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Imitation with Intention and Memory: an Experiment

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Abstract

Three results emerge from a simple experiment on imitation. First, I find behavior which strongly suggests an intention to imitate. Second, players imitate successful other players rather than repeating successful actions. Third, to find imitation examples, players use several periods of memory. This lends support to learning models with a non-trivial role of memory.
The experiment analyzes imitation in an individual learning context. It supplements the results obtained for imitation in evolutionary processes.

JEL classification: D01, D83

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1 Introduction

There are two reasons for imitation. First, imitation can be necessary for the development of skills. This applies to tasks that require practice, like eating with chop sticks or walking on one's hands. Second, imitation can be useful to achieve high outcomes, but no information or skill is acquired. For example, buying the same stocks as André Kostolany would not have meant to learn why he picked which stocks, but to profit from his knowledge without acquiring it oneself. In such cases, the necessary information is received *before* the imitation, when one learns what person is worthwhile imitating. Skill is not required.

The experiment described in this paper focuses on the second kind of imitation. It is designed to mimic situations where players make decisions in a changing environment, but cannot learn from imitation in the sense of acquiring skill or information through imitating others. It is particularly relevant under circumstances where players have (or think they have) different levels of information, and can observe others' current behavior.
The experiment shows that people imitate even if they cannot obtain information or acquire skill by doing so. Overall, 39% of all decisions in the experiment show an intention to imitate, but are consistent neither with genuine learning nor with randomization strategies. This result complements previous experimental research (e.g., Apesteguia/Huck/Oechssler, 2006; Selten/Apesteguia, 2002) that focussed on showing that behavior was *consistent* with an imitation strategy, but could not show whether it was actually driven by imitation motives.

The second point of the paper concerns the choice of imitation examples, that is, whom or what players imitate.[1] In the literature, people are usually assumed to repeat an action that was successful either in the period just before the decision (e.g., Vega-Redondo, 1997; Selten/Ostmann, 2001) or in some period during the time the player can recall (e.g., Alos-Ferrer, 2004; Josephson/Matros, 2004). In experiments, players only have the opportunity to imitate past strategies (e.g., Huck, Normann, Oechssler, 1999). In contrast, the hypothesis in this experiment is that players imitate other players, rather than repeating particular actions. The main difference between the two concepts is that successful players have long-term strategies that make them successful in changing environments. One-shot actions, on the other hand, may be successful in one period, but not necessarily in another. To distinguish the two concepts, repeating others' actions is costless in the experiment, while imitating players is costly. Nevertheless, participants frequently imitated successful players.

Finally, the experiment sheds some light on the use of memory in individual decisions. Even though some theoretical models account for multi-period memory (e.g., Alos-Ferrer, 2004), the experimental literature so far usually considered the case where only last period's payoffs can be recalled and used in the decision(e.g., Huck/Normann/Oechssler, 1999, Altavilla/Luini/Sbriglia, 2006).[2] In this experiment, unlimited memory of all previous periods is induced by providing informa-

[1] I choose the term "imitation examples" following Selten/Ostmann's (2001) "success examples".

[2] It should be noted that under this assumption it becomes undistinguishable whether actions or players are imitated.

tion on all actions and payoffs to all participants throughout the experiment. The results suggest that players indeed use this information when making their decisions. Although 85% of all imitation decisions are consistent with considering only last period's payoffs and imitating the player with the highest payoff there, over 80% of the decisions in the relevant periods are also consistent with considering the payoffs of the last 2 to 17 periods. Considering all past periods and weighting them with a discount factor also supports the hypothesis that results of more than one past period are relevant for players' decisions. Finally, a regression shows that the payoffs of up to four periods prior to the decision have a significant impact on the choice of imitation examples.
The results of the experiment are consistent with the behavioral rules suggested by Alos-Ferrer (2004) and Bergin/Bernhardt (1999), with the restriction that the experimental design is not well suited for a rigorous test of these rules. In contrast, the win-stay lose-shift rule suggested by Dixon (2000) and Oechssler (2002) receives only weak support in this context.

The situations that are mimicked in the experiment, where the environment changes and some players may be better informed than others, are common in real market situations. For example, consider a atomistic market where a new firm enters. This firm may follow the marketing strategy of a firm that proved successful in the market, without understanding yet why this strategy is actually profitable. Assuming that the strategy and payoffs of the successful firm are observable, the new firm does not learn anything from imitation that it could not learn from pure observation. However, by imitating it may ensure high payoffs until it has finally learned to successfully market its products itself.
Similar examples exist for individual decision making. Assume an investor who wants to invest in stocks and does not have much knowledge about the market. But he happens to know that George Soros recently bought shares of the publicly traded company X. By buying such stocks, the investor will not learn anything new about the market, since stock prices are observable. He may nevertheless imitate Soros, believing that this increases his payoffs until he has finally learned to make profitable investment decisions himself. In both cases, the relevant increase in information occurs *before* the imitation. The new firm learns by observation which firms are successful in the market, and the newcomer learns who are successful investors. Practicing skills is not necessary.

Imitation processes have been analyzed theoretically by Vega-Redondo (1997), Schlag (1998, 1999), Selten/Ostmann (2001), and more recently by Fudenberg/Imhof (2005) and Levine/Pesendorfer(2006). In these models, any behavior is defined as imitation which leads to the individual choosing an action which was played last period. Only the exact action the individual should choose is determined differently. While Vega-Redondo and Selten/Ostmann use an imitate-the-best rule, Schlag proposes a proportional rule, where each strategy which yields a higher outcome than one's own is imitated with a probability proportional to the difference in outcomes.
These models' focus on last period's outcomes applies well to evolutionary contexts, where periods can be interpreted as generations, and individuals enter and drop out of the population each period. For individual learning within relatively short time (either by people or firms), however, such a limited memory seems a re-

strictive assumption. Alos-Ferrer (2004) and Josephson/Matros (2004) relax this restriction and include multi-period memory in their models. Alos-Ferrer modifies the imitate-the-best rule, such that players remember the payoffs of $K + 1 > 1$ periods, and imitate the strategy which yielded the highest payoff in memory. He notes, however, that more sophisticated strategies are imaginable, i.e., to imitate the strategy with the highest recalled average payoff, the average population payoff and the highest within-period payoff.

The experimental literature so far followed the evolutionary, no-memory approach of the earlier imitation models. For example, Apesteguia/Huck/Oechssler (2006) set up a Cournot market game and test the different predictions that the theoretical models yield for this market. On the aggregate level, different informational settings allow them to distinguish between the models according to the quantities players choose, i.e., the equilibrium the market converges to. On the individual level, the authors find that many players' behavior is consistent with imitation in the majority of periods. However, given the experimental setting, it seems impossible to distinguish explicitly between behavior that looks like imitation but is the result of other strategies, and behavior which is actually driven by imitation motives.[3] This problem equally applies to the experiments of Selten/Apesteguia (2002), Huck/Normann/Oechssler (1997), Altavilla/Luini/Sbriglia (2006). It is described in more detail below.

Consider a situation where in an oligopoly market game player 1 sets price x and obtains payoff a. Player 2 sets price y and obtains payoff $b > a$. In the next period, player 1 also sets price y. In the experiments mentioned above, this would be interpreted as evidence for imitation in individual behavior. This inference, however, is based on the very broad interpretation of "imitation" as any behavior which makes an individual choose an action that was successful in the past. In particular, it does not require an intention to imitate. How, then, does learning occur which is not imitation? If somebody learns by observing others that in chess the player wins who keeps his king until the end, and then tries to keep her king when playing herself - does she imitate? Or did she just learn the rules of the game, and now plays by them?[4]

In this paper, I choose a narrower definition of imitation, in order to be able to distinguish between behavior which is imitating in the colloquial sense of the word (copying, mimicking) on one hand, and behavior which involves observation and genuine learning on the other hand.[5] Imitation in the sense of practicing to acquire skills is not considered.

According to this narrower definition of imitation, players' behavior is imitating if they have an intention to do what somebody else does or did, and do not have sufficient understanding of the situation to choose a successful action themselves. This means that player 1 may truly have wanted to imitate player 2. However, he

[3] The authors note that a questionnaire that the participants filled in after the experiment gives hints that some players indeed intended to imitate.

[4] Even trial and error learning could be classified as imitation with this definition, namely imitation of one's own past successful actions.

[5] I define as *genuine learning* all strategies that lead to an expected increase in relevant knowledge about the game, i.e., its structure and rules. This includes complex strategies like Bayesian updating from the observation of the strategies and payoffs of others, but also simple strategies like trial and error.

may as well have learnt the structure of the market from observation in the first period, and then used this knowledge to pick the action with the higher expected payoff in the second.

In the next section I explain the design of the experiment. The results are presented and discussed in section 3. Some concluding comments are provided at the end.

2 Experimental design

Participants in the experiment had to choose cells from a table. Each cell returned points. The pattern according to which cells were matched to points changed, but not necessarily in each round. Participants knew that this change occurred according to a regular, non-trivial rhythm. They also knew that other players might have more or less information than they themselves. However, they did not know for sure whether there were others with a different amount of information, nor whether they were better or worse informed than others, nor of what the difference in information consisted. I will call the better informed players "informed", and the less informed players "uninformed".

Informed players saw tables like this

a1	b2	c3
b3	a3	a2
c2	c1	b1

They knew that a-cells were always best, b-cells were medium and c-cells were always worst. The position of the cells in the table changed, but players could observe this. However, the ranking of the three cells of a particular letter also changed. In some period, a1 could be best, in another a2, and in yet another a3. The rhythm of this change was not known to the informed players but could be learnt during the experiment. So the task for informed players was in each period to choose an a-cell and find out during the experiment in which period which a-cell returned the highest number of points.[6]

Uninformed players saw the following table in each period:

a	b	c
d	e	f
g	h	i

[6]It was not explicitly stated that they should only choose from a-cells. But it was clearly stated that a-cells were always best.

This table did not contain any payoff-relevant information. Players knew that each cell contained points, and that these point might change every period. But they did not see the a-cells. Hence, it was their task to find out among all cells - instead of just the a-cells - which cells yielded the highest points in which period.

Instead of choosing a cell themselves, players could name another player, whose cell choice was then also valid for them. They had to make this decision before they saw other players' current choices, that is, when making the decision to imitate another player, they did not know his cell choice.[7] For example, player 3 might have decided in period 5 to imitate player 7. Player 7 chose, say, cell c and received 14 points. Only afterwards did player 3 learn about the choice of player 7, and the number of points he received.

After each round, all players' cell choices and points were made visible to all participants, and this information about all rounds was available on screen throughout the experiment. For consistency, the choices of one type of player were translated into the strategy space of the other. For example, an $a1$ choice of an informed player appeared as a b, e etc. choice on the screen of uninformed players, depending on its position in the relevant period. Similarly, a b, f etc. choice of an uninformed player appeared as a $b1$, $c3$ etc. choice on the screen of informed players, depending on the positions in the relevant period. This means that all information that was generated during the experiment and was relevant for learning how to obtain a high number of points was available to all players at all times. Imitating another player did not increase the players' information. Rather, since by imitating others players did not generate their own data points (no cell choice), imitation reduced overall information compared to choosing one's own cell.

Players could earn between 1 and 15 points by choosing a cell themselves. If they chose to imitate a player, they received the number of points of the imitated player, minus a fee. There was a "cheap" treatment, in which this fee was one point, and an "expensive" treatment, where the fee was three points.

The experiment lasted for 30 periods, without any practice periods. In each session there were 2 informed and 12 uninformed players (except for session 5, where there were only 10 uninformed players for technical reasons). Four sessions were conducted for the "cheap" treatment, and three for the "expensive" treatment. In sum, there were 48 uninformed players in the "cheap" treatment, and 34 in the "expensive" treatment. Treatments differed only in the size of the fee. Participants were informed that after the 30 periods one period was chosen randomly, of which payoffs were paid out immediately. Points were exchanged into EUR according to the rate 1 point = 0.7 EUR for uninformed players and 1 point = 0.5 EUR for informed players. The different exchange rates were chosen in order to account for the difference in information and give players roughly equal expected payoffs. At the end of the instructions test questions ensured that all participants understood the rules of the experiment.
Participants were students of Humboldt Universität zu Berlin and Technische Universität Berlin, with mostly non-economics majors. The experiments took place at Technische Universität Berlin in June 2006. The experiments were computer-

[7]The words "imitate" or "imitation" were not used anywhere in the experiment. See also the translated instructions in the appendix.

ized using z-tree (Fischbacher, 1999). Sessions lasted about 60 min. The average amount earned was 9.8 EUR.

3 Results

3.1 Imitation intention

The first question the experiment addresses is whether players have an intention to imitate. Imitation is defined as players following the cell choices of other players, although they do not know yet what this choice is.

Overall, uninformed players imitated in 39% of the decisions they made (959 of 2460). In the cheap treatment they imitated in 44.3% of their decisions (638 of 1440), while in the expensive treatment they imitated in 31.5% of the decisions (321 of 1020).[8] This shows that in both treatments players imitated to a significant degree.

For the interpretation of the numbers, it should be noted that in the first periods it was not yet obvious that some players obtained higher payoffs, while in the second half of the experiment several uninformed players had learnt to play the game successfully themselves. The share of imitation decisions in the periods when imitation was sensible is therefore even higher than the numbers show. For example, the share of uninformed players' imitation decisions in periods 6 to 23 is 54% in the cheap treatment and 37% in the expensive treatment. This is also reflected in the distribution of imitation decisions over the 30 periods, which is shown in figure 1 and table 4 in the appendix. Imitation really starts in the 5th or 6th period, i.e., when it becomes obvious what players are successful. It levels off towards the end when more players understand the rhythm of changes. Note that the distribution of points in the table could only be fully learnt after the 14th period.[9]

— insert figure 1 here —

The higher price of imitation in the expensive treatment led to a lower, but still considerable amount of imitation. The difference in the average number of imitations per player is significant at the 1%-level (Wilcoxon-Mann-Whitney test). It should, however, be noted that the size of the reduction is mainly driven by one of the three sessions of this treatment with a very low amount of imitation (14% vs. 46% and 36% in the other two sessions). Since otherwise there were no significant differences between the treatments, for the following analysis the data is aggregated over both treatments.

[8]Informed players mainly existed to serve as imitation examples, i.e., to have high average payoffs and give uninformed players a reason to imitate. Their behavior is therefore not included in the analysis of the extent of imitation. For completeness, when I analyze the mechanics of imitation below, the few imitation decisions of informed players (10 in all sessions) are nevertheless included.

[9]The rhythm of changes was such that the first three periods were not connected to the rhythm, and then a sequence over 9 periods was repeated 3 times.

The observed amount of imitation can be attributed to an *intention* to imitate, since genuine learning as well as randomization strategies can be ruled out as motives for imitating other players in this experiment.
To see this, consider first "genuine" learning strategies, i.e., strategies that increase the player's knowledge about the game. If a player imitates in the experiment, he does not learn the payoff of any cell choice from his own behavior. The cell choices and payoffs of other players are displayed throughout, independently of the players choice. Accordingly, imitation does not increase a player's knowledge of the game. Rather, by reducing the number of data points, it (weakly) decreases the available information.
Consider, second, randomization, i.e., that players are confused or bored and randomly choose actions between which they are indifferent. For this strategy to include imitation in the experiment, imitation had to be costless. But even in the cheap treatment, imitation cost uninformed players an equivalent of 70 EUR-Cent. In the expensive treatment this increased to an equivalent of 2.1 EUR. With an expected payoff from the entire experiment of about 10 to 15 EUR, few participants can be expected to ignore these costs. Any cell choice that a player wishes to play, including the random choice, can be achieved more cheaply if he chooses it himself.
Hence, players who imitate can be expected to do so intentionally.

3.2 Imitation of players or repetition of actions

The second question the experiment addresses is whether participants repeat successful past actions (cell choices) or imitate successful players.

The extent to what players imitate other players was outlined above. Do they also "imitate" by repeating past actions? On average, 25,7% of the players that chose their own cell chose the cell that was most successful last period. However, the pattern of cells was such that doing so yielded one of the 2 highest payoffs in 14 out of the 29 possible imitation periods (48%), a fact that was fairly easy to observe. In addition, choosing always cell "c" was a good strategy for a "simple" learner, since it yielded high payoffs in 23 periods. This "c" strategy would have resulted in 12 periods of repetition of the highest payoff from last period, or 41%. Since the observed 25% are clearly below these figures, the data does not suggest an intention to repeat past actions beyond what random and simple learning imply.

Is this result particular to the experimental design? The answer is yes and no. It is particular, because it will not hold in very stable settings, where what is the best action in one period is most likely also the best action in all other periods. Optimal play in such settings can be learned by observing it once, and imitation is not necessary. The result could not be obtained in the settings of previous experiments either, because there players did not have the opportunity to imitate other players' current behavior.

However, the result is also fairly general, because the crucial features of the design are frequently encountered in real life. What makes imitation of successful players attractive is that one can obtain high profits without actually understanding the game. In an economic context, this applies, e.g., to situations where markets change, but not all players know when or how, or how to react to a given change.

For example, in oligopolistic markets, some firms may be good in predicting their competitors behavior, while others lack the experience to do so. If given the chance, the latter may then prefer to imitate the former, instead of repeating the formers' behavior of another period.

It is also interesting to see whether participants, in addition to imitating successful other players, learnt how to play the game themselves. Figure 2 and table 4 show the average number of points obtained from own cell choices, conditional on players actually choosing their own cell. It shows an increase in the second half of the experiment, which indicates that some people have learnt the pattern, and choose their own actions. The increase is significant at $p < 0.01$ (Wilcoxon-Mann-Whitney test). The players who do not learn the pattern mostly continue to imitate.

— insert figure 2 here —

3.3 Choice of imitation examples

The third, and somewhat more complex question is, which players are actually imitated. In particular, do people use multi-period memory to identify imitation examples? Or is it a good approximation to consider only last period's outcomes when explaining players' imitation decisions?

Approaching this question, I make the assumption that only such players become imitation examples, i.e., are imitated, that have maximum payoffs according to some measure.[10] I call this the *maximization rule*. In general, this measure, which I denote S for *score*, is of the form

$$S_t^i = \sum_{n=t-s}^{t-1} \delta^{t-1-n} P_n^i \tag{1}$$

where δ denotes the discount factor applied to the results of previous periods, s denotes the number of periods taken into consideration, and P_n^i denotes the number of points player i received in period n. t is the period when the imitation decision is made, such that only the results of periods prior to t can be taken into account. Equation (1) gives one S per period per player, which can then be compared to this period's scores of all other players of the same session. $\Delta S_t^i = S_t^i - S_t^{max}$ denotes the difference between player i's score and the maximum score S^{max} in period t in this session. I then assess which parameters s and δ in (1) minimize the number of imitation decisions that deviate from the maximization rule, i.e., all decisions where for the imitated player i $\Delta S_t^i < 0$.

This approach yields three results. I first set $\delta = 1$ and then choose s optimally for each imitation decision. With this approach, 98% of all imitation decisions (946 of 969) imitate a player for whom $S_t^i = S_t^{max}$. If one allows for $\Delta S = -1$ as error margin, this goes up to more than 99% (963 of 969). However, to obtain these figures, one has to allow for different values of s across imitating players and periods.

[10]This means that I do not follow the approach of Schlag (1998).

Second, I leave $\delta = 1$ but apply the same s to all imitation decisions. I then consider all periods when $t - s > 0$, i.e., periods where s previous periods could have been taken into account. For example, to assess the share of decisions that are consistent with considering the payoffs of the previous 13 periods, I consider all decisions in periods 14 to 30. This approach shows that for $s = 1$, in 85% of the imitation decisions in relevant periods players imitated a player i for whom $S_t^i = S_t^{max}$, i.e., the decisions were in line with the maximization rule. This seems strong support for the assumption that players consider only one past period when making their decision. However, for considering up to 17 periods, i.e., $2 \leq s \leq 17$, in more than 80% of the decisions the imitating players also follow a player for whom $S^i = S^{max}$. Up to $s = 26$, still more than half of the decisions are consistent with imitating a player with the maximum average payoff. This result is summarized in figure 3 and table 4 in the appendix.

— insert figure 3 here —

Third, I set $s = t - 1$, i.e., I consider the results of all available periods, and optimize the discount factor such that it minimizes the number of deviations from the maximization rule. Since players' scores may now differ in only very small amounts, I repeat the analysis for different error margins. Figure 4 shows the number of deviations from the maximization rule depending on δ. An error margin of, e.g., 0.1 means that all imitation decisions for which the score of the imitated player i was $S^i \geq S^{max} - 0.1$ are accepted as being consistent with the maximization rule.

— insert figure 4 here —

The data show that for error margins of 0.01 and 0.1 points a discount factor of 0 - considering only last period - yields the least number of deviations from the maximization rule (see table 4 in the appendix). However, the mathematical abilities and calculation efforts that are implied in these low error margins are high. If one allows for some limitations in the subjects' cognitive abilities or efforts, and accepts error margins of 0.5 to < 1 point from the maximum, higher discount factors, i.e., a higher weight on previous periods, yield less deviations from maximization. Indeed, even a discount factor of $\delta = 1$, i.e., attaching equal weight to all previous periods, leads to higher compliance with the maximization rule than considering only the last period.

Finally, a regression shows that the points of up to four periods prior to the imitation decision have a significant impact on the decision. I run a panel regression with fixed effects, where the independent variables are a player's achieved points per period. The dependent variable is the share of others that imitated a certain player in a given period, relative to all players that imitated in this period. Hence, if in period 12 six players imitated, and four of them imitated player 8, this variable for player 8 in period 12 is $\frac{2}{3}$.
The results are displayed in table 4 in the appendix. They show that the points of the two periods prior to the decision are significant at $p < 0.01$, while the points of three and four periods prior to the decision are significant at $p < 0.05$.[11]

[11]It should be noted that the independent variables suffer from multicollinearity, with average

3.4 Test of other learning rules

As the last step of the analysis, I consider some of the rules suggested in the literature, and test whether the data is consistent with their implications. Dixon (2000) and Oechssler (2002) propose a win-stay lose-shift learning rule, according to which individuals' reference level for gains/losses is the average population payoff. Players stick with an action as long as it returns payoffs above their reference level, and experiment with other actions if payoffs fall below the reference level. Applied to this experiment, one would expect that if individuals who chose their own action last period and obtained below-average payoffs would switch to imitating other players, while those who obtained above-average payoffs keep on choosing their own action. The results show, however, that only 30% of the players with below-average payoffs turned to imitation in the next period. Nevertheless, among those that started imitating, 70% had below-average payoffs in the previous period.

Alos-Ferrer (2004) suggests a rule according to which individuals "imitate the strategy that yielded the highest payoff in memory". This rule is almost fully consistent with the players' imitation decisions if one assumes that strategies equal players. With all the results that are displayed on the screen being in the "memory" of players, only 9 imitation decisions ($< 1\%$) are such that the imitated player does NOT have the maximum payoff of 15 points in some period prior to the decision. Unfortunately, this result is not particularly instructive. The reason is that the design of the experiment, i.e., its stochastic component, is such that after only few periods, even pure randomization would most likely lead to the majority of players having obtained the maximum payoff in some period. Then, no matter what player is imitated, the decision is in line with the rule.
The same result obtains for the approach suggested by Bergin/Bernhardt (1999). In their model, players imitate one of the actions that performed best relative to other actions in a particular period, and consider all periods within their memory. If one again assumes that players' memory in the experiment is comprised of all past periods, only 6 imitation decisions are not consistent with this rule ($< 1\%$). However, the interpretation of this result suffers from the same problems as the rule of Alos-Ferrer.

4 Conclusion

The experiment shows that players have an intention to imitate other players they perceive as being more successful. When choosing imitation examples, they consider more than only last period's payoffs, but focus on players that are successful in the long run. The results of the experiment apply to market situations that are characterized by a changing environment and players that have different levels of information or experience. More generally, they show that imitation exists as a strategy to increase payoffs, even if no information or skill is acquired. This lends

correlation coefficients between the significant variables of between 0.40 and 0.60. This is to some extent also reflected in the correlation between the dummy variables and the independent variables. This problem does, however, not seem so severe that it compromises the results of the regression.

support to the interpretation of the results of earlier experiments. It suggests that the behavior observed there is not only consistent with imitation, but that players indeed had the intention to imitate.

Some limitations of the experimental design should finally be mentioned. First, it is not able to determine with ultimate certainty the number of periods that individual players consider when choosing imitation examples. To obtain this, the design would have to guarantee that different lengths of memory in most cases imply different decisions, which is too often not the case here. Second, and for similar reasons, the results do not yield clear implications for which of the behavioral rules that are suggested in the literature players comply with. To explicitly test for their validity, the stochastic structure of the game would have to be amended such that not almost any behavior is in line with these rules.

Appendix A

Period	Average number of imitations, treatment "cheap"	Average number of imitations, treatment "expensive"	Average number of points obtained from own cell choice
1	0.00	0.00	8.0
2	0.75	2.11	10.0
3	1.75	2.17	9.1
4	2.25	2.78	7.3
5	5.00	3.61	9.4
6	6.50	5.44	11.3
7	3.50	2.61	9.4
8	6.75	5.50	10.8
9	5.00	3.22	8.7
10	6.50	6.06	9.5
11	6.75	5.28	10.9
12	6.50	4.67	9.5
13	8.00	4.61	9.2
14	8.00	6.17	12.8
15	7.50	5.11	11.7
16	7.75	4.67	10.1
17	8.25	6.44	10.7
18	7.00	5.72	12.0
19	7.00	4.33	12.7
20	5.00	4.00	13.5
21	6.25	4.72	12.5
22	6.75	4.33	12.2
23	5.75	5.00	13.4
24	4.75	4.67	13.9
25	4.50	3.94	12.1
26	6.00	5.11	12.8
27	5.50	3.22	13.2
28	4.75	3.56	13.9
29	3.75	3.28	14.1
30	4.00	4.00	14.1

Table 1: Average imitations and points per period. (Fig. 1 and 2)

s	share		s	share		s	share
1	0.856		11	0.832		21	0.760
2	0.830		12	0.836		22	0.734
3	0.830		13	0.825		23	0.718
4	0.834		14	0.810		24	0.681
5	0.834		15	0.806		25	0.629
6	0.826		16	0.803		26	0.561
7	0.828		17	0.800		27	0.488
8	0.839		18	0.786		28	0.449
9	0.823		19	0.775		29	0.400
10	0.830		20	0.758			

Table 2: Share of imitation decisions in the relevant periods that are consistent with imitating the player with the maximum average points over s periods. (Fig. 3)

discount factors	error margins 0.01	0.1	0.5	0.999	1.0
0.00	*0.924*	*0.924*	0.924	0.924	*0.973*
0.05	0.895	0.922	0.928	0.965	0.966
0.10	0.900	0.917	0.933	0.965	0.966
0.15	0.896	0.911	0.933	0.966	0.966
0.20	0.897	0.911	0.934	0.967	0.967
0.25	0.897	0.911	0.936	0.968	0.968
0.30	0.898	0.910	0.937	0.968	0.968
0.35	0.891	0.908	*0.939*	0.972	0.972
0.40	0.891	0.906	*0.939*	0.972	0.972
0.45	0.891	0.912	0.937	*0.973*	*0.973*
0.50	0.896	0.906	*0.939*	0.970	0.970
0.55	0.893	0.905	*0.939*	0.970	0.970
0.60	0.894	0.904	0.938	0.970	0.970
0.65	0.895	0.905	0.935	0.972	0.972
0.70	0.895	0.903	0.935	0.971	0.971
0.75	0.895	0.901	0.934	0.971	0.971
0.80	0.895	0.902	0.935	0.972	*0.973*
0.85	0.895	0.904	0.932	0.971	0.971
0.90	0.895	0.905	0.935	0.971	0.971
0.95	0.894	0.904	0.935	0.969	0.969
1.00	0.895	0.906	0.937	0.968	0.968

Table 3: Share of imitation decisions that are consistent with imitating the player with the maximum average points over all periods, depending on discount factors and error margins allowed for the maximum rule. (Fig. 4) Optimum shares are emphasized.

Fixed-effects (within) regression — Number of obs =2880

R-sq: within = 0.0404 — Group variable (i): m

between = 0.4132 — Number of groups = 96

overall = 0.2032

corr(u_i, Xb) = 0.3844 — F(10,2774)= 11.67 — Prob > F = 0.0000

Variable	**Coefficient** (std. error)	**t**	$P > \|t\|$	95% Conf. Intervall
points(-1)	.0012688 (.0004766)	2.66	0.008	.0003342 .0022033
points(-2)	.0020659 (.0004977)	4.15	0.000	.0010901 .0030417
points(-3)	.0011261 (.0005032)	2.24	0.025	.0001393 .0021128
points(-4)	.0010724 (.0005099)	2.10	0.036	.0000725 .0020723
points(-5)	.0005475 (.0005169)	1.06	0.290	-.000466 .001561
points(-6)	.0003268 (.0005279)	0.62	0.536	-.0007084 .0013619
points(-7)	.0006156 (.0005385)	1.14	0.253	-.0004403 .0016716
points(-8)	.0000704 (.0005449)	0.13	0.897	-.0009981 .0011388
points(-9)	.0007364 (.0005543)	1.33	0.184	-.0003504 .0018232
points(-10)	-.0000528 (.0005273)	-0.10	0.920	-.0010868 .0009812
const	.0191582 (.0051821)	3.70	0.000	.0089969 .0293194

σ_u = .1650182 σ_e = .13010806

ρ = .61665651 (fraction of variance due to u_i)

F test that all $u_i = 0$: F(95, 2774) = 40.79 Prob > F = 0.0000

Table 4: Panel Regression. The variable $points(-s)$ denotes the number of points the individual received s periods prior to the imitation decision.

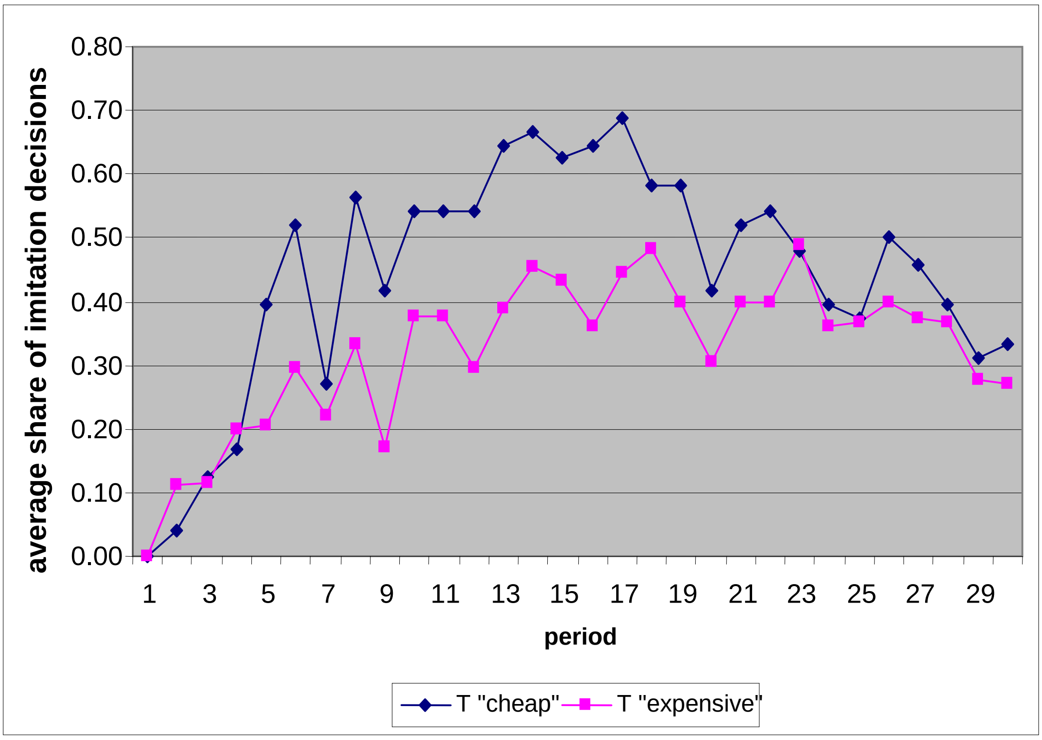

Figure 1: Average share of imitation decisions of uninformed players per period per treatment.[1]

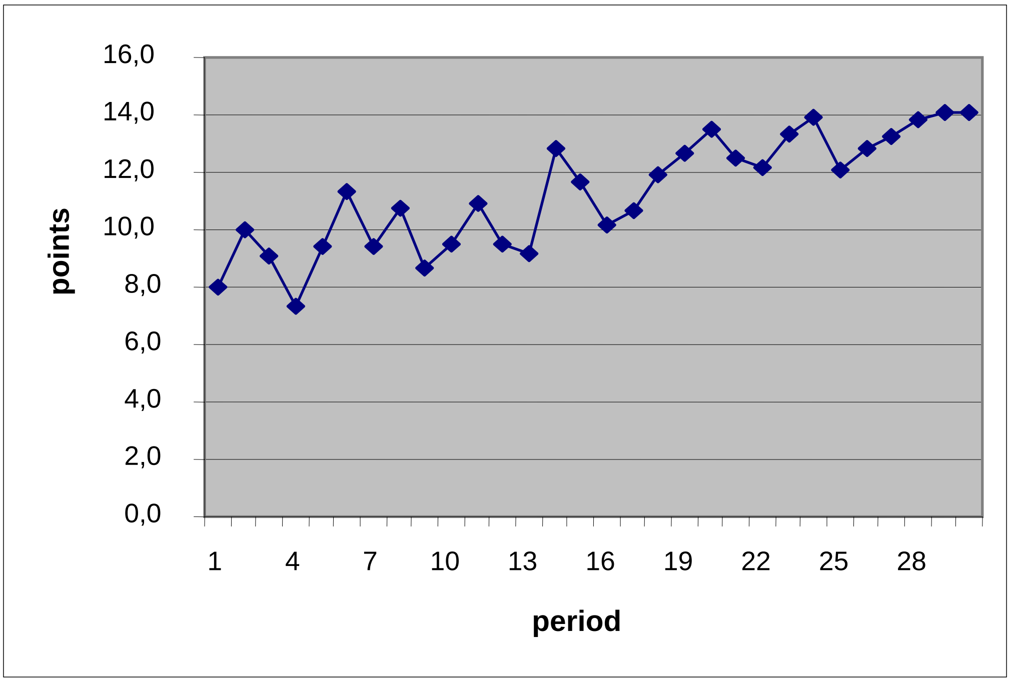

Figure 2: Average number of points obtained from choosing a cell oneself, contingent on players actually choosing their own cell.

[1] The parallel ups and downs for both treatments in periods 4-10 are probably due to a special feature of the change of the point distribution in the table. In some periods at the beginning, it may have seemed as if the rhythm of changes was simpler than it actually was, which may have caused some people in each treatment to give up imitation and choose a cell themselves. After finding out that they were mistaken, they started imitating again. Due to the limited number of players, however, it is impossible to reach a conclusive interpretation of this effect.

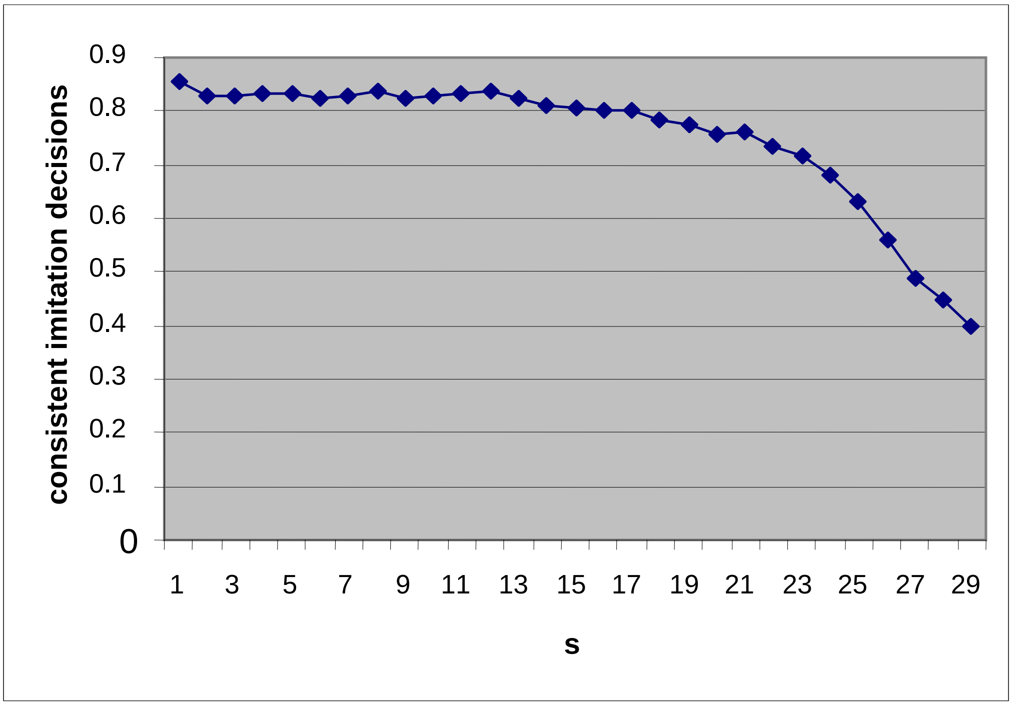

Figure 3: Share of imitation decisions that imitate the player with the maximum score if considering s periods, relative to all decisions in periods t>s. δ = 1.

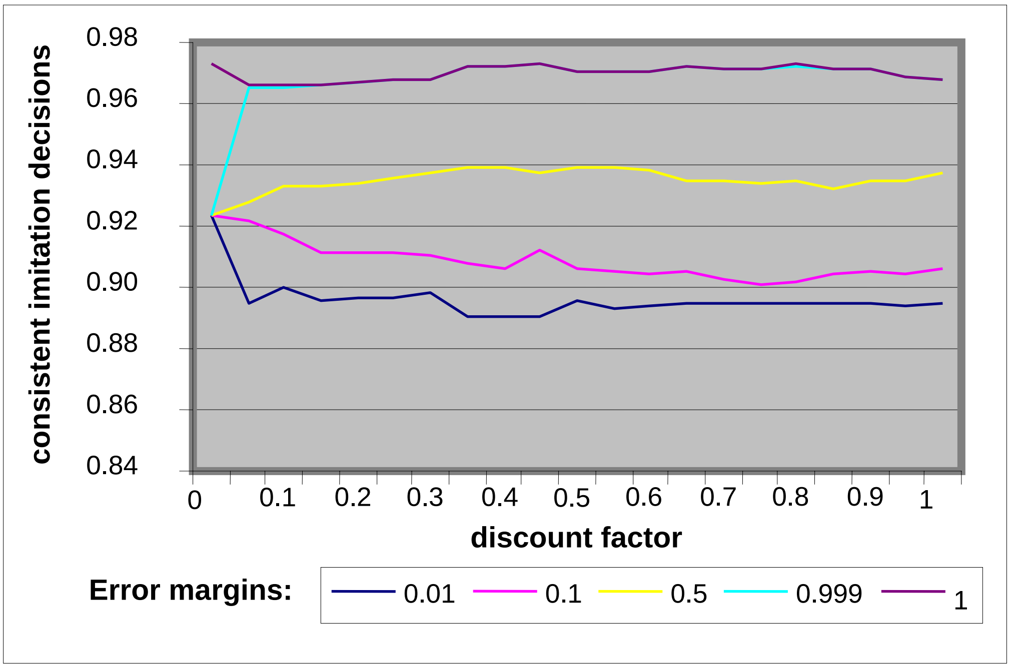

Figure 4: Share of imitated players with maximum score in the period previous to the imitation decision, depending on the discount factor applied to past periods and the error margins allowed.

Appendix B

This is the translated version of the instructions informed players received:

Instructions

The experiment you will now participate in is part of a research project financed by the Deutsche Forschungsgemeinschaft (DFG). It aims at analyzing economic decision making.

In the experiment you can earn a considerable amount of money, which depends on your decisions. Accordingly, it is important that you read the instructions carefully.

Please note that these instructions are only for your use. You are not allowed to pass on any information to other participants. Similarly, during the entire experiment it is not permitted to talk to other participants. If you have a question, please raise your hand. We will than come to you and answer your question. Please do not ask your question allowed. If you do not comply with these rules, we have to stop the experiment.

General information

The experiment consists of 30 periods. In each period you make a decision. According to these decisions you receive points. At the end of the experiment, these points are exchanged into Euro and paid out in cash. The course of the experiment, your decisions and the payoffs are explained in detail in what follows.

Decision

In each period a table with nine cells appears on your screen, which may look like this:

a1	b2	c3
b3	a3	a2
c2	c1	b1

cells are always labelled with a1-a3, b1-b3, c1-c3. In each period you can choose one of those cells and receive points for your decision.

cells that are labelled with the letter *a* return the highest number of points. cells that are labelled with the letter *b* return medium numbers of points. cells that are labelled with the letter *c* return the lowest number of points. However, cells that are labelled with the same letter can still return different numbers of points. For example, cell a1 can return a higher or a lower number of points than cells a2 and a3 etc.

The pattern of the table, i.e., the points returned by the cells, changes. This change occurs according to a certain rhythm. The logic of the letters - a for the highest points, b for medium points, c for the lowest points - is preserved by the change, but the relation of points within the letters can change. Hence, in one period cell b1 may return a higher number of points than cell b2, while in the next period b2 returns a higher number of points than b1.

When you have decided for a cell, please type it in under "Your cell choice" and press "OK". The number of points returned by the cells then appears on your screen and is added to your account. The choice of cells happens just once every round, it cannot me amended later on.

In each period, the distribution of points over the different cells is the same for all participants. It is, however, possible, that other participants have more or less information about this distribution than you do yourself.

Instead of choosing a cell yourself, you can also choose one of the other participants, whose cell choice is then also valid for you. To do so, you simply type in the number of the player you have chosen under "Your chosen player". You then receive the same number of points as this player, less one point as "fee". You only learn the cell choice of this player after you have chosen him. Note that you can only choose a cell OR a player, not both. Just as for the cell choice, the choice of a player is binding. Even if you are not happy with the cell choice of this player afterwards, you cannot change your number of points anymore.

If you want to choose a cell yourself, you simply leave the box "Your chosen player" empty.

Example:

You see the following table:

a1	b2	c3
b3	a3	a2
c2	c1	b1

Case 1: You choose cell a1 and receive 12 points. (This number of points is fictitious. It has no relation to the true number of points in the experiment.)
Case 2: You decide to follow the choice of player 3. In the box "Your chosen player" you type "3". This player chooses cell a1. He receives 12 points, and you receive 12-1=11 points.

After each period cell choices and points of all players are displayed. The first row shows the number of the period, the following rows show the cell choices and points of all players. F1 denotes the cell choice of player 1, P1 his number of points. F2 denotes the cell choice of player 2, P2 his number of points etc. The cell choices and points of all players are visible on screen throughout the entire experiment. If a player chose another player rather than a cell, the box of is cell choice stays empty.

After all 30 periods are played one period is drawn randomly, which is then relevant for payoffs. The number of points that you received in this period is then exchanged into EUR according to the following rate:

$$2 \text{ points} = 1 \text{ EUR}$$

In addition you receive 3 EUR for your participation. The sum of show up fee and the payoff from your decisions is then paid out in cash immediately.

Questions

Please answer the following questions to ensure that you have understood the instructions.

1. Player 1 chooses a cell with the label b, player 2 chooses a cell with the label c. Who receives the higher number of points?

2. Player 1 chooses a cell with the label a. Player 2 also chooses a cell with the label a. Who receives the higher number of points?

3. Player 1 decides to choose the cell that player 2 chooses. Player 2 receives 10 points. How many points does player 1 receive?

4. In period 4, player 1 chooses an a cell in the upper right corner of the table. In period 5, he again chooses the cell in the upper right corner. Does he receive the same number of points?

This is the translated version of the instructions uninformed players received:

Instructions

The experiment you will now participate in is part of a research project financed by the Deutsche Forschungsgemeinschaft (DFG). It aims at analyzing economic decision making.

In the experiment you can earn a considerable amount of money, which depends on your decisions. Accordingly, it is important that you read the instructions carefully.

Please note that these instructions are only for your use. You are not allowed to pass on any information to other participants. Similarly, during the entire experiment it is not permitted to talk to other participants. If you have a question, please raise your hand. We will than come to you and answer your question. Please do not ask your question allowed. If you do not comply with these rules, we have to stop the experiment.

General information

The experiment consists of 30 periods. In each period you make a decision. According to these decisions you receive points. At the end of the experiment, these points are exchanged into Euro and paid out in cash. The course of the experiment, your decisions and the payoffs are explained in detail in what follows.

Decision

In each period the following table appears on your screen:

a	b	c
d	e	f
g	h	i

cells are labelled with the letters *a* to *i*. In each period you can choose one of those cells and receive points for this. The letters do not contain any information about the numbers of points that are assigned to these cells. They simply serve to improve clarity. The points that are assigned to these cells change. However, this change occurs according to a regular pattern.

When you have decided for a cell, please type it in under "Your cell choice" and press "OK". The number of points returned by the cells then appears on your screen and is added to your account. The choice of cells happens just once every round, it cannot me amended later on.

In each period, the distribution of points over the different cells is the same for all participants. It is, however, possible, that other participants have more or less information about this distribution than you do yourself.

Instead of choosing a cell yourself, you can also choose one of the other participants, whose cell choice is then also valid for you. To do so, you simply type in the number of the player you have chosen under "Your chosen player". You then receive the same number of points as this player, less one point as "fee". You only learn the cell choice of this player after you have chosen him. Note that you can only choose a cell OR a player, not both. Just as for the cell choice, the choice of a player is binding. Even if you are not happy with the cell choice of this player afterwards, you cannot change your number of points anymore.

If you want to choose a cell yourself, you simply leave the box "Your chosen player" empty.

Example:

You see this table:

a	b	c
d	e	f
g	h	i

Case 1: You choose cell a and receive 12 points. (This number of points is fictitious. It has no relation to the true number of points in the experiment.)
Case 2: You decide to follow the choice of player 2. In the box "Your chosen player" you type "3". This player chooses cell a. He receives 12 points, and you receive 12-1=11 points.

After each period cell choices and points of all players are displayed. The first row shows the number of the period, the following rows show the cell choices and points of all players. F1 denotes the cell choice of player 1, P1 his number of points. F2 denotes the cell choice of player 2, P2 his number of points etc. The cell choices and points of all players are visible on screen throughout the entire experiment. If a player chose another player rather than a cell, the box of is cell choice stays empty.

After all 30 periods are played one period is drawn randomly, which is then relevant for payoffs. The number of points that you received in this period is then exchanged into EUR according to the following rate:

$$1.5 \text{ points} = 1 \text{ EUR}$$

In addition you receive 3 EUR for your participation. The sum of show up fee and the payoff from your decisions is then paid out in cash immediately.

Questions

Please answer the following questions to ensure that you have understood the instructions.

1. Player 1 chooses a cell with the label e, player 2 chooses a cell with the label g. Who receives the higher number of points?

3. Player 1 decides to choose the cell that player 2 chooses. Player 2 receives 10 points. How many points does player 1 receive?

4. In period 4, player 1 chooses cell c. In period 5, he again chooses cell c. Does he receive the same number of points?

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