Extrapolation in Games of Coordination and Dominance Solvable Games.

Friederike Mengel*
Maastricht University

Emanuela Sciubba†
Birkbeck College London

April 2, 2010

Abstract

We study extrapolation between games in a laboratory experiment. Participants in our experiment first play either the dominance solvable guessing game or a Coordination version of the guessing game for five rounds. Afterwards they play a 3x3 normal form game for ten rounds with random matching which is either a game solvable through iterated elimination of dominated strategies (IEDS) or a pure Coordination game. We find strong evidence that participants do extrapolate between games. Playing a strategically *different* game hurts compared to the control treatment where no guessing game is played before and in fact impedes convergence to Nash equilibrium in both the 3x3 IEDS and the Coordination game. Playing a strategically *similar* game before leads to better (faster) learning in the second game. We also find evidence for 'naive extrapolation'. Participants tend to choose actions which are labeled similarly to succesful actions in the guessing game with higher probability in the first rounds of the 3x3 game. This effect is much stronger in the Coordination games. On balance extrapolation helps play in games solvable through deliberative reasoning (such as IEDS), but the effect is ambigous in games where some intuition is needed to reach a Nash equilibrium (such as pure Coordination games).

Keywords: Game Theory, Learning, Extrapolation

JEL-classification: C72, C91.

Preliminary Draft - Please do not circulate

*Department of Economics (AE1), Maastricht University, PO Box 616, 6200 MD Maastricht, The Netherlands; Tel:+31-43-38 83891; Fax:+31-43-38 84878; E-mail: f.mengel@maastrichtuniversity.nl

†Department of Economics, Mathematics and Statistics, Birkbeck, University of London, Malet Street, London WC1E 7HX. e.sciubba@bbk.ac.uk

1 Introduction

How people learn in any given games has received a lot of attention both by Economic theorists and in Experimental Economics. In many cases of interest, though, decision-makers are faced with many different strategic situations, and the number of possibilities is so vast that a particular situation is practically never experienced twice. A tacit assumption of standard learning models is that players extrapolate their experience from previous interactions similar to the current one.

How people transfer knowledge between seemingly quite different situations has received much less attention in the literature.[1] But without understanding what knowledge is acquired and extrapolated from playing a given game it will be hard to make predictions about behavior in other games. Taking the argument to an extreme one may even argue that only if we understand which knowledge people extrapolate from one game to other games can we really understand what they have learned in the first place. For example if we observe that behavior in a game converges to some action profile we do not know yet whether people have learned anything beyond 'Choosing X seems quite good'. Basic questions of interest are whether people are able to learn and extrapolate strategic content (such as the ability to engage in iterated elimination) between different contexts and whether they engage in naive extrapolation, i.e. tend to choose actions that were succesful in one context again in other very different contexts.

From an applied perspective understanding when and how extrapolation takes place is important for at least two reasons. If extrapolation takes place play in any given game can be very different from what is otherwise expected. Identifying regularities on extrapolation can hence a) help to make predictions in such games and b) help policy maker to design/frame games in such a way that "desired" extrapolation takes place.

In this experiment we study extrapolation between games systematically. We let participants interact in two different games and study (i) whether extrapolation takes place and (ii) how participants extrapolate from the first game to the second game they play.

Empirically extrapolation is most interesting if it occurs between two very different games. In all our treatments the two games studied differ in the action set, the set of players, the number of players, the framing of the game (payoff matrix versus guessing game), the payoffs and the repeated nature of the game. The only dimension in which our games may be similar is their 'strategic nature'.[2] In some treatments both games are solvable through deliberative reasoning (in particular through iterated elimination of dominated strategies, IEDS). Or both game are Coordination games, i.e. some intuition is needed to solve them.

As a first game we use variants of the so called 'guessing game' which we let participants play 5 times repeatedly in fixed groups of four (Nagel, 1995). In the first (standard) variant all participants have to simultaneously guess a number between 0 and 100. The participant closest to 70% of the average guess wins five Euros. This game is solvable through IEDS and the unique Nash equilibrium is that everyone guesses zero. In the second variant the participant closest to the average guess wins. This second variant is hence a Coordination game, where every outcome in which all participants choose the same number is a Nash equilibrium. The second variant actually corresponds to Keynes's original 'Gedankenexperiment'. (Keynes, 1936).

[1]For some theoretical work illustrating such effects see Jehiel (2005),Mengel (2007) or Steiner and Stewart (2008). Experimental literature will be discussed below in detail.

[2]Some other papers have studied learning transfer among similar games. Gneezy et al (2010) for example show that participants are able to 'learn' backward induction by playing similar games. See also Rapoport et al (2000).

As a second game participants play one of two possible 3x3 normal form games for ten rounds and are randomly rematched each round. One of the 3x3 games is a game solvable through IEDS with a unique Nash equilibrium and the other game is a pure Coordination game with three Nash equilibria, which are strict, not pareto ranked, but where one is risk dominated.

We are interested in behavior in the second game. For each game - the IEDS and the Coordination game - we have three treatments (hence a total of six treatments). One where only the 3x3 game is played, one where the 3x3 game is preceded by the 70% version of the guessing game and one where it is preceded by the 'Keynes' (100%) version.

We find that, as expected, guesses converge towards zero (with an average of about 9 in the last round) in the standard guessing game (70% version) and converge to about 40-50 in the 100% version of the guessing game. In both the 3x3 Coordination game and the 3x3 IEDS game behavior in all three treatments is significantly different. Hence participants do extrapolate between games. Playing a strategically *different* game hurts play even compared to the situation where no other game is played before and in fact impedes convergence to Nash equilibrium in both dominance solvable and Coordination games. One possible explanation for this fact could be that playing a Coordination game where intuition or some 'gut-feeling' is needed to reach a Nash equilibrium brings participants into the wrong 'mode' to play a game which is solvable through IEDS afterwards and vice versa. In fact Kuo et al. (2009) have found evidence that two different brain regions are involved when people play these different classes of games. Playing a strategically *similar* game before leads to better (faster) learning in the second game.

We observe two types of extrapolation. First there is 'naive extrapolation', i.e. participants initially (in the first round of the 3x3 game) play actions with a similar label to the outcome in the guessing game with increased probability. This effect is much stronger in the 3x3 games where some intuition is needed to solve them (the Coordination game in our experiment), which is intuitive since 'naive extrapolation' can be rational in such games. In the IEDS games this effect is very weak, but statistically significant. Secondly we also observe improved learning if a strategically similar game has been played before.

In our design the effect of 'naive extrapolation' is purposely detrimental, i.e. distracting from the Nash equilibrium in the IEDS games and pointing to a risk and (weakly) payoff dominated action in the Coordination games. Hence on balance playing a strategically similar game before unambigously improves play (through faster learning) in the dominance solvable games, while in Coordination games the effect is ambigous in our experiment.

In addition our results also allow us to gain some insight into a common interpretation of the guessing game. The results in this game have typically been explained by differing capabilities of participants to engage in iterated elimination of dominated strategies (IEDS). The fact that play converges over time is often rationalized through level k learning theory and some argue that participants 'learn' about IEDS over time.[3] Some recent studies, though, have challenged these views. Grosskopf and Nagel (2007) for example have shown that even in the two player version of the guessing game, where choosing zero is a weakly dominant strategy, many participants deviate from this optimal strategy. In Grosskopf and Nagel (2009) they explain these (and other) results through an adaptive learning procedure.

Our results show that participants do learn something about IEDS in the guessing game, since they are able to extrapolate such knowledge to a different game which is solvable through IEDS. In line with Grosskopf and Nagel's (2009) explanation it seems to be mostly the quality (and speed) of learning which

[3]See Nagel (1995) or Stahl (1998) among many others.

is positively affected by extrapolation in our experiment. Playing a different game (not solvable through IEDS) before does *not* lead to better learning on the other hand. This is additional evidence that game theoretic concepts such as IEDS are 'learnable'.[4]

There are a few other papers in the experimental literature dealing with learning transfers, extrapolaton or categorization. Stahl and Haruvy (2009) have studied learning transfer between 'dissimilar' symmetric normal form games.[5] They find that a model of experience-weighted attraction learning augmented with action relabeling performs well in explaining the initial choices in each game. Grimm and Mengel (2009) have studied learning in a multiple games environment, where participants face different normal form games randomly drawn in each period. They have found evidence that participants categorize games into analogy classes in which they choose the same action. Huck, Jehiel and Rutter (2007) also find evidence for categorical thinking in an experiment. Grosskopf et al.(2010) find support for case based decision making as proposed by Gilboa and Schmeidler (1995).

Other than the papers mentioned above we are not aware of studies that systematically study extrapolation between different games. Several studies have found more or less explicit evidence that there is learning transfer between games. Examples are Weber (2003) in a study of 'feedback-less' learning, Rapoport et al. (2000), Cooper and Kagel (2003, 2008) or Chong et al. (2006) among others. Other studies have analyzed learning across games which are very similar except for one or two parameters or payoffs. Camerer et al (1998) look at learning transfer between IEDS guessing games with different parameters. Selten et al. (2003) let subjects submit strategies for tournaments with many different 3×3 games and find that the induced fraction of pure strategy Nash equilibria increases over time.

The paper is organized as follows. In Section 2 we describe the experimental design. In Section 3 we present our hypotheses and in Section 4 we present the results. Section 5 concludes. Some regression tables

2 Design

The experiment was conducted in February 2010 at Maastricht University. 144 students participated in one of the following treatments T1-T6:

T1: In T1 participants were randomly rematched for ten rounds to play the game shown in Table 1.

T2: In T2 participants were randomly rematched for ten rounds to play the game shown in Table 2.

	H	M	L
H	$10, 10$	$8, 12$	$16, 8$
M	$12, 8$	$10, 10$	$6, 6$
L	$8, 16$	$6, 6$	$10, 10$

Table 1: 3x3 IEDS game

T3: In T3 participants were first matched in fixed groups of four players to play the 70% version of the guessing game during five rounds. In this game all group members have to simultaneously guess a number between 0 and 100. The participant closest to 70% of the average guess wins five Euros and ties are resolved

[4] See also Gneezy et al. (2010) among others.

[5] For them the term dissimilar means that there is no re-labeling of actions which makes games monotonic transformations of each other. This is true for all our games considered even for those that we call 'strategically similar'. See also Rankin et al (2000).

	H	M	L
H	$10, 10$	$8, 6$	$8, 8$
M	$6, 8$	$10, 10$	$6, 6$
L	$8, 8$	$6, 6$	$10, 10$

Table 2: 3x3 Coordination game

randomly. Afterwards they were randomly matched for ten rounds to play the game shown in Table 1.

T4: In T4 participants were first matched in fixed groups of four players to play the 100% version of the guessing game during five rounds. In this game all group members have to simultaneously guess a number between 0 and 100. The participant closest to the average guess wins five Euros and ties are resolved randomly. Afterwards they were randomly matched for ten rounds to play the game shown in Table 2.

T5: In T5 participants were first matched in fixed groups of four players to play the 70% version of the guessing game during five rounds. Afterwards they were randomly matched for ten rounds to play the game shown in Table 1.

T6: In T6 participants were first matched in fixed groups of four players to play the 100% version of the guessing game during five rounds. Afterwards they were randomly matched for ten rounds to play the game shown in Table 2.

The treatment structure is summarized in Table 3.

	3x3 IEDS	3x3 Coordination
No first game	T1	T2
70% guessing game	**T3**	T5
100% guessing game	T6	**T4**

Table 3: Treatments

Written Instructions were distributed at the beginning of each phase, i.e. in T3-T6 participants knew at the start of phase 1 that there would be a second phase in the experiment but did not know what it would look like.[6] Matching groups were of size 8 in all treatments. Participants were informed that they were matched with the same group of participants in the first phase and that they would be randomly rematched in each period in the second phase. In T3-T6 participants were told in addition in the Instructions for phase 2that 'they will likely be paired up with participants who they have *not* played with in phase 1'. Actions H,M,L were labeled 'High','Medium' and 'Low' in the experimental Instructions and were labeled as shown in Tables 1 and Coordination-game on the decision screens during the experiment. Before the start of each phase we asked some control questions to make sure that participants understood the respective game.

At the end of each round of the guessing game participants were informed about the different guesses made in their group and about whether they won or not. At the end of each round of the 3x3 game participants were told their action choice and that of their match as well as their payoff.

In addition to a show up fee of 2 Euros overall earnings were the sum of earnings from all rounds. Earnings from the first phase were directly given in Euros. Earnings from the second phase were given in ECU (experimental currency unit) and converted into Euros according to the exchange rate 1Euro=20ECU. The experiment lasted between 35 (T1 and T2) to 60 minutes (T3-T6) and participants earned on average

[6] Sample Instructions for T3 can be found in the Appendix.

12,20 Euros with a minimum of 6,40 Euros and a maximum of 32 Euros.

3 Hypotheses

The most basic hypothesis we wish to test is Hypothesis 0 which claims that there is no extrapolation between games. This hypothesis amounts to saying that there should be no treatment differences in how the 3x3 game is played between T1, T3 and T6 and no no treatment differences between T2,T4 and T5.

Hypothesis 0 There is no extrapolation between games. [T1=T3=T6 and T2=T4=T5]

The following hypotheses 1a and 1b capture the idea that extrapolation is not arbitrary, but depends on whether or not the first game (from which participants extrapolate) is strategically similar or different from the second game. By strategically similar we mean 'being solvable through IEDS' or 'being a pure Coordination game'.

Hypothesis 1a Extrapolation "improves" play if a strategically similar game has been played before.

Hypothesis 1b Extrapolation "hurts" play if a strategically different game has been played before.

Taken together the hypotheses 1a and 1b imply the following ranking: T3 $\geq$ T1 $\geq$ T6 (where $\geq$ here means 'better play') and T4 $\geq$ T2 $\geq$ T6. We could as well derive a weaker hypotheses from those two conjectures which would say something like 'It does not matter whether a strategically similar or a strategically different game has been played before'. We chose to state a rather strong or 'daring' hypothesis, but we will not be satisfied by simply rejecting it.

Our last hypothesis states that extrapolation may be more effective in games which can be solved through deliberative reasoning (in particular games solvable through IEDS) as opposed to games which have to be solved through intuition. The conjecture is that since in the first class of games there is a unique way of solving the game, extrapolation may be more effective in such games.

Hypothesis 2 Extrapolation is more effective if games can be solved by deliberative reasoning (as opposed to games which have to be solved intuitively).

4 Results

4.1 Behavior in the Guessing Games

Let us start by describing behavior in the guessing games. The following two graphs illustrate the distribution of guesses in the 70%-version and the 100-version of the game. While in the 70%-version guesses are decreasing over time, there is no such time trend in the Keynes game (100%-version), where most guesses are concentrated around 50. Variance remains higher in the 100% version. Clearly both games are played differently. In the 70% (IEDS)-version behavior seems to converge over time towards the unique Nash equilibrium where everyone guesses 0. In the Keynes guessing game the focal Nash equilibrium seems to be to bid 50, which is the amount where most initial guesses are concentrated. In fact in the Keynes version 65% of guesses are in the interval [40,60] and 29% of guesses equal exactly 50 already in Period 1. In the standard version these numbers are less than half (29% in the interval [40,60] and 14% of exactly 50). By Period 5 no guesses are higher than 30 anymore and 65% of guesses are below 10 in this version.

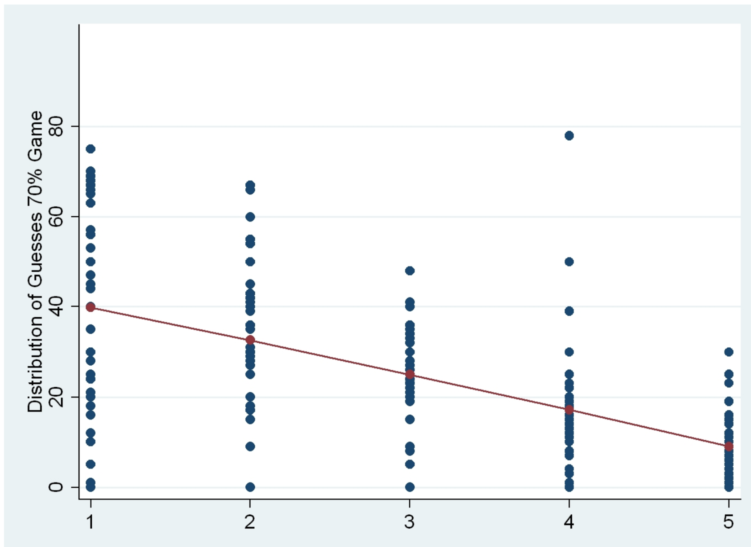

Figure 1: Distribution of Guesses 'IEDS guessing game' (70%-version).

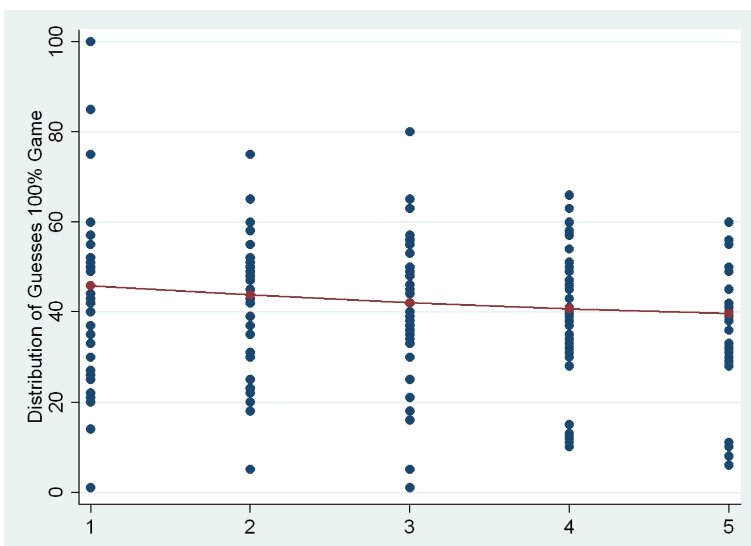

Figure 2: Distribution of Guesses 'Keynes guessing game' (100%-version).

A simple panel data OLS regression indicates that while there is a clearly negative time trend in T3 and T6 there is no significant time trend in T4 and T5. The regression table can be found in the Appendix. The following table illustrates the average guess in period 5 (i.e. the last round of the guessing game) in the different treatments.

	T3	T5	T4	T6
average guess period 5	9.41	8.91	36.83	43.25
(Standard Deviation)	(6.39)	(7.02)	(13.92)	(10.05)

Table 4: Average Guess in last period of Guessing Game.

As expected average guesses in the 70% version of the game (T3 and T5) are much lower than average guesses in the 100% version of the game (T4 and T6) and those differences are statistically significant. (Mann-Whitney, $p < 0.0001$). Also, as expected, there are no treatment differences between T3 and T6 or between T4 and T5.

4.2 Extrapolation in Games solvable through IEDS

Now we are ready to look at extrapolation. Let us start with the games which are solvable through deliberative reasoning, i.e. the games solvable through IEDS. Remember that the unique Nash equilibrium in this game is (M,M). Table 5 illustrates the distribution of choices in the 3x3 IEDS game. There seem to be somewhat more $M-$ choices in T3 compared to the other treatments and somewhat less $H-$ choices. On average, though, there is not much difference.

	H	M	L
T1	0.29	0.70	0.01
T3	0.21	0.75	0.04
T6	0.24	0.70	0.06

Table 5: Average share of H/M/L choices in the 3x3 IEDS game.

To see treatment differences we have to look at the distribution of choices over time. Figure 3 illustrates the share of M-choices (i.e. Nash choices) over time in the three treatments.

The first thing to notice is that while participants seem to learn the Nash equilibrium in treatments T1 and T3, there is no convergence in treatment T6. Also learning seems to be better in T3 compared to T1 (especially faster as the Figure and the regression below illustrate) but it is substantially worse in T6. Playing a game largely based on intuition seems to hurt effective learning in games based on reasoning. Table 6 shows that, indeed, there is very little learning in treatment T6 compared to other treatments. One possible explanation for this fact could be that playing a Coordination game where intuition or some 'gut-feeling' is needed to reach a Nash equilibrium brings participants into the wrong 'mode' to play a game which is solvable through IEDS afterwards. In fact Kuo et al. (2009) have found evidence that two different parts of the brain may be used to play these different classes of games.

We also ran panel data logit regressions to explain the share of M choices in the IEDS game through the time period, treatment dummies as well as interaction terms. The period variable counts from $6, ...15$ and time period in T1 is normalized to this count. The baseline is treatment T1. The results are presented in table 7.

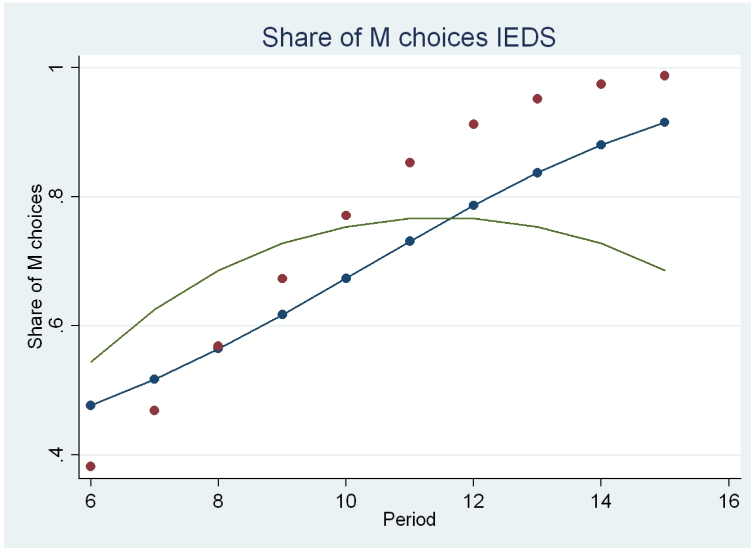

Figure 3: Share of M Choices over time in the 3x3 IEDS game. The dotted line displays T1 (only 3x3 IEDS game), the dots are T3 (70%-version then 3x3 IEDS game) and the line without dots represents T6 (100%-version then 3x3 IEDS game).

Learning	
T1	0.50
T3	0.55
T6	0.12

Table 6: Percentage of M choices. Difference between period 10(15) and period 1(6).

$M-$ Choices in IEDS Game	(1)	(2)
constant	-0.6506^{**}	-0.3768
	(0.1226)	(0.4207)
period	0.3608^{***}	0.3389^{***}
	(0.0682)	(0.0632)
T3	-4.3673^{***}	-4.9408^{***}
	(1.1366)	(1.1033)
T6	0.8455	
	(0.8986)	
periodXT3	0.3924^{***}	0.3942^{***}
	(0.1247)	(0.1222)
periodXT6	-0.2423^{***}	-0.1817^{***}
	(0.0905)	(0.0633)
ρ	0.4918	0.4917

Table 7: Panel Data Logit Regression $^{***}1\%, ^{**}5\%, ^{*}10\%$. $((\Pr > \mathcal{X}^2) < 0.0001)$

The results from the regression confirm our intuitions derived from the Figure. The positive coefficient on period indicates that over time people learn to play the equilibrium. There are significantly less $M-$ choices in T3 than in T1 initially. The positive coefficient on periodXT3 shows that there is faster learning in T3 compared to T1, implying that starting in period 10 approximately (i.e. the 5th period of the IEDS game) there are more $M-$ choices in T3 compared to T1.[7] The coefficient on T6 is not significant, i.e. initially there are not significantly more $M-$ choices in T6 compared to T1. On the other hand the negative coefficient on periodXT6 shows that convergence to equilibrium is much worse in T6 compared to T1 (and hence also T3). We also ran the same regression but including a square term period^2 as well as interaction terms period^{2}XT3 and period^{2}XT6 and found that we can jointly omit them from the regression ($\Pr > \mathcal{X}^2 = 0.1548$).

Clearly the evidence rejects Hypothesis 0 that there is no extrapolation across games. Play in all three treatments is pairwise significantly different.

It also seems that playing a strategically similar game before (like it is the case in T3) helps convergence to equilibrium. There is a both a higher share of $M-$ choices in the last period in T3 compared to T1 and T6 and learning is faster in T3 compared to the other treatments. Clearly also playing a strategically different game hurts. Learning is much worse in T6 compared to the other treatments.

Why are there initially less $M-$ choices in T3, though? One may conjecture that there is some 'naive' extrapolation, i.e. that participants choose the action 'high' 'medium' or 'low' which they coordinated on in the first game. This would mean that there should be more $L-$ choices initially in T3 compared to T1 and more $M-$ choices initially in T6 compared to T1. Table 8 shows the percentages of M and L choices in the first period of the 3x3 game.

	L in period 1 (6)	M in period 1 (6)
T1	0	0.46
T3	0.08	0.41
T6	0.08	0.54

Table 8: Naive Extrapolation - M and L choices in the first period of the 3x3 IEDS game.

This table suggests that there is only a weak effect of naive extrapolation in the IEDS game. Still there are more $L-$ choices in T3 initially compared to T1 and more $M-$ choices in T6 compared to T1. A Mann-Whitney test shows that the distribution of choices in the first round does not differ pairwise between any two treatments. ($p > 0.1529$). We do find significant differences in the distribution of $L-$ choices between T1 and T3 if we focus on the first five rounds of play (Mann-Whitney, $p = 0.0269$). Still the distributions of $M-$ choices between T1 and T6 do not significantly differ (Mann-Whitney, $p = 0.2160$).

Note also that while such 'naive' extrapolation seems to make no sense in games solvable through reasoning, it can make sense in an intuitive game such as the pure Coordination games. There the first game can serve as a Coordination device. We will come back to this in the next subsection.

4.3 Extrapolation in Coordination Games

Let us now see whether and how extrapolation affects pure Coordination games, i.e. a game which is not solvable through reasoning but where some intuition has to be used to reach an equilibrium. Table 9 shows the percentage of H/M/L choices across all period.

[7] Note that since the graph depicts the predictions for the quadratic rather than linear regression the intersection of the two

	H	M	L
T2	0.98	0.01	0.00
T4	0.52	0.27	0.20
T5	0.78	0.01	0.19

Table 9: Overall share of H/M/L choices in Coordination game

Quite amazingly in T2 participants coordinate immediately on the equilibrium (H,H). Hence choosing "High" rather than "Low" seems more focal. ("Medium" is risk dominated). In both T4 and T5 coordination is worse with a significant share of participants choosing L. Interestingly in T4 where participants play the Coordination version of the guessing game before many more participants choose the risk dominated action M. This is a strong indicator that some participants may try to use the Coordination version of the guessing game (where Coordination occurred on the Medium guesses) as a Coordination device in the following game.

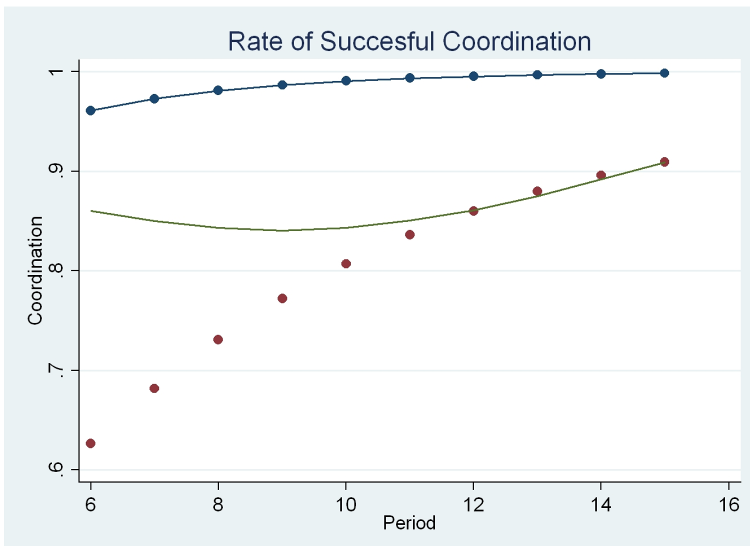

Figure 4: Rate of Succesful Coordination over time in the 3x3 Coordination Game. The dotted line shows treatment T2 (only 3x3 Coordination Game). The dots indicate Coordination in T4 (first 100% version guessing game, then 3x3 Coordination). The line without dots represents treatment T5 (first 70% version guessing game, then 3x3 Coordination game).

Figure 4 shows the percentage of succesful Coordination (on any of the Nash equilibria) over time. in T2 there is almost perfect coordination on (H,H) from the beginning. In T4 initially Coordination is worst, but then there is a steep learning curve with more than 90% of succesful Coordination eventually. In T5 there is more Coordination initially than in T4 (but less than in T2) but again there is almost no learning. Hence, as in the case of the IEDS games, learning is better if a strategically similar game was played before. Playing a strategically different game seems to distort learning significantly.

Again we ran panel data logit regressions to explain the rate of succesful Coordination in the Coordination game through the time period, treatment dummies, square as well as interaction terms. Table 10 shows the results of this regression. The baseline treatment is T2.

The regression table 10 shows that Coordination is worse in T5 and T4 compared to T2 and improves

curves there is already around Period 8.

Succesful Coordination	(1)	(2)
const	3.8889^{**}	2.3902^{**}
	(1.8058)	(1.0487)
period	0.4339	1.5065^{***}
	(0.9876)	(0.2574)
periodXperiod	-0.0040	-0.1154^{***}
	(0.1081)	(0.0143)
T4	-16.4971^{***}	-14.4743^{***}
	(2.6468)	(1.6394)
T5	-17.1326^{***}	-15.8419^{***}
	(2.6252)	(1.7421)
periodXT4	2.5340^{**}	1.1813^{***}
	(1.0694)	(0.2552)
periodXT5	1.1562^{**}	0.2795^{***}
	(0.6656)	(0.0611)
periodXperiodXT4	-0.1258	
	(0.1100)	
periodXperiodXT5	-0.1015	
	(0.1099)	
ρ	0.4450	0.4432

Table 10: Panel Data Logit Regression *** 1%,** 5%,* 10%

over time (more so in the treatments where it is worse). Unlike in the case of IEDS games, this time we cannot omit the period^2 terms entirely from the regression $\left((\Pr > \mathcal{X}^2\right) < 0.0001)$, but we can omit the interaction terms periodXperiodXT4 and periodXperiodXT5 $\left((\Pr > \mathcal{X}^2\right) = 0.4021)$.

Again hypothesis 0 is clearly rejected, since behavior in all three treatments significantly differs. Now, though, also hypothesis 1a has to be rejected. Playing a strategically similar game before in this case hurts Coordination, inspite of the fact that learning curves are steeper. The reason seems to be that playing a different coordination game before increases the amount of strategic uncertainty in the second game. Of course in a different Coordination game such extrapolation may help. The lesson is that in games which cannot be solved through reasoning, such as pure Coordination games, extrapolation can go either way.

Finally let us again have a look at behavior in the first period to see whether there is some evidence for 'naive'extrapolation, which as mentioned before can make quite some sense as a Coordination device. Table 11 shows the percentage of $M-$ and $L-$ choices in the first period of the 3x3 Coordination game.

	L in period 1 (6)	M in period 1 (6)
T2	0	0.04
T4	0.16	**0.25**
T5	0.13	0.08

Table 11: Naive Extrapolation - M and L choices in the first period of the 3x3 Coordination game.

Table 11 shows that participants seem to use the outcome of the guessing game as a Coordination device for the Coordination game in treatment T4, i.e. in the treatment where the guessing game was already about Coordination. Consistently with naive extrapolation there are more M choices in the first period of the game in T4 compared to T2 (Mann-Whitney, $p = 0.0430$). This is in spite of the fact that action M is risk dominated. There are also more L choices in both T5 and T4 compared to T2 (Mann-Whitney, $p = 0.0387, p = 0.0767$).

5 Conclusions

We conducted an experiment to study whether and how people extrapolate between very different, but strategically similar games. We found clear evidence that extrapolation does occur between games. Playing a strategically *different* game hurts convergence to Nash equilibrium, while playing a strategically *similar* game before leads to better (faster) learning in the second game. We also find evidence for 'naive extrapolation'. Participants tend to choose actions which are labeled similarly to succesful actions in different previous games.

Extrapolation seems to work somewhat differently for games which can be solved through deliberative reasoning as opposed to games where some intuition is needed to reach a Nash equilibrium. 'Naive extrapolation' is much more prominent in the latter class of games, possibly because some participants try to use the first game as a Coordination device for the second game. As a consequence extrapolation can have a negative effect on overall play. Still, also in these games, learning is better if a strategically similar game has been played before. Hence in intuitive games such as pure Coordination games the lesson is that 'things can go either way'. Overall extrapolation seems more effective if games are solvable through deliberative reasoning.

These results can be very helpful to make predictions about outcomes or design mechanisms in applications. Understanding how knowledge is transfered between games and how this depends on the type of strategic situation faced can also inform theoretical models of learning across games and categorization. Most of the current literature on categorization or learning across games focuses on what we have called 'naive extrapolation' (See e.g. Steiner and Stewart, 2008 or Mengel, 2007). Improved learning via extrapolation of strategic context seems harder to model and to understand. There is large scope for future research to understand these effects.

References

[1] Camerer, C., T. Ho and K. Weigelt (1998), Iterated Dominance and Iterated Best Response in Experimental p-Beauty Contests, American Economic Review, 88(4), 947-969.

[2] Chong, J-K., C. Camerer and T. Ho (2006), A Learning-based Model of Repeated Games with Incomplete Information, Games and Economic Behavior, 55(2), 340-371

[3] Cooper, D. J. and J. H. Kagel (2003), Lessons Learned: Generalizing Learning across Games, American Economic Review, 93(2), 202-207

[4] Cooper, D. J. and J. H. Kagel (2008), Learning and Transfer in Signaling Games, Economic Theory, 34, 415-439

[5] Gilboa, I. and D. Schmeidler (1995), Case-Based Decision Theory, The Quarterly Journal of Economics, 110(3), 605-639.

[6] Gneezy, U., A. Rustichini and A. Vostroknutov (2010), Experience and Insight in the Race Game, Journal of Economic Behavior and Organization, forthcoming.

[7] Grimm, V. and F. Mengel (2009), An Experiment on Learning in a Multiple Games Environment, Meteor Research Memorandum Maastricht University.

[8] Grosskopf, B. and R. Nagel (2007), The Two-Person Beauty Contest, Games and Economic Behavior, 62 (1), 2008, pp. 93 - 99.

[9] Grosskopf, B. and R. Nagel (2009), Unraveling in Two-Person Guessing Games, working paper.

[10] Grosskopf, B., R. Sarin and E. Watson (2010), An Experiment on Case-Based Decision Theory, Games and Economic Behavior, forthcoming.

[11] Haruvy, E. and D. Stahl (2009), Learning Transference between dissimilar symmetric normal-form games, working paper.

[12] Huck, S., P. Jehiel and T. Rutter (2007), Learning Spillover and Analogy Based Expectations: A Multi Game Experiment, working paper UCL.

[13] Jehiel, P.(2005), Analogy-based expectation equilibrium, Journal of Economic Theory 123, 81-104.

[14] Keynes, J.M. (1936), The general theory of interest, employment and money. London: Macmillan.

[15] Kuo, W.J., T. Sjoestrom, Y.P. Chen, Y.H. Wang and C.Y. Huang (2009), "Intuition and Deliberation: Two Systems for Strategizing in the Brain", Science 324, 519-522.

[16] Mengel, F. (2007), Learning Across Games, IVIE working paper.

[17] Nagel, R. (1995), Unraveling in Guessing Games: An Experimental Study, American Economic Review 85 1313-1326.

[18] Rankin, F., J. B. van Huyck and R. Battalio (2000), Strategic Similarity and Emergent Conventions: Evidence from Similar Stag Hunt Games, Games and Economic Behavior 32, 315-337.

[19] Rapoport, A., A. Seale and E. Winter (2000), An experimental study of coordination and learning in iterated two-market entry games, Economic Theory 16 (3), 1432-1479.

[20] Selten, R., K.Abbink, J.Buchta and A.Sadrieh (2003), How to play 3×3 games. A strategy method experiment, Games and Economic Behavior 45, 19-37.

[21] Steiner, J. and C. Stewart (2008), Contagion Through Learning, Theoretical Economics 3, 431-458.

[22] Weber, R.A. (2003), Learning and transfer of learning with no feedback: An experimental test across games, working paper Carnegie Mellon University.

A Additional Regression Tables

guess	70% version	100% versiom
constant	46.820***	48.325***
	(3.81)	(3.38)
period	−6.836**	−2.650
	(2.74)	(2.286)
period*period	−0.1443	0.1875
	(0.4488)	(0.3739)
ρ	0.3543	0.5532

Table 12: Panel data OLS regression of Guesses.

B Sample Instructions T3

Welcome and thank you for participating to this experiment.

This is an experiment in the economics of decision making. The instructions are simple. If you follow them closely and make appropriate decisions, you may make an appreciable amount of money that will be paid to you, in cash, at the end of the experiment. For your participation you will receive 2 Euros. Further winnings in the experiment depend on your decisions and that of others as well as random events.

There are two phases to this experiment. Detailed instructions for the second phase will be distributed to you after the first phase has been completed.

Instructions for the first phase

- In this first phase you will play a simple guessing game together with 3 other participants in the experiment.
- Guess a number between 0 and 100 (inclusive).
- In order to win, try to guess the number closest to 70 percent of the average of all numbers guessed by the participants in your group (including yourself). The guess closest to this number, i.e. the guess closest to
$$0.7 \times \frac{\text{the summation of all guesses}}{4}$$
wins. If people tie for the closest guess, the winner will be selected randomly from amongst those people.
- The winner receives 5 euros.
- You will play this guessing game 5 times, always with the same participants.
- After each period we will inform you about the different guesses made and whether you won or not.
- The winnings for the first phase of this experiment are equal to the sum of the winnings you may have made in the 5 rounds of the guessing game.

Enjoy!

Instructions for the second phase

- In this second phase you will likely be paired up with participants who you have *not* played with in phase 1. There are ten rounds in this second phase and in each round you will be randomly rematched with a new participant.
- In this phase you have to make one out of three possible bids, labeled High, Medium and Low.
- Your winnings depend both on your bid and on your partner's bid.
- The choices that both you and your partner make are blind: you will have to choose your bid without knowing what your partner is choosing; similarly, your partner will choose his bid without knowing what you are choosing.
- However both you and your partner are fully aware of the consequences in terms of winnings for both of each combination of bids. The winnings from each combination of bids by yourself and your partner are summarised in the table below. Winnings are stated in ECU (Experimental Currency Units).

	your partner bids *High*	your partner bids *Medium*	your partner bids *Low*
you bid *High*	you win 10 your partner wins 10	you win 8 your partner wins 12	you win 16 your partner wins 8
you bid *Medium*	you win 12 your partner wins 8	you win 10 your partner wins 10	you win 6 your partner wins 6
you bid *Low*	you win 8 your partner wins 16	you win 6 your partner wins 6	you win 10 your partner wins 10

- After each period we will let you know which action your interaction partner in that period has chosen and how much money you earned.
- Your winnings are equal to the sum of your winnings and converted into Euros according to the exchange rate 1 Euro=20ECU.

Enjoy!