Universität St.Gallen

Do Institutions Promote Rationality?

An Experimental Study of the Three-Door Anomaly

Tilman Slembeck and Jean-Robert Tyran

Department of Economics   University of St. Gallen

Do Institutions Promote Rationality?

An Experimental Study of the Three-Door Anomaly

Tilman Slembeck and Jean-Robert Tyran[1]

Author's address: Dr. Tilman Slembeck
                     Varnbüelstrasse 19
                     9000 St. Gallen
                     Tel.   +41 71 224 25 49
                     Fax   +41 71 224 28 15
                     Email   tilman.slembeck@unisg.ch
                     Website   http://www.slembeck.ch/slem-eng.html

Author's address: Dr. Jean-Robert Tyran
                     Volkswirtschaftliche Abteilung
                     Bodanstr.1
                     9000 St. Gallen
                     Tel.   +41 71 224 23 15
                     Fax   +41 71 224 28 15
                     Email   jean-robert.tyran@unisg.ch
                     Website   http://www.vwa.unisg.ch/tyran/

Abstract

The three-door problem is an astounding example of a systematic violation of a key rationality postulate. In this seemingly simple individual decision task, most people initially fail to correctly apply Bayes' Law, and to make the payoff-maximizing choice. Previous experimental studies have shown that individual learning reduces the incidence of irrational choices somewhat, but is far from eliminating it. We experimentally study the roles of communication and competition as institutions to mitigate the choice anomaly. We show that the three-door anomaly can be entirely eliminated by these institutions.

Keywords

JEL Classification

1. Introduction

Over the last decades, a vast literature has accumulated demonstrating that people violate basic rationality postulates of economics in many ways (see Camerer 1995 for a survey). The empirical demonstration of these so-called choice anomalies has provided fruitful impulses to economics, stimulating research in fields like bounded rationality and behavioral economics (Rabin 1998). The demonstration of these anomalies in individual choice is interesting in itself, and decision making anomalies may have important economic consequences. However, skeptics of behavioral research argue that establishing that anomalous behavior is common at the individual level is insufficient to conclude that these anomalies translate into important effects in the economy and society (see Rabin 2001 or Conlisk 1996 for a discussion).

There are potentially many factors disallowing simple extrapolation from findings in the experimental laboratory to more complex environments in society and economy. The two most important mechanisms affecting how individual irrationality translates into economic and social outcomes are *learning* and *institutions*. First, people may need some time to learn optimal decisions. This is particularly the case when decision problems are unfamiliar to subjects or unusually complicated. Indeed, in many experiments behavior tends to converge to equilibrium choices over time (Camerer 1995). Second, social and economic institutions may transform and possibly eliminate anomalies in individual choice (Frey and Eichenberger 1994). For example, Becker (1962: 8) famously stated that "households may be irrational and yet markets quite rational". Some market environments, such as the double auction, are so powerful that they "can generate aggregate rationality not only from individual rationality but also from individual irrationality" (Gode and Sunder 1993: 119). Third, by a combination of the two mechanisms, social and economic institutions may also promote learning. Institutions may facilitate learning, thereby promoting individual rationality.

This paper investigates the effect of learning and institutions on the incidence of rational decisions in the three-door problem. The three-door problem is an apparently simple individual decision making task. Expected payoffs of one option are twice as high as in the other option, and the problem has a clear rational choice prediction. This prediction is found by straightforward application of Bayes' Law. In previous experimental studies, however, people were found to

systematically choose the inferior option. Since Bayes' Law is a key postulate of economic rationality, the anomaly seems to put into perspective the relevance of much work in the economics of uncertainty and information. In a thought-provoking paper, Friedman (1998) has investigated the first of the two mechanisms potentially invalidating this conclusion. He has shown that while the three-door anomaly can be considerably mitigated by providing experimental subjects with ample opportunities to learn, the anomaly is surprisingly persistent in an institution-free environment. Friedman (1998: 942) notes that "despite the use of strong treatments, many subjects continued to make lots of irrational choices. The three-door anomaly declined substantially but did not actually disappear in 15 periods."

Our study builds on Friedman (1998), and extends the study in three respects. First, we replicate one of Friedman's treatments in a computerized environment. This allows us to run the experiment for more periods, enabling us to investigate the effects of individual learning in more detail. Second, we investigate the effects of simple institutions on the incidence of non-rational behavior in the three-door task. In particular, we analyze how communication in groups and competition among decision makers affects the prevalence of the three-door anomaly. Third, we investigate how the two mechanisms interact. That is, we analyze whether these institutions provide better learning environments.

Our results show that while learning from one's own experience has some mitigating effect, the effect fades, and the anomaly is strikingly persistent in an institution-free environment. For example, even after 40 repetitions of the task, the incidence of rational choices remains clearly below 50 percent. In contrast, the effect of competition and communication is immediate and strong. We show that each of these institutions strongly reduces the anomaly, and that if the two institutions are combined, the anomaly is completely eliminated. We observe an incidence of 100 percent rational choices in several periods when decisions are embedded in both of these institutions. This complete elimination can be partially be explained by improved learning in an institution-embedded environment. In particular, we show that learning and institutions interact.

The paper is organized as follows. Section 2 explains the three-door problem and shortly reviews the relevant literature. Section 3 explains the experimental design and presents results. Section 4 provides some concluding remarks.

2. Competition, Communication, and the Three-Door Anomaly

The three-door problem is inspired by a once-popular TV game-show hosted by Monty Hall. In the stylized version of the game – as studied in the experiments – a subject first chooses between three options, called doors. Only one of these doors hides a prize while the other two doors return no payoff. However, the chosen door is not immediately opened. Rather, one of the remaining two doors which does *not* contain the prize is opened by the experimenter.[1] Next, the subject is asked whether he or she would like to *remain* with the initial choice or *switch* to the other unopened door. The rational choice is to switch to the door not initially chosen, since switching doubles the odds of winning the prize from $^1/_3$ to $^2/_3$. This follows from a straightforward application of Bayes' Law. Call the three doors A, B, and C. Suppose the subject initially chooses door A. Assume that the experimenter opened door B. The exact probability of winning the prize by switching to door C therefore is (Rasmusen 1989: 384):

$$\Pr(\textit{Prize behind } C \mid \textit{Experimenter opens } B) =$$

$$= \frac{\Pr(\textit{Experimenter opens } B \mid \textit{Prize behind } C) \cdot \Pr(\textit{Prize behind } C)}{\Pr(\textit{Experimenter opens } B)}$$

$$= \frac{(1) \cdot (^1/_3)}{(1) \cdot (^1/_3) + (^1/_2) \cdot (^1/_3)} = {}^2/_3$$

The intuition for this result is as follows. If the subject initially chooses randomly among the three doors, he or she finds the prize with a probability of $^1/_3$, and does not find the prize with $^2/_3$. Since the experimenter must open an non-chosen door that does not contain the prize, the strategy *switch* is guaranteed to yield the prize whenever the door containing the prize was not chosen in the initial choice (i.e., in $^2/_3$ of the cases). As a consequence, the strategy *remain* yields the prize only when the door containing the prize was randomly chosen in the first trial (i.e., in $^1/_3$ of the cases).

---

[1]The experimenter chooses randomly if there is a choice between two doors which do not contain the prize.

The three-door problem has been studied in a number of controlled laboratory experiments by psychologists (e.g., Granberg and Brown 1995, Granberg and Dorr 1998) and economists (e.g., Friedman 1998, Page 1998). A result common to all experiments is that a large majority of experimental subjects do not switch but rather choose to remain with their original choice. The number of decisions to switch as a percentage of all decisions, i.e., the *switch rate*, typically is below 20 percent in these studies. Similarly low switch rates have been found to prevail in different cultures (Granberg 1999). Friedman (1998) demonstrated that the anomaly is also surprisingly persistent when experimental subjects are given the opportunity to repeat the task (including full statistical information about past behavior), and when they are provided with various learning aids. While switch rates increased upon repetition of the task, they remained below 60 percent.

The systematic and persistent violation of rationality has awarded the three-door problem the status of a leading choice anomaly for several reasons. First, the three-door choice task is simple in comparison to choices required in many economic settings (there are only two options to choose from in the second stage). Second, the anomaly is surprisingly persistent, and despite the apparent simplicity of the problem the optimal choice seems to be exceedingly difficult to learn. Thus, Friedman (1998: 936) states: "Indeed, I am not aware of any anomaly that has produced stronger departures from rationality in a controlled laboratory environment." Third, the three-door problem is a straightforward application of Bayes' Law. Since Bayes' Law is a central building block of modern economic theory, the anomaly seems to cast serious doubt on the predictive power of the economics of uncertainty and information. As we show in this paper, however, this conclusion seems to be premature since the anomaly can be entirely eliminated when relevant institutions are part of the environment.

In order to test the impact of institutions, we study two simple settings that are hypothesized to reduce the prevalence of the anomaly. Our experiment involves a 2 by 2 design (see next section for details). In all four conditions, subjects repeat the task several times, and are provided with immediate feedback about the outcomes of their decisions, enabling them to learn from their own experience. The treatments differ with respect to communication and competition.

Communication is a natural feature in all social settings, including economic decisions. Sociologists have argued for a long time that people do not take economic action in isolation, and

that "social embeddedness" may considerably affect economic outcomes in a variety of ways (e.g., Granovetter 1985). Blinder and Morgan (2000) argue that many economically important decisions are made by groups. In open communications ideas are exchanged and decision making processes are made explicit. When decisions are taken by groups rather than individuals, reasons have to be voiced and actions need to be justified within the group.

It seems plausible that the additional resources (e.g., brain power) available to groups tends to foster rationality. Indeed, some experimental research suggest that small groups make better use of feedback (Davis and Harless 1996), and that group interactions appear to stimulate learning (Tindale 1989). However, the claim that groups take more rational decisions as general rule seems to be wrong. Whether individuals or groups perform better depends, in general, on both the nature of the task and the process of decision making within the group (see Davis 1992 for an overview). In our study we introduce communication by having small groups of subjects instead of isolated subjects take the three-door task. Comparing the performance of groups and individual subjects allows to assess the effects of communication on rationality.

Competition has long been trusted to correct for irrational behavior (see, e.g., Arrow 1987). Competitive markets are thought to select rational agents as survivors, and irrational agents are expected to exit the market (e.g., go bankrupt). Empirical evidence, however, is mixed in that some anomalies disappear in market settings while others are surprisingly persistent (see Knez et al. 1985, Camerer 1987, List 2000, Hung and Plott 2001). Among the wide range of competitive mechanisms rank-order competition provides strong incentives to increase decision making effort since payoffs are a function of relative performance (Mookherjee 1990). For instance, the literature on the design of incentive schemes for workers suggest that rank-order tournaments among workers increase effort levels and reduce problems of moral hazard, free-riding or shirking substantially. Experimental studies have confirmed this tendency (Nalbantian and Schotter 1997). Competition was implemented in the present study by rewarding experimental subjects' performance relative to the performance of other subjects (or groups of subjects). The rank-order competition we implement is public in that all information concerning behavior, outcomes, and the relative standings of all contestants are made public repeatedly in the course of the experiment. This allows contestants to compare their relative performance and to learn from the behavior of others. We speculate that the opportunity for social comparison may also provide non-monetary incentives to "win over others."

Both institutions – communication and competition – may promote rationality in various ways. Communication allows to reflect and discuss the pros and cons of behavioral strategies and to evaluate feedback with additional brain power. This may help to solve the three-door problem right away, or it may facilitate learning from experience. Competition provides additional incentives to solve the problem right away and to increase learning effort. In addition, because of its publicness, competition offers opportunities to learn from errors or success of other contestants. Our experiment serves to test whether communication and competition tend to foster rational decision making at all, and, if so, which of these conjectures is most appropriate.

3. Experiment

Section 3.1. explains the experimental design and the procedures. Section 3.2. presents the main results, and section 3.3. provides an econometric analysis of learning and institutions. In section 3.4., we provide a discussion of why the three-door anomaly is so persistent in an institution-free environment.

3.1. Design and Procedures

Our experiment involves a total of four treatments. A 2 by 2 design (see Table 1) was chosen to isolate the effects of competition and communication, to evaluate their comparative relevance, and to detect potential interaction effects. All treatments have in common that the three-door problem is repeated for 40 periods and that track record information is provided automatically by the computer for each period. Track record information means that subjects obtain information about their own past decisions, their own cumulative earnings, as well as about hypothetical cumulative earnings for the strategies "always remain" and "always switch" (see Appendix A5).

The treatment (BASE) is a replication of Friedman's "track record" treatment. It serves as a control treatment against which the effects of communication and competition can be evaluated. In BASE, subjects face the three-door problem in an *institution-free environment*. Subjects worked individually and proceeded at their own pace. Subjects earned 10 points each time the prize was found, and 0 points otherwise. Points were cumulated throughout the

experiment and converted into money at a commonly known exchange rate of 0.75 Swiss Francs (0.50 US\$, approx.) for 10 points at the end of the session when subjects were paid their earnings in cash.

Table 1: Overview of treatments

		Communication	
		No	Yes
Competition	No	**Base Line** BASE (12 individual)	**Communication** COMM (33 in groups of 3)
	Yes	**Competition** COMP (12 individual)	**Competition & Communication** CC (36 in groups of 3)

Notes: The number of experimental subjects is given in parentheses. All subjects and groups of subjects repeated the task 40 times.

The competition treatment (COMP) differs from BASE in that the exchange rate depends on the relative standing or rank of a subject's cumulative earnings compared to others as shown in Table 2. Hence, rank-order competition was introduced by ranking the 12 subjects involved in this treatment according to their cumulative points earned at the end of the session, and subjects were paid according to the exchange rate associated with their rank in period 40. This procedure, including Table 2, was explained to subjects at the beginning of the experiment (see instructions in Appendix A2). Furthermore, in order to inform subjects about their relative standings during the experiment, at the end of rounds 10, 20, 30, and 40 the cumulative points and the decisions of all 12 subjects were publicly displayed on screens. That is, subjects were informed about how often other subjects chose to remain or switch on all previous trials. This allowed subjects to assess their own relative success up to that point in time, and to compare their own behavior with that of others. It should be stressed, however, that subjects were unable to identify the identity of other subjects by this information.

Table 2: Payment scheme for rank-order competition

Rank	1	2	3	4	5	6	7	8	9	10	11	12
Rate	1	0.95	0.9	0.85	0.8	0.75	0.7	0.65	0.6	0.55	0.5	0.45

Notes: Rank refers to a subject's (or group's) relative position in terms of cumulative earnings. *Rate* is the exchange rate in Swiss Francs at which 10 points are converted into cash. Table 2 was used in COMP and CC.

It should be noted that the rank-order competition we implement differs from standard tournaments in that competition does not affect the optimal choice. Hence, competition would be irrelevant if all contestants were rational and egoistic. For such an agent, switch is the dominant choice irrespective of what others do. However, in the presence of rank-order competition the average sanction for being irrational is the higher the more rational competitors are. In this sense, rank-order competition provides additional incentives to take or learn the rational choice.

The communication treatment (COMM) involved 11 separate groups of 3 subjects each. Each group faced the same task as in the base line treatment. Groups, however, had to discuss their decisions and act as a single decision maker in that they worked on a single computer. In the event that they did not agree on a decision, group members had to vote over what decision was to be taken by the group based on a simple majority rule. However, most decisions were taken unanimously. Communication was allowed only within groups, but never between groups. The payment scheme was identical to that in BASE (i.e., there was a fixed exchange rate of 0.75 Swiss Francs for each prize found), and each group member received the monetary outcome earned by the group.

Finally, treatment (CC) combines both institutions. While there was communication within groups of 3 subjects (as in COMM), there was also rank-order competition between the 12 groups as in the COMP treatment (see Table 2). Treatment CC serves to test for possible interaction effects of the two institutions.

It is worthwhile to repeat differences in available information among treatments. While decision makers are provided with summary statistics about their own actual decisions and the strategies "always switch" and "always remain" in all treatments, decision makers in COMP and CC obtain additional information. At the end of periods 10, 20, 30, and 40 they are informed about actual choices and relative standings of all contestants. Hence, this additional information provides opportunities for imitation learning. In the treatments involving communication (COMM and CC), learning from others is also possible. To provide an extreme example, assume that a third of all subjects understands the Bayesian logic, and that these subjects are evenly spread among all groups. If these subjects succeed to convince at least one other group member to switch, one would observe 100 percent switching. Hence, social learning through persuasion provides a potential leverage for rationality with communication.

A total of 93 freshmen from the University of St. Gallen volunteered for participation. They were allocated randomly to the treatments. All four treatments were run simultaneously in four different rooms so that no information about the content of the experiment could leak to subjects before the experiment started.

3.2. Main Results

Our presentation of results focuses on the incidence of rational decisions, i.e., the relative frequencies of decisions to switch to the unopened door not initially chosen. Figure 1 shows these switch rates averaged over blocks of 5 periods. The figure shows that switch rates differ substantially between treatments from the beginning of the experiment. Average switch rates in periods 1 to 5 are 13% (BASE), 22% (COMP), 29% (COMM), and 45% (CC) respectively. Fisher's exact tests reveal that BASE is different from each of the other treatments at the 10 percent level.[2] Therefore, we observe *immediate treatment effects*: communication by itself and the incentive from competition by itself have a marked impact. For example, switch rates are about twice as high when subjects take decisions in groups, and hence communicate within their group (COMM) than when they take decisions in isolation (BASE). When communication and competition are combined (CC), we observe another significant treatment effect (exact Fisher tests for periods 1 to 5 provide the following results: CC vs. COMP: $p = 0.004$, CC vs. COMM:

---

[2] Exact Fisher tests for periods 1 to 5 provide the following results: BASE vs. COMP: $p = 0.094$, BASE vs. COMM: $p = 0.022$, BASE vs. CC: $p = 0.000$

$p = 0.033$). Switch rates in CC are about twice as high as in the absence of communication, and about three times as high as in the absence of communication and competition. Note that the significant immediate treatment effects in the treatments involving competition (i.e., COMP and CC) do not arise from imitation learning, since information about one's own rank and about the decisions of the competitors is revealed for the first time at the end of period 10. Interestingly, this information did not seem to improve switch rates. In both COMP and CC the switch rates are not significantly different in periods 10 and 11 according to a Fisher Exact test at the 10 percent level. Also, the effect of institutions on the rationality of behavior appears to be very *persistent*. From period 16 on, for instance, the difference in average switch rates between CC and BASE is never less than 50 percentage points (see Figure 1).

Figure 1: Switch rates in blocks of 5 periods
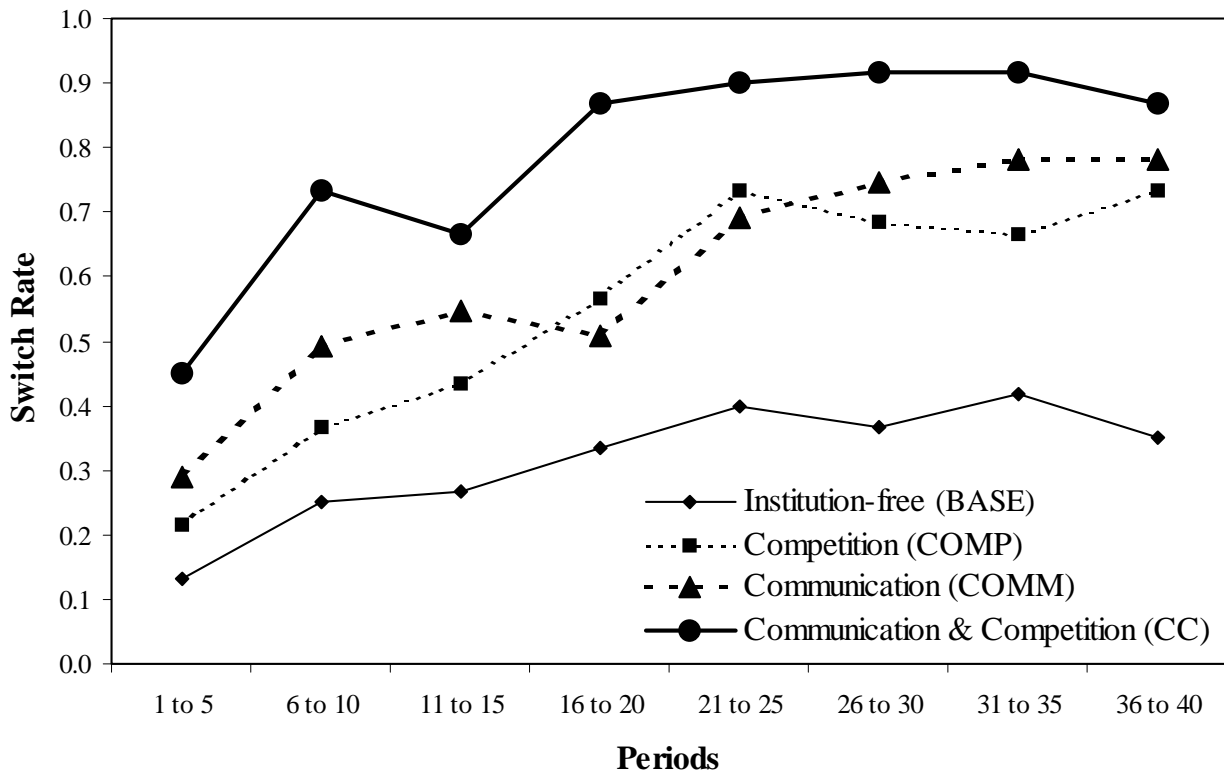
Subjects appear to learn from experience in all treatments. As can be seen from Figure 1, by the end of the experiment (periods 36 to 40), average switch rates have increased to 35%

(BASE), 75% (COMP), 78% (COMM), 87% (CC). Note that average switch rates in the treatments involving institutions are now more than twice as high as in the institution-free treatment BASE. Therefore, it is not only the case that competition and communication improve the rationality of decisions from the very beginning of the experiment, these institutions also provide better learning environments. To illustrate, the overall increase in the switching rate in the institution-free treatment BASE is only about 20 percentage points, whereas the increase is almost 50 percentage points in the treatments involving communication and competition. However, most of the learning appears to take place in the first 25 periods because thereafter we observe switch rates to even fall in some periods (see Figure 1). Thus, we do not find support for Friedman's (1998: 940) suggestion that "subjects would choose switch more than 90 percent of the time after about T = 60" in the institution-free treatment (BASE).

These main results suggest that strong information and repetition alone does not seem to be a sufficient condition for fully rational behavior in this task. Quite strikingly, the average switch rate in periods 31-40 in BASE is a mere 38.3 percent, clearly below what would result from purely random choice between the two options. At the same time, the data strongly suggest that the three-door anomaly can be entirely eliminated in environments that provide rich opportunities and strong incentives for learning such as institutions of communication and competition. In particular, we find switch rates of 100 percent in two treatments involving institutions in several periods (in COMM: period 33; in CC: periods 27, 33, 40).

3.3. Econometric Analysis

Following Friedman (1998), we estimate a simple learning model. In addition, we isolate the effects of communication and competition on the probability to switch and analyze interaction effects between learning and institutions. The variables *Switchbonus, Switchwon* and *Switchlost* are suggested by learning theories. Reinforcement learning (see Erev and Roth 1998) suggests the variable *Switchbonus*, defined as the earnings from always switching minus earnings from always remaining, cumulated from the first period to the most recent period. Directional learning (see Selten and Buchta 1998) suggests *Switchwon*, a dummy variable equal to 1 if the decision maker switched and won the prize in the most recent period. Analogously, *Switchlost* is equal to 1 if and only if the decision maker switched in the preceding period but did not win the prize. We also estimate the effects of communication and competition. The variable

Competition is equal to 1 if payoffs depended on the ranking of points relative to other decision-makers, as explained in Table 2. Hence, *Competition* is a dummy variable equal to 1 in treatments COMP and CC. Analogously, the variable *Communication* is equal to 1 in treatments COMM and CC. Finally, the variable *Competition * Communication* captures the interaction effect between competition and communication, and is equal to 1 in treatment CC.

Table 3 shows the results from a maximum-likelihood probit estimation of the marginal effects dF/dx in column (2). These estimates show the change in probability for an infinitesimal change in the independent continuous variable, and the discrete change in the probability for dummy variables. The table shows that both learning theories have some predictive success. As can be seen from the coefficient of *Switchbonus*, the effect of a subject's cumulative history seems to be relatively minor in size, though. Cumulative experience of additional success from switching (with each success yielding an income of 10 points) increases the probability to switch by 1.7 percent. The effects of the most recent experience are captured by *Switchwon* and *Switchlost*. These effects are very pronounced. In particular, the probability of switching is 32.2 percent higher if switch was chosen in the preceding period and won. The probability to switch is 21.5 percent lower if switch was chosen in the preceding period but lost. These findings are in line with the results obtained by Friedman (1998: 944). The positive estimate for *Time* indicates that there is some overall trend to increasingly choose switch which is not captured by the other learning variables, and the negative coefficient for the variable *Time²* indicates that this trend is non-linear and falling over time.

The second group of variables in Table 3 shows that the effects of competition and communication are similar in magnitude, and that the two effects are independent. In particular, the coefficient for the variable *Competition* shows that competition increases the probability of switching by 14.4 percent, and communication does so by 15.5 percent. Interestingly, there are no significant interaction effects between communication and competition. The insignificant estimate for *Competition * Communication* indicates that the effectiveness of one institution does not depend on the level of the other. Therefore, the effects of the two institutions are basically additive in our analysis.

Table 3: Marginal effects from probit estimation

	Dependent Var.	dF/dx	Std. Err.	z	$P > |z|$
	Switch	(2)	(3)	(4)	(5)
Learning	Switchwon	0.3323	0.0486	6.14	0.000
	Switchlost	-0.2149	0.0518	-4.09	0.000
	Switchbonus	0.0017	0.0005	2.99	0.003
	Time	0.0135	0.0054	2.49	0.013
	Time^2	-0.0003	0.0001	-2.66	0.008
Institutions	Competition	0.1435	0.0675	2.10	0.035
	Communication	0.1549	0.0670	2.29	0.022
	Competition* Communication	0.0468	0.0523	0.89	0.375
Interaction of Learning & Competition	Competition* Switchwon	-0.1434	0.0649	-2.21	0.027
	Competition* Switchlost	0.1407	0.0571	2.31	0.021
	Competition* Switchbonus	-0.0006	0.0007	-0.82	0.415
	Competition* Time	0.0057	0.0032	1.77	0.076
Interaction of Learning & Communication	Communication* Switchwon	0.0032	0.0639	0.05	0.961
	Communication* Switchlost	-0.0964	0.0651	-1.49	0.136
	Communication* Switchbonus	-0.0019	0.0007	-2.59	0.010
	Communication* Time	0.0089	0.0032	2.76	0.006

Number of obs = 1880, Log likelihood = -956.88, Pseudo R^2 = 0.2571

The third and fourth group of variables in Table 3 serve to analyze whether institutions provide better learning environments. Here, we interact the institution variables with the learning variables. As can be seen from the table, the interaction of *Competition* and *Switchwon* and *Switchlost* is rather strong. This indicates that in the presence of competition decision makers react less to the most recent experience. The estimate for the interaction between *Competition* and *Switchbonus* is insignificant, suggesting that competition by itself does not improve learning from accumulated experience. However, in the presence of competition, there is an additional (weakly significant) positive effect on the tendency to choose the rational action, as can be seen from the coefficient *Competition * Time*.

The last group in Table 3 shows that communication per se does not lead to a significantly different reaction to the most recent experience (see insignificant estimates for interaction with *Switchwon* and *Switchlost*). However, somewhat surprisingly, groups are less able to infer the rational solution from accumulated experience than individual subjects as is indicated by the negative coefficient for *Communication * Switchbonus*. Whether this finding is indicative of free-riding within groups or of "groupthink" remains unclear. It is important to note, however, that communication induces additional rationality over time. This is indicated by the positive estimate in the last line.

We conclude the following from this analysis. First, there is significant learning, some of which can be explained by leading learning theories. Second, institutions promote rationality in that they lead to higher levels of switch rates. Third, learning interacts with institutions in the sense that institutions provide better learning environments. The learning theories we have tested, however, fail to account for the bulk of improved learning. The institutions under investigation affect learning quantitatively and qualitatively. Graphically speaking, institutions both shift the "switch trajectory" of Figure 1 upwards and at the same time make it steeper.

3.4. Why is the three-door anomaly so persistent?

Practice improves performance, and our experiment is no exception to this rule. We observe a clear increase in rationality over time in all treatments, and the variables suggested by learning theories have been found to be highly significant. However, consistent with the so-called power law of practice (Erev and Roth 1998), we observe that learning is more pronounced in early periods, and fades over time. In all treatments, most of the improvement in rationality takes

place in the first 20 periods. While there is significant learning in the early periods, switch rates in our institution-free treatment (BASE) remain strikingly low throughout the experiment. For example, the average switch rate in the last 5 periods (periods 35-40) is still clearly worse than 50 percent which would result from completely random choice among the two alternatives.

To understand why the anomaly is so pronounced and persistent, we have to address to two questions. Why are choices in the first period of the institution-free treatment so strikingly biased against rational choice? Why are subjects so hesitant to change behavior according to experience accumulating over time?

Concerning the question of first-period choices, we suggest that the anomaly involves two stages. At the first stage, subjects appear to be simply unable to calculate the correct probabilities. A post-experimental questionnaire and discussions with subjects after the experiment reveal that most subjects believed at the beginning of the experiment chances of winning the prize to be 50 percent for both strategies remain and switch (see also Granberg and Brown 1995 and Nickerson 1996 for similar findings). This failure to apply Bayes' Law, however, does not explain why most subjects choose to remain in the first period. That is, given that subjects assume equal probabilities, they should choose to remain or switch with equal probabilities. Instead, only 16.7 percent of subjects chose to switch in the first period of the institution-free treatment BASE. To account for this tendency to choose to remain, we speculate that a second stage involves psychological factors, such as anticipated regret (Granberg and Brown 1995: 5) or dissonance reduction (Gilovich et al. 1995).

The idea is as follows. Given the subjects' (incorrect) intuition that the probability is ½ for each option, it is more regrettable for them *not* to win the prize by switching than not to win it by remaining. This is because ex-post regret is anticipated to be comparably stronger when subjects believe that they "already had" the prize, but then switched, as compared to when they believe that they "did not have" the prize in the first place, but then chose to remain. Hence, subjects feel committed to their original choice because they aim to avoid regret or cognitive dissonance later on. Post-experimental conversations suggest that regret is a main psychological factor in our experiment that induces subjects to remain when assuming equal probability. The three-door problem seems to an example of a case where people ignore dependencies between events that are in fact dependent, but mentally construct dependencies that should not matter

according to Bayes' Law (see Slembeck 2002 for a detailed discussion). Taken together, these two stages may explain why initial choices are so much biased against the rational choice.

This still leaves us with the second question: Why is learning so slow in the institution-free treatment? It seems to be the case that the intuition of equal chances of winning for the two options is so strong that feedback information indicating the superiority of switching is simply neglected, and is, instead, attributed to chance. We now illustrate how difficult it is to learn the rational choice for someone believing the two options to be equal but (for the sake of the illustration) being otherwise trained in statistics. Suppose a subject holds the Null hypothesis Prob(switch) = Prob(remain), but is willing to reject the hypothesis in favor the alternative hypothesis that Prob(switch) > Prob(remain) if sufficient evidence accumulates against the Null hypothesis. When can this Null hypothesis be rejected at the confidence level $\alpha = 0.05$? Suppose the decision maker observes that switch won 7 times after 10 periods (i.e., suppose 7 "successes" out of 10 "trials"). According to a Binomial test, the one-tailed probability is $\text{Prob}[Y \geq 7, N = 10, p = 0.5] = 0.172$. Since $0.172 > \alpha$, the Null hypothesis cannot be rejected. The same is true of 14 successes after 20 periods since $\text{Prob}[Y \geq 14, N = 20, p = 0.5] = 0.058 > \alpha$. The hypothesis can be rejected by a very narrow margin with 20 successes after 30 periods ($\text{Prob}[Y \geq 30, N = 30, p = 0.5] = 0.049 < \alpha$), and can be more clearly rejected with 27 successes after 40 periods ($\text{Prob}[Y \geq 27, N = 40, p = 0.5] = 0.0195 < \alpha$). Note that these examples involve cases that are close to the expected values of successes (i.e., $^2/_3 N \cong$ # successes). However, if the evidence by bad luck is slightly less favorable, it may not be possible to reject the Null hypothesis even after 40 periods. For example, suppose only 25 successes are observed after 40 periods. In this case, $\text{Prob}[Y \geq 25, N = 40, p = 0.5] = 0.077 > \alpha$. Note that observing 25 or less successes of switch in 40 trials is quite probable (34.2 percent). Hence, this exercise illustrates that the (wrong) belief that switch and remain are equally likely to be successful is more difficult to reject with less experience, and is quite likely not to be rejected even by the end of the experiment.

This discussion just serves to illustrate that even someone trained in statistical hypothesis testing may find it quite hard to reject the hypothesis of equal probability. Quite plausibly, however, our subjects (and we suspect that this holds for almost any subject pool) are not as sophisticated as that. An more naive approach makes it even harder to reject one's prior beliefs. Suppose that subjects assumed that the two options yield the prize with equal probability, and

that they randomize between switch and remain. Assume that subjects only take the *overall* success rate into account, thereby ignoring potential differences in success rates between the two options. Then, the evidence seems to confirm their prior belief (since $\frac{1}{2} \cdot \frac{1}{3} + \frac{1}{2} \cdot \frac{2}{3} = \frac{1}{2}$), and no amount of experience will induce them to reject their maintained hypothesis.

4. Conclusions

We show that a combination of competition and communication yields behavior that converges quite closely to the rational solution upon repetition of the three-door task. Given the striking persistence of the anomaly with regard to repetition in an institution-free environment (as in BASE), our study presents evidence for strong effects of social institutions, such as communication in groups, as well as economic institutions, such as rank-order competition, for convergence toward rationality. When both institutions are combined, information processing and learning appear to be much improved, and the anomaly can be entirely eliminated.

Three remarks on the broader implications of our results with respect to the relevance of anomalies seem appropriate. First, the fact that we succeed in eliminating the three-door anomaly does not imply that *every* choice anomaly will be entirely eliminated by communication and competition. The three-door anomaly is a particularly clear-cut case of a cognitive limitation, i.e., a failure to choose the income-maximizing option when no motive other than money-maximization can plausibly be invoked. However, if "anomalies" involve non-selfish motives (e.g., fairness, reciprocity), even fiercest competition may not induce behavior consistent with standard economic predictions (see Fehr and Falk 1999).

Second, our finding that people learn to overcome the three-door anomaly when they communicate and compete – as they do in everyday life – does not imply that this (or any other) anomaly is irrelevant in everyday economic and social interaction. The reason is that learning may be considered as slow and requires several repetitions in our experiment. One may reasonably question whether "stationary replication" is a natural feature of everyday life (Loewenstein 1999). Therefore, it remains an open empirical question and a matter of application, whether the relatively low incidence of rational decisions we observe in the early periods or the very high incidence of rationality observed in late periods is more representative

for behavior outside the laboratory (and should be taken as an indication of how relevant violations of Bayesian updating are).

Third, while we show that simple and natural institutions can eliminate the three-door anomaly, our study cannot be more than a small step in the long-term endeavor to understand when and why institutions promote rationality. As is well known from much research in experimental economics, subtle changes in the institutional design may strongly alter behavioral effects. Hence, how much our results hinge upon the design of our experiment with regard to group size, the competition mechanism, and the type of information feedback remains an open question.

In all, we believe that the debate on anomalies can be made more fruitful if future research not only investigates the existence and (non-)persistence of anomalies, but also explores how robust these anomalies are with respect to socially and economically relevant institutions.

References

Arrow, Kenneth J. (1987): Rationality of Self and Others in an Economic System, in Robin M. Hogarth and Melvin W. Reder, eds. *Rational Choice – The Contrast Between Economics and Psychology*, Chicago and London: Chicago University Press, 201–215.

Becker, Gary S. (1962): Irrational Behavior and Economic Theory, *Journal of Political Economy*, 70(1), 1–13.

Blinder, Alan S. and Morgan, John (2000): Are Two Heads Better Than One? An Experimental Analysis of Group vs. Individual Decision Making, *NBER Working Paper* No. 7909, National Bureau of Economic Research, Cambridge MA.

Bull, Clive; Schotter, Andrew and Weigelt, Keith (1987): Tournaments and Piece Rates: An Experimental Study, *Journal of Political Economy*, 95(1), 1–33.

Camerer, Colin (1987): Do Biases in Probability Judgement Matter in Markets? Experimental Evidence. American Economic Review 77(5): 981-97.

Camerer, Colin (1995): Individual Decision Making, in John H. Kagel and Alvin E. Roth (eds.): *Handbook of Experimental Economics*, Princeton: Princeton University Press, 587-703.

Conlisk, John (1996): Why Bounded Rationality?, *Journal of Economic Literature*, 34(2),669-700.

Davis, James H. (1992): Some Compelling Intuitions about Group Consensus Decisions, Theoretical and Empirical Research, and Interpersonal Aggregation Phenomena: Selected Examples 1950-1990, *Organizational Behavior and Human Decision Processes*, 52(1), 3–38.

Davis, Douglas D. and Harless, David W. (1996): Group vs. Individual Performance in a Price-Searching Experiment, *Organizational Behavior and Human Decision Processes*, 66(2), 215–227.

Erev, Ido and Roth, Alvin E. (1998): Predicting How People Play Games: Reinforcement Learning in Experimental Games with Unique, Mixed Strategy Equilibria, *American Economic Review*, Vol. 88(4), 848–881.

Fehr, Ernst and Falk, Armin (1999): Wage Rigidity in a Competitive Incomplete Contract Market, *Journal of Political Economy*, 107(1), 106–134.

Frey, Bruno S. and Eichenberger, Reiner (1994): Economic Incentives Transform Psychological Anomalies, *Journal of Economic Behavior and Organization*, (23)2, 215–234.

Friedman, Daniel (1998): Monty Hall's Three Doors: Construction and Deconstruction of a Choice Anomaly, *American Economic Review*, 88(4), 933–946.

Gilovich, T., Medvec, V. H., and Chen, S. (1995): Commission, Omission, and Dissonance Reduction: Coping with Regret in the "Monty Hall" Problem. *Personality and Social Psychology Bulletin*, 21, 185–190.

Gode, Dhananjay K. and Sunder, Shyam (1993): Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Irrationality, *Journal of Political Economy*, 101(1), 119–137.

Granberg, Donald (1999): Cross-Cultural Comparison of Responses to the Monty Hall Dilemma, *Social Behavior and Personality*, 27, 431–438.

Granberg, Donald and Brown, T. A. (1995): The Monty Hall Dilemma, *Personality and Social Psychology Bulletin*, 21, 711–723.

Granberg, Donald and Dorr, Nancy (1998): Further Exploration of Two-Stage Decision Making in the Monty Hall Dilemma, *American Journal of Psychology*, 111(4), 561–579.

Granovetter, Mark (1985): Economic Action and Social Structure: The Problem of Embeddedness, *American Journal of Sociology*, 91, 481–510.

Hung, Angela A. and Plott, Charles R. (2001): Information Cascades: Replication and an Extension to Majority Rule and Conformity-Rewarding Institutions, *American Economic Review*, 91(5), 1508–1520.

Knez, Peter; Smith, Vernon L. and Williams, Arlington W. (1985): Individual Rationality, Market Rationality, and Value Estimation. *American Economic Review, Papers and Proceedings,* 75(2), 397-402.

Loewenstein, George (1999): Experimental Economics from the Vantage-Point of Behavioural Economics, *Economic Journal*, 109(453), F23–34.

List, John (2000): The Effect of Market Experience on the WTA/WTP Disparity: Evidence from a Field Experiment with Sports Memorabilia. Working paper University of Arizona, April 2000.

Lucas, Robert E. (1987): Adaptive Behavior and Economic Theory, in Robin M. Hogarth and Melvin W. Reder (eds.): *Rational Choice – The Contrast Between Economics and Psychology*, Chicago and London: Chicago University Press, 217–242.

Mookherjee, Dilip (1990): Rank Order Competition and Incentives: An Organizational Perspective, in *Economic Theory and Policy: Essays in Honour of Dipak Banerjee*, edited by Bhaskar Dutta and others, Oxford University Press, New Delhi.

Nalbatian, Haig R. and Schotter, Andrew (1997): Productivity Under Group Incentives: An Experimental Study, *American Economic Review*, 87(3), 314–341.

Nickerson, Raymond S. (1996): Ambiguities and Unstated Assumptions in Probabilistic Reasoning, *Psychological Bulletin*, 120, 410-433.

Page, Scott E. (1998): Let's Make a Deal, *Economics Letters*, 61(2), 175–180.

Rabin, Matthew (1998): Psychology and Economics, *Journal of Economic Literature*, 36(1), 11–46.

Rabin, Matthew (2001): A Perspective on Psychology and Economics. Forthcoming in *European Economic Review*.

Rasmusen, Eric (1989): *Games and Information*, Cambridge, MA: Blackwell Publishers.

Selten, Reinhard and Buchta, Joachim (1998): Experimental Sealed Bid First Price Auctions with Directly Observed Bid Functions. In: D. Budescu, I. Erev, R. Zwick (eds.): *Games and Human Behavior. Essays in Honor of Amnon Rapoport*. Mahwah: L. Erlbaum Ass, 79–102.

Smith, Vernon L. (1962): An Experimental Study of Competitive Market Behavior, *Journal of Political Economy*, 70(2), 111–137.

Slembeck, Tilman (2002): Dependent vs. Independent Events: On the Psychology of the Monty Hall Problem, unpublished working paper, Department of Economics, University of St.Gallen.

Sunder, Shyam (1995): Experimental Asset Markets: A Survey, in John H. Kagel and Alvin E. Roth, eds., *Handbook of Experimental Economics*, Princeton: Princeton University Press, 445–500.

Tindale, R. Scott (1989): Group vs. Individual Information Processing: The Effects of Outcome Feedback on Decision Making, *Organizational Behavior and Human Decision Processes*, Vol. 44, 454–473.

Appendix: Subject instructions

SubjectNo._____

Welcome to Today's Experiment!

This decision making experiment is financed by the Research Fund of the University of St.Gallen.

The Rules:

1.   There are three doors (1, 2 and 3) to choose from.

2.   Behind <u>one</u> of the doors there is a prize hidden. The other two doors are empty. There is only one prize. The computer determines randomly which door contains the prize.

3.   Please choose the door you think is the winning door by clicking on it.
(see screen "First Choice" in the appendix)

1.   **The computer** will then open a door that <u>does not</u> contain the prize.
(see screen "Second Choice" in the appendix)

The computer is programmed such that
a) the door you first chose is not opened *and*
b) the opened door does never contain the prize.
Note that in case there are two possibilities to open an empty door under b), the computer will make a random selection which door to open.

5.   **You** then have the choice to either **Remain** with your initial choice or to **Switch** to the other unopened door by clicking the appropriate button with your mouse.
(see screen "Second Choice" in the appendix)

6.   **The computer** will then show you where the prize was. If you chose the winning door, you will receive 10 points – otherwise you will earn nothing.
(see screen "Result" in the appendix)

• This situation will be repeated several times.

• All rounds are identical.

• On the screen you will see the running total of your earnings as the experiment proceeds.

Payments

•   At the end of the experiment the points collected are converted into money (Swiss Francs) at a rate of **10 Points = 0.75 Swiss Francs**.
Example: You have earned a total of 300 Points. You will be paid 22.50 Swiss Francs.

- The total of your earnings will be paid to you in cash at the end of the session.

Important Notices:

– There is no time pressure. You may proceed at your own pace.
– Please work independently of others in the room. Do not speak and do not attempt to look at the screens of others. You will be excluded from the experiment immediately, if you violate this rule.
– What you do in this experiment will be recorded anonymously. Your behavior has no influence on your studies. What you earn is your own business.
– Please raise your hand when you have finished the experiment.
– All information given by the experimenters is correct and true. There are no hidden traps.

- **If you have any further questions, please raise your hand.**

- **Otherwise please complete Questionnaire 1 now.**

- **After completing the Questionnaire, you may begin the experiment by turning on the screen of your computer. Start with point 1. of the rules.**

```
Please return these instructions to the experimenters at the
              end of the session - Thank you.
```

SubjectNo._____

Welcome to Today's Experiment!

This decision making experiment is financed by the Research Fund of the University of St.Gallen.

The Rules:

1. There are three doors (1, 2 and 3) to choose from.

2. Behind <u>one</u> of the doors there is a prize hidden. The other two doors are empty.
    There is only one prize. The computer determines randomly which door contains the prize.

3. Please choose the door you think is the winning door by clicking on it.
    (see screen "First Choice" in the appendix)

4. **The computer** will then open a door that <u>does not</u> contain the prize.
    (see screen "Second Choice" in the appendix)

    The computer is programmed such that
    a) the door you first chose is not opened *and*
    b) the opened door does never contain the prize.
    Note that in case there are two possibilities to open an empty door under b), the computer will make a random selection which door to open.

5. **You** then have the choice to either **Remain** with your initial choice or to **Switch** to the other unopened door by clicking the appropriate button with your mouse.
    (see screen "Second Choice" in the appendix)

6. **The computer** will then show you where the prize was. If you chose the winning door, you will receive 10 points – otherwise you will earn nothing.
    (see screen "Result" in the appendix)

• This situation will be repeated several times.

• All rounds are identical.

• On the screen you will see the running total of your earnings as the experiment proceeds.

Payments

•   At the end of the experiment participants will be ranked according to the total number of points obtained.

•   The person with the highest overall score will be ranked first, the one with the second highest number of points will be ranked second .... and so on.

- Depending on the rank at the end of the experiment the points earned will be converted into money (Swiss Francs) according to the following table.

Rank	10 Pts. =
1	1.00 SFR.
2	0.95 SFR.
3	0.90 SFR.
4	0.85 SFR.
5	0.80 SFR.
6	0.75 SFR.
7	0.70 SFR.
8	0.65 SFR.
9	0.60 SFR.
10	0.55 SFR.
11	0.50 SFR.
12	0.45 SFR.

- *Example*: Suppose you have earned 280 Points and are ranked 4th. In this case your payment is SFR. 23.80 (= 280/10 x 0.85)

• The total of your earnings will be paid to you in cash at the end of the session.

Important Notices:

– There is no time pressure. You may proceed at your own pace.
– Please work independently of others in the room. Do not speak and do not attempt to look at the screens of others. You will be excluded from the experiment immediately, if you violate this rule.
– The computer will sometimes automatically be stopped. Please raise your hand in this case. You will then be informed about the current standings of all other groups.
– What you do in this experiment will be recorded anonymously. Your behavior has no influence on your studies. What you earn is your own business.
– Please raise your hand when you have finished the experiment.
– All information given by the experimenters is correct and true. There are no hidden traps.

• **If you have any further questions, please raise your hand.**

• **Otherwise please complete Questionnaire 1 now.**

• **After completing the Questionnaire, you may begin the experiment by turning on the screen of your computer. Start with point 1. of the rules.**

GroupNo._____

Welcome to Today's Experiment!

This decision making experiment is financed by the Research Fund of the University of St.Gallen.

The Rules:

The experiment is run in groups of three persons each. All groups work <u>independent</u> of each other. All groups (repeatedly) face the following task:

1. There are three doors (1, 2 and 3) to choose from.

2. Behind <u>one</u> of the doors there is a prize hidden. The other two doors are empty.
    There is only one prize. The computer determines randomly which door contains the prize.

3. Please choose the door you think is the winning door by clicking on it.
    (see screen "First Choice" in the appendix)

4. **The computer** will then open a door that <u>does not</u> contain the prize.
    (see screen "Second Choice" in the appendix)

    The computer is programmed such that
    a) the door you first chose is not opened *and*
    b) the opened door does never contain the prize.
    Note that in case there are two possibilities to open an empty door under b), the computer will make a random selection which door to open.

5. **You** then have the choice to either **Remain** with your initial choice or to **Switch** to the other unopened door by clicking the appropriate button with your mouse.
    (see screen "Second Choice" in the appendix)

6. **The computer** will then show you where the prize was. If you chose the winning door, you will receive 10 points – otherwise you will earn nothing.
    (see screen "Result" in the appendix)

• This situation will be repeated several times.

• All rounds are identical.

• On the screen you will see the running total of your earnings as the experiment proceeds.

How to proceed within the group

a) One group member (beginning with person A) picks one of the three doors by clicking with the computer mouse (see step 3 above).
b) After the computer has revealed an empty door, the group discusses whether to remain with that choice or to switch to the other unopened door.
c) The group takes a majority vote whether to "REMAIN" or "SWITCH". The result is recorded in the "Group protocol" and implemented by clicking the appropriate button (see step 5 above).

This procedure is identical for all rounds. In round 2 person B starts with step a), in round 3 person C starts with step a), in round 4 person A starts with step a)... etc.

Payments

- At the end of the experiment the points collected are converted into money (Swiss Francs) at a rate of **10 Points = 0.75 Swiss Francs**.
  Example: Your group has earned a total of 300 Pts. You will be paid 22.50 Swiss Francs.

- The total earnings will be paid to *each group member* in cash at the end of the session.

Important Notices:
– There is no time pressure. You may proceed at your own pace.
– Please work independently of other groups in the room. Do not speak too loud and do not attempt to look at the screens of other groups. You will be excluded from the experiment immediately, if you violate this rule.
– What you do in this experiment will be recorded anonymously. Your behavior has no influence on your studies. What you earn is your own business.
– Please raise your hand when you have finished the experiment.
– All information given by the experimenters is correct and true. There are no hidden traps.

- **If you have any further questions, please raise your hand.**

- **Otherwise please complete Questionnaire 1 now. Each person is required to complete the Questionnaire independent of other group members.**

- **After completing the Questionnaire, you may begin the experiment by turning on the screen of your computer. Start with step a) under "*how to proceed within a group*".**

```
Please return these instructions to the experimenters at the
          end of the session - Thank you.
```

```
A4 Instructions for Treatment CC
   (translated from German)
```

GroupNo._____

Welcome to Today's Experiment!

This decision making experiment is financed by the Research Fund of the University of St.Gallen.

The Rules:

The experiment is run in groups of three persons each. All groups work <u>independent</u> of each other. The groups compete among each other: The more points a group scores relative to other groups, the higher is the rate at which points are converted into cash at the end of the experiment (see Section "Payments" below).

All groups (repeatedly) face the following task:

1. There are three doors (1, 2 and 3) to choose from.

2. Behind <u>one</u> of the doors there is a prize hidden. The other two doors are empty.
   There is only one prize. The computer determines randomly which door contains the prize.

3. Please choose the door you think is the winning door by clicking on it.
   (see screen "First Choice" in the appendix)

4. **The computer** will then open a door that <u>does not</u> contain the prize.
   (see screen "Second Choice" in the appendix)

   The computer is programmed such that
   a) the door you first chose is not opened *and*
   b) the opened door does never contain the prize.
   Note that in case there are two possibilities to open an empty door under b), the computer will make a random selection which door to open.

5. **You** then have the choice to either **Remain** with your initial choice or to **Switch** to the other unopened door by clicking the appropriate button with your mouse.
   (see screen "Second Choice" in the appendix)

6. **The computer** will then show you where the prize was. If you chose the winning door, you will receive 10 points – otherwise you will earn nothing.
   (see screen "Result" in the appendix)

• This situation will be repeated several times.

• All rounds are identical.

• On the screen you will see the running total of your earnings as the experiment proceeds.

How to proceed within the group

a) One group member (beginning with person A) picks one of the three doors by clicking with the computer mouse (see step 3 above).
b) After the computer has revealed an empty door, the group discusses whether to remain with that choice or to switch to the other unopened door.
c) The group takes a majority vote whether to ”REMAIN“ or ”SWITCH“. The result is recorded in the ”Group protocol“ and implemented by clicking the appropriate button (see step 5 above).
This procedure is identical for all rounds. In round 2 person B starts with step a), in round 3 person C starts with step a), in round 4 person A starts with step a)... etc.

Payments

• At the end of the experiment groups will be ranked according to the total number of points obtained.

• The group with the highest overall score will be ranked first, the one with the second highest number of points will be ranked second .... and so on.

• Depending on the rank at the end of the experiment the points earned will be converted into money (Swiss Francs) according to the following table.

Rank	10 Pts. =
1	1.00 SFR.
2	0.95 SFR.
3	0.90 SFR.
4	0.85 SFR.
5	0.80 SFR.
6	0.75 SFR.
7	0.70 SFR.
8	0.65 SFR.
9	0.60 SFR.
10	0.55 SFR.
11	0.50 SFR.
12	0.45 SFR.

- *Example*: Suppose your group has earned 280 Points and is ranked 4th. In this case your payment is SFR. 23.80 (= 280/10 x 0.85)

• The total earnings will be paid to *each group member* in cash at the end of the session.

Important Notices:
− There is no time pressure. You may proceed at your own pace.
− Please work independently of other groups in the room. Do not speak too loud and do not attempt to look at the screens of other groups. You will be excluded from the experiment immediately, if you violate this rule.
− The computer will sometimes automatically be stopped. Please raise your hand in this case. You will then be informed about the current standings of all other groups.
− What you do in this experiment will be recorded anonymously. Your behavior has no influence on your studies. What you earn is your own business.
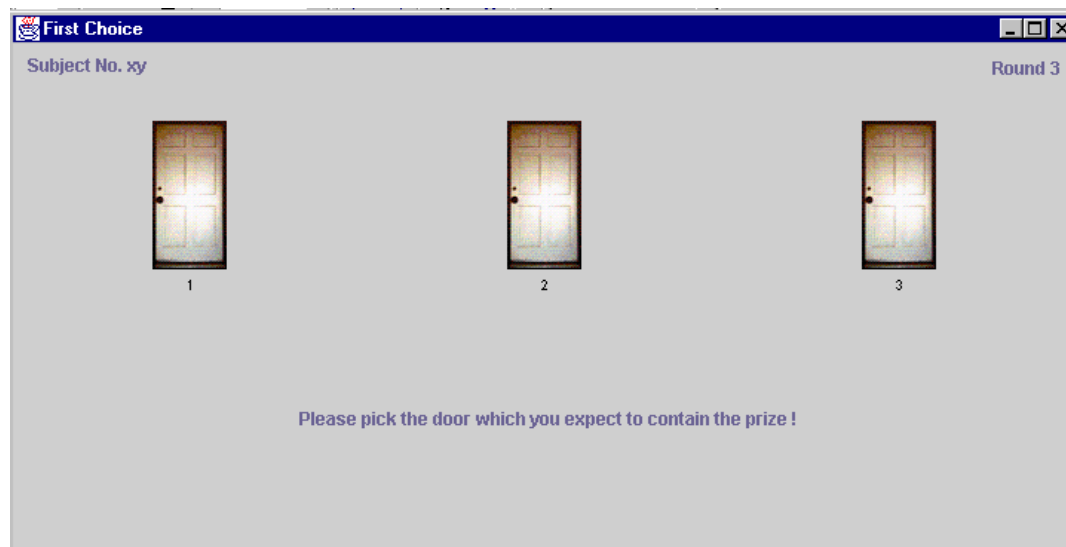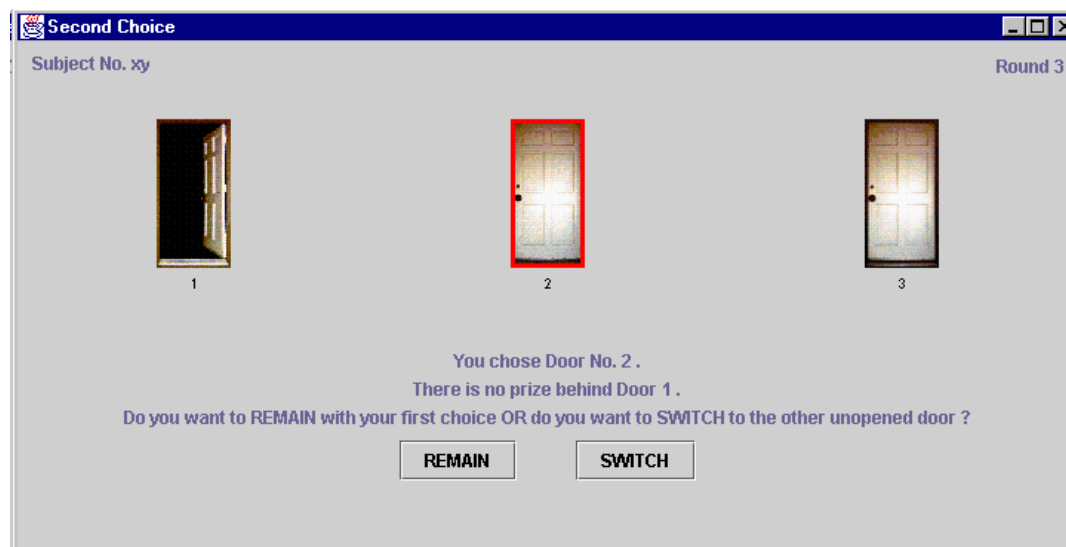
– Please raise your hand when you have finished the experiment.
– All information given by the experimenters is correct and true. There are no hidden traps.

- **If you have any further questions, please raise your hand.**

- **Otherwise please complete Questionnaire 1 now. Each person is required to complete the Questionnaire <u>independent</u> of other group members.**

- **After completing the Questionnaire, you may begin the experiment by turning on the screen of your computer. Start with step a) under "*how to proceed within a group*".**

```
Please return these instructions to the experimenters at the
              end of the session - Thank you.
```

A5: Appendix to Instructions (Example)

Screen „First Choice"

First Choice

Subject No. xy — Round 3

1   2   3

Please pick the door which you expect to contain the prize !

Screen „Second Choice"

Second Choice

Subject No. xy — Round 3

1   2   3

You chose Door No. 2 .
There is no prize behind Door 1 .
Do you want to REMAIN with your first choice OR do you want to SWITCH to the other unopened door ?

[REMAIN]   [SWITCH]

In this example door #2 was chosen.

Screen „Result"

Result

Subject No. xy — Round 3

1   2   3

Prize was behind Door No. 3.

Your earnings in this round are 0.00.

[Next Round]

Your total earnings so far: Pt. xx

In this example "REMAIN" was chosen.
The prize was behind door # 3. There were no earnings this time.

A5 (continued): Example of statistical feedback screen:

[Note to readers: Display of individual "track record information" as given after each choice throughout the experiment in all treatments].

STATISTICS OF YOUR DECISIONS AFTER ROUND 5	
Actual Choices	Number of times you chose to REMAIN: 3
	Number of times you chose to SWITCH: 2
	Points earned so far: Pt. 30.00
Hypothetical Choices	Number of points for ALWAYS REMAINING: Pt. 10.00
	Number of points for ALWAYS SWITCHING: Pt. 40.00

In this example 5 rounds haven been finished so far.
The screen tells you your actual past choices and current earnings,
along with hypothetical information about what would have happened
if you had ALWAYS chosen to REMAIN and
if you had ALWAYS chosen to SWITCH in the past.