit formation and catching up with the Joneses. *American Economic Review, 80*(2), 38–42.

Akerlof, G. (2007). The missing motivation in macroeconomics. *American Economic Review, 97*(1), 5–36.

[8]Both $U_i(C_i; C_{ia})$ and $U_i(C_1, \ldots, C_N)$ would be equivalent to $u_i(C_i - C_{ia})$ as a value, but note that whether C_{ia} is given or not would make a difference in utility function as a concept.

[9]For the sake of simplicity, the model described here is a more simplified than the model in the original paper (Bhatt et al. 2017).

Andreoni, J. (1989). Giving with impure altruism: Applications to charity and Ricardian equivalence. *Journal of Political Economy, 97*(6), 1447–1458.

Banerjee, A. V., & Duflo, E. (2011). *Poor economics: A radical rethinking of the way to fight global poverty*. Public Affairs.

Becker, G., & Murphy, K. M. (1988). A theory of rational addiction. *The Journal of Political Economy, 96,* 675–700.

Beshears, J., Choi, J. J., Laibson, D., & Madrian, B. C. (2008). How are preferences revealed? *Journal of Public Economics, 92*(8–9), 1787–1794.

Bhatt, V., Ogaki, M., & Yaguchi, Y. (2015). Normative behavioural economics based on unconditional love and moral virtue. *Japanese Economic Review, 66*(2), 226–246.

Bhatt, V., Ogaki, M., & Yaguchi, Y. (2017). Introducing virtue ethics into normative economics for models with endogenous preferences. Rochetser Center for Economic Research Working Paper No. 600. Rochester, NY.: University of Rochester.

Heckman, J. J. (2013). *Giving kids a fair chance*. Cambridge, MA: The MIT Press.

Ito, T., Kubota, K., & Ohtake, F. (2015). *The hidden curriculum and social preferences*. The Institute of Social and Economic Research. Discussion Paper, 954.

Kaneko, M., & Nakamura, K. (1979). The Nash social welfare analysis. *Econometrica, 47*(2), 423–435.

Kőszegi, B., & Rabin, M. (2008). Choices, situations, and happiness. *Journal of Public Economics, 92*(8–9), 1821–1832.

Mulligan, C. B. (1997). *Parental priorities and economic inequality*. University of Chicago Press.

Pollak, R. A. (1978). Endogenous tastes in demand and welfare analysis. *American Economic Review, 68*(2), 374–379.

Ramsey, F. P. (1928). A mathematical theory of saving. *The Economic Journal, 38,* 543–559.

Rawls, J. (1971). *A theory of justice*. Cambridge, MA: The Belknap Press of Harvard University Press.

Sachs, J. D. (2013). Restoring virtue ethics in the quest for happiness. In J. Helliwell, R. Layard, & J. Sachs (Eds.), *World happiness report* (pp. 80–97). New York: UN Sustainable Development Solutions Network.

Sandel, M. (2009). *Justice: What's right thing to do?* Farrar Straus & Giroux.

Sen, A. K. (1974). Choice, ordering and morality. In S. Korner (Ed.), *Practical reason* (pp. 55–66). New Haven, NY: Yale University Press.

Sunstein, C. R., & Thaler, R. H. (2003). Libertarian paternalism is not an oxymoron. *University of Chicago Law Review, 70*(4), 1159–1202.

Thaler, R. H., & Sunstein, C. R. (2008). *Nudge: Improving decisions about health, wealth, and happiness.* Yale University Press.

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