An Experimental Investigation on Learning and Context Effects

Novarese, Marco and Chelini, Chiara and Spada, Anna and Ambrosino, Angela and Trigona, Carla

Centre for Cognitive Economics - Dipartimento di Scienze Giuridiche ed Economiche - Università Amedeo Avogadro

27 December 2010

An Experimental Investigation on Learning and Context Effects

Marco Novarese[1], Chiara Chelini[2], Anna Spada[1], Angela Ambrosino[3], Carla Trigona[4]

[1] Università del Piemonte Orientale "Amedeo Avogadro", Dipartimento di Scienze Giuridiche ed Economiche, via Mondovì 6, 15100 Alessandria, Italy.

[2] Institut Jean Nicod, Ecole Normale Supérieure, 29, rue d'Ulm, 75005 Paris, France.

Corresponding Author: chiara.chelini@ens.fr. Phone number: +33667635154. Fax number: +33144322699.

[3] Università di Siena, Dipartimento di Economia Politica, Piazza San Francesco 7, 53100, Siena, Italy.

[4] Università di Torino, Dipartimento di Economia "Cognetti De Martiis", via Po 53, 10124 Torino, Italy.

December 2010

Abstract

This paper revisited Gregory Bateson's theory of hierarchical learning through an experiment testing the existence of context effect and learning spill-over in two following games: a coordination game and a two-step battle-of-the sexes. The first part of the experiment is seen as a kind of training period. The different treatments of the coordination game are, in fact, designed so to reinforce different representations of the games, requiring to look at different aspects of a series of images shown in the screen. The second game allows testing if differences in training determine different behaviors in a same situation. Our experiment suggests that the preliminary training influences how the second game is perceived. While the incentive structure of the battle-of-the sexes is not identical to the coordination game, the presence of an image determines a different kind of context similarity with the previous one.

Keywords: hierarchical learning, Bateson, experiment, context effects, coordination

JEL Classification: B5, D03, Z19

1. Introduction

This paper aims at testing if a reinforced representation of a situation can influence subsequent choices in similar but not identical tasks. The experiment shown here, in fact, studies the effect of the experience in playing a coordination game on the behavior in a following two steps battle of the sexes. In the previous literature, there are few articles trying to investigate this kind of effect. In some previous articles investigating this kind of effect, different terms to explain how preliminary experiences can affect following behavior are used. In the managerial literature Levinthal and March (1993) use the expression "the myopia of learning", focusing on the negative effect of experience, which in their view can sometimes be a bad teacher. Egidi and Narduzzo (1997) talk about path dependence in a complex organisational task; participants are trained with a specific configuration in a card game, and then play with a different one, requiring a new strategy. Camerer et al. (2000) show the transfer of precedent from two following games. Huck et al. (2007) study "learning spillover" (due to analogy based expectations) from different coordination games with a 3x5 matrix. With many differences, all of these analysis show that a strategy learned in a context can be transferred to a different one, that is to a different game or to a new problem, similar but not identical to a previous one.

This paper proposes additional evidence on this transfer of strategies, starting from a theoretical representation of learning processes based on Bateson (1972). In his view, learning can be represented as a hierarchical process made of different steps, with an increasing level of knowledge. The possibility to use past knowledge is related to the capability to perceive the similarity between a new context and another experimented in the past. At a first stage, agents adapt to their environment, through a trial-and-error process. The solution defined in such a process and the general relation between stimuli and answers affects further learning steps. This representation allows to take into account different aspects of learning, pointing out to the need of considering the strategies played, but also the representation of the situation. It also allows for reflecting on the relation between individual and environment.

Next section presents the theoretical background. The following describes the experiment. At this point, it is possible to state clearly our hypothesis. Results follow in section 5. The concluding section discusses results and their main implications.

2. Theoretical Background

Traditional game theory predicts that equilibrium selection will converge on the unique Nash solution. In case of multiple equilibria, rational players will play a mixed strategy corresponding to a probability equal to 1/n strategies (Harsanyi, 1988). But, "predicting which of many equilibria will be selected is perhaps the most difficult problem in game theory." (Camerer 2003, p. 336). In fact, the "selection problem is essentially unsolved by analytical theory and will probably be solved only with a healthy dose of observation" (Camerer 2003, p. 336). The need for empirical observation is the aim of our research.

For this purpose, in the construction of the experiment we consider learning processes, and in particular Gregory Bateson's learning theory, presented in his book "Step to an ecology of the Mind" (1972), and use images to create strong decisional frames.

We consider learning processes because the problem of equilibrium selection has recently been analysed in coordination games under incomplete information conditions (Cabrales et al. 2007): plausible explanations of results converging on risk-dominant strategies have been the activation of a learning process in iterated games (Cabrales et al. 2007) and social learning mediated by higher status players whose choices tend to be imitated (Eckel et al. 2007).

In particular, we consider Bateson's learning theory because it represents a theoretical reference useful for an interdisciplinary dialogue with other disciplines. In his work, he takes in account both psychological and biological insight in order to explain how people perceive a strategic situation. Besides, his model can be used to understand how a game can be represented by agents, according to their experience.

Economists studied learning mainly in stable logical contexts, with given structures of material incentives, like in social learning models and cooperative iterated games. While the former refer to the frequency of a particular response which tends to be imitated by other social actors among the same population in similar contexts (Bowles 2004; Witt 2003), in the latter the Pareto-dominant strategy can be selected for a matter of “precedent” and “collective rationality” (Axerlod 1984), according to an evolutionary game theoretic account.

But, in real-life interactions, contexts are not always stable and people make decisions in different kinds of situations at the same time. What happens in these cases can be understood considering Gregory Bateson’s learning theory. In his view, learning can be described as a hierarchical process involving different levels of change. Such levels can be better understood if compared to the laws of motion.

“Zero learning” is the absence of motion, and it can be defined as the absence of change and stasis in decisions taken at different times. In some way, a “zero learning” is the result of already acquired knowledge which leads to a stable situation, in which a given context is responded to with a well-defined strategy or reaction. The subject can also tend to give highly skilled responses for a particular context and he or she can have a set of already available alternatives which result particularly suitable to given situations, but the responses are fixed, given the context and there is no correction or tendency toward change. In ordinary, non technical parlance, the word "learn" is often applied to what is here called "zero learning," i.e., to the simple receipt of information from an external event, in such a way that a similar event at a later and appropriate time will convey the same information: I learn from the factory whistle that it is twelve o'clock. Zero learning, then, can be defined as the absence of trial-and-error experimentation.

The next step, “learning one”, is a change in the behavior practiced in zero learning: it is, in fact, a revision of choice in a given set of alternatives. The change is, generally, adaptive and depends upon feedback loops, which can be determined both by natural selection and individual reinforcement. In both cases, there must be a process of trial and error and a mechanism of comparison between new choices and previous strategies. Examples of learning one are the cases of instrumental reward and instrumental avoidance. These models are typical of the Western philosophy based on free will, since prizes or punishments are due to the agents’ behavior and the same kind of interpretation is applied to economics, in which payoff or utility depends on the agents’ choices.

The further step in Bateson' theory is learning two. It determines a different and faster way to develop an action in order to deal with a new situation, based on a previous successful strategy. Learning one determines a specific segmentation, according to which an agent recognizes a context and then reacts to a stimulus by using a given strategy. The same punctuation can later be used in a different situation. This process leads to the creation of habits: a same approach is applied to solve an entire class of problems, which are seen as similar.

Choices determined by instinct and genetic reactions belong to zero learning, as do pre-programmed responses derived from past habituation. The player of a Von Neumannian game, by definition, is capable of all the computations necessary to solve whatever problems a game may present; they are incapable of not performing these computations whenever they are appropriate; they always obey the findings of their computations. Such a player receives information from the events of the game and acts appropriately upon that information. However, their learning is limited to what is here called zero learning (Bateson 1972, p. 284).

A relevant difference between zero learning and learning one is that in the latter, at time t+1, an agent 1 behaves in a different way in respect to time t; because at time t+1 he has undertaken training. Moreover, he behaves differently from an agent 2, who has been trained in a different setting or has not been trained.

Then, in the definition of learning one, there is an implicit definition of context: the stimulus is somehow the same at time t and t+1, and this notion of *sameness* delimits the notion of context as well, which must be the same in both periods. Without this assumption of repeatable contexts there could just be zero learning. Having a repeatable context is necessary for allowing any kinds of learning, as here defined. If the context changes every time, no learning (one) can occur. Every situations would be different from the others and experience could not be used. Yet, this fact makes it necessary to define when agents perceive to be in a same given context. There should be some kind of *context marker* informing the agent. In particular, "we may regard context as a collective term for all those events which tell the organism among what set of alternatives he must make the next choice" (Bateson 1972, p. 289). Following this interpretation, a context is considered as the set of all possible elements that characterize a situation as a specific one. This is recognizable by all those who share the same perception of the fundamental elements that determine the situation in this specific way. Given the information of the context marker, agents know how to react to a given stimulus. Such stimulus can be seen as an elementary signal. The context marker represents a meta-signal which defines how the stimulus has to be read. An organism could, in fact, respond, to the same stimulus differently in different contexts. When the agent learns to react to the stimulus, they also learn to classify the meta-signal and to define a context and then to make a given choice.

Defining how an agent acts in a given context is easier in a mathematical or logical world where specific structures make the contexts stable, like in standard game theory. Standard Economics and Game Theory do not need this richer representation as they are based on the idea that people react just to the mathematical representation of a situation, based on the material incentive. Contexts do not matter. The problem arises when the analysis is brought into reality or tries to be more realistic, and the logical structure is enriched with data, variables, information: this is exactly what we try to do in our experiment , passing from a pure logical game to a richer representation of the reality.

Experimental Economics (Tversky et al. 1981; Smith, 2008) has showed the relevance of a different kind of incentives and of the frame as agents react to different variables. The model proposed by Bateson helps in understanding how strategies and decisions need to be related to a specific frame, in order to use the past experience. Context markers can activate a specific process of segmentation, that is the ability to recognize the stimuli to react to. The process of segmentation is the particular and subjective perception of external reality; it is the way we perceive a situation as punctuated with a particular sequence of stimuli and choices.

All situations which are perceived as resolvable with a same kind of strategy can now be defined as similar, as both learning one or two might intervene. Because of learning two, different situations (as different games) can be managed with the same strategy.

This particular interpretation is a key point in order to understand our results and seems to find a plausible application in field experiments as well, like those run in different small scale societies (Henrich 2000; Henrich et al. 2001). In these experiments it emerged that subjects play according to rules and models of the world that shape their ordinary social and private life. For instance, people can refuse very high offers in a ultimatum game because they are motivated by a sense of honour and obligation: if they are accepting the offer now, they will have to pay back a higher offer in the future. This example explains how the same game and the same kind of situation can have different meanings and can be subjected to different kind of interpretations, according to the values, cultural practices and habits that a particular member of a population can have. It also shows how the same person can find similarities between different situations, behaving according to the same representation.

In our study of frame and learning processes as causes of equilibrium selection predictability, we use of an image to create a context, is consistent with the "labelling" processes which has been started by Schelling's work on focal points (Schelling 1960): the way in which strategies are described and perceived can influence choices and the expectations players formulate on them. Our image allows to create a kind of frame: so our experiment can be related to the stream of research which investigates how differences in the game's presentation to the players can determine different choices (Hoffman et al.1994; Mehta et al.1994; Sugden 1995; Larrick et al. 1997; Camerer 1998; Warglien et al. 1999; Hoffman et al. 2000, Sugden et al. 2006). However, the originality of the present research rests on studying the influence of the first game on the second, testing the viability of Bateson's hierarchical learning theory.

3. The Experiment: method and description of the game

We ran an experiment of two parts: the first is a coordination game, the second is a two-step battle-of-the sexes game. The first game runs for 18 rounds, the second for 9. A computer randomly and anonymously paired up subjects in the lab. These couples remained unchanged throughout the experiment. In each turn, subjects were shown both their own and their partner's choices and payoffs.

3.1. The Coordination Game

Let us consider the first part of our experiment: the coordination game. In each turn subjects had to pick one word between two possible alternatives. Words in this double-choice option represent written numbers (for example “four; five”). Along with the two words subjects were shown an image. The images appearing next to the decision options represented a set of two numbers in Arabic characters. Each of them was represented in several point of the images either in scattered orders or followed some precise patterns . The images could either present both the numbers in the double-choice option or just one of them and another one that was not presented in the double-choice. One of the two numbers was drawn more frequently. For instance, when subjects had to coordinate in choosing one word out of "five" and "four", an image with "5" and "4" in Arabic characters was presented (see figure 1, used at round seven) and the "5" occurred more frequently in the image. In another round, when subjects needed to coordinate in choosing between "four" and "eight", an image with "8" and "7" in Arabic characters was presented, and the "8" occurred more frequently (see figure 2, used at round 1). In every round both words and image changed.

Figure 1. The image used in the game at round 7 of the first game

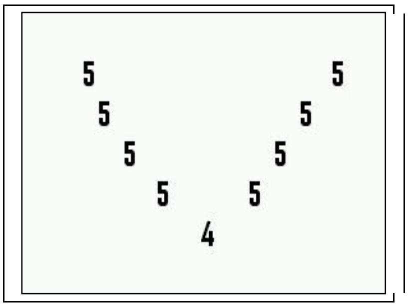
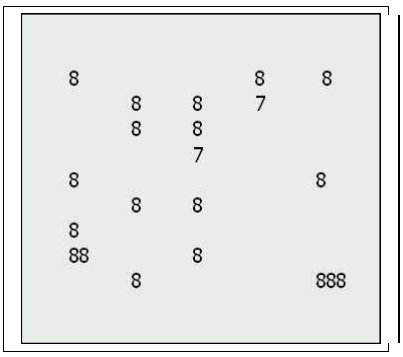


Figure 2. The image used in the game at round 1 of the first game



We ran three treatments, with different payoff structure of the game. In the first treatment subjects got more when picking the same number. Numbers appeared at random on the screen of each player and they might not be visualized in the same order for each of them. So what was seen as the first number for player one, could be the second for player two. The picture appearing next to the words was the same. In the instructions there was no direct reference to the image as a possible tool for coordinating. Yet, obviously, the picture were supposed to play a fundamental role, as it seemed to be the easier way to coordinate. Subjects could learn to choose the word of the most frequent number in the picture, or even the opposite one. They could just look at the image and find the most focal number (generally, but not always, the most frequent). Table 1 shows a matrix referring to this treatment. Choosing the same number allowed subjects to score points. The important thing for paired subjects is achieving coordination, regardless on which number. This is the reason why in the following matrix we simply refer to “number A” and “number B”.

Table 1. Pay-off matrix for the first treatment

P1/P2	Choose number A	Choose number B
Choose number A	(6,6)	(0,0)
Choose number B	(0,0)	(6,6)

In the second treatment, the numbers to be chosen and the image appearing next to the text were the same as in the previous treatment, but in order to score points, subjects were not just supposed to pick the same number; they both had to choose the lowest one. In other cases each of them obtained zero points. Here the images were the same of the treatment one. The game was characterized by imperfect information: players just knew that they would obtain a zero payoff when their choice were different. The instructions just said that if they both picked a same specific number (without specify that has to be the lowest one) they would have obtained a reward. The instructions also said that the winning number could be inferred as it followed a specific rule. Table 2 shows the implicit payoff matrix for this game.

Table 2. Pay-off matrix for the second treatment

P1/P2	Choose the lowest number	Choose the highest number
Choose the lowest number	(6,6)	(0,0)
Choose the highest number	(0,0)	(0,0)

The third treatment was similar to the second one. Each of the player score six points if both of them choose the lowest number; but each time coordination was achieved by following the wrong rule (i.e, the highest number) both players scored a negative payoff of minus seven. In absence of any coordination, both of them score zero pints. Here the image were again the same of the treatment one and two. Players could not infer this from the instructions: the game was characterized by information withholding, so that they had to figure out the payoff structure of the game while playing. In this treatment the instructions said that the score depended on the choices of both players and that they could either win or lose a same amount of money. Table 3 shows the implicit payoff matrix.

Table 3. Pay-off matrix for the third treatment

P1/P2	Choose the lowest number	Choose the highest number
Choose the lowest number	(6,6)	(0,0)
Choose the highest number	(0,0)	(-7,-7)

3.2. The battle-of-the sexes game

The second part of the experiment (turns 19 up to 27) was a two-step battle-of-the sexes game. It was built up as an ultimatum game, but proposers could not make their own personal offer, because they had to choose between two different possible amounts only. The roles of the two players, i.e. proposers and receivers, were randomly selected by the computer. Again, at each round, players were shown an image. The images used in this game were similar to the previous ones. Each turn of the game was, therefore, characterized by a choice among two numbers and by the appearance of an image. The first player had to pick one of the two numbers presented in a double-choice option. The first player's proposal was communicated to the second one who had to accept it or not. Receivers were aware of the possible payoffs and the alternative decisions available and saw the same image as the proposers. If the first number (expressed as a word) was selected and the receiver approved it, the proposer got a payoff of seven and the second player a score of five. Otherwise, if the second number (expressed as a word) was selected and approved, the proposer got five points and the second player obtained seven. If the proposal was not accepted both players got zero points.

Table 4 shows the list of choices for each turns in all the experiment: the last column indicates the most frequent number in the picture of that round. In the following analysis we will divide the battle-of-the sexes in two periods, too: from turns 19 up to 23 (we call this the third period, just to avoid using the adjective first and second, assigned here to the two games), and from turns 24 up to 27 (i.e., the fourth period). While in the third period the lowest number in the two-choices option and the most frequent number in the image do not coincide, in the fourth period they do.

Table 4. List of all numbers in the double-choice alternative for each treatment

Turn	**1st choice**	**2nd choice**	**MFN**
1	Four	eight	eight
2	Three	six	three
3	One	two	one
4	Two	four	two
5	Seven	fourteen	seven
6	Four	eight	four
7	Four	five	five
8	Three	seven	three
9	Four	nine	nine
10	One	eight	eight
11	One	two	one
12	Two	seven	two
13	Eight	nine	nine
14	Two	three	three
15	Five	seven	five
16	Four	nine	four
17	Three	nine	nine
18	Five	eight	eight
19	Two	four	four
20	One	two	two
21	Three	seven	seven
22	Four	eight	eight
23	Four	nine	nine
24	Three	six	three
25	Two	five	two
26	Two	seven	two
27	Two	four	two

3.3. Experimental session

We enrolled seventy students, attending their first year at the Faculty of Law. They had no prior background in behavioral economics. A total of 24, 18, 28 subjects participated in the first, second and third treatment, respectively. Players were paid according to their payoffs: each point gained was exchanged for 0.07 cents of Euros.

4. Aims and hypotheses

The goal of our experiment is to find out if and how the experience matured in the first game influences the choices made in the second one. For this purpose, the first and the second games of the experiment are made up with some similarities. A first analogy between the two games is that both of them can be considered and perceived as coordination game. In fact, the battle-of-the sexes has been classified by Camerer (2003) as a coordination game even if it is characterized by divergent rather than common interests.. The second analogy is the presence of an image in both game, and more in general, the presence of similar visualizations and tasks in the two games. These analogies could make possible that the first game of the experiment works as a training which possibly affects choices in the second one.. a two-step battle-of-the sexes game.

In the battle of the sexes, the equilibrium selection, among the possible ones, is not a just logical problem. Since in our experiment, the game is repeated, the equilibrium selection is more complicated and several strategies are possible. At least three possible ways to perceive the game are possible:

- rational choice; player one chooses the number most convenient for himself, counting up on the acceptance of the player two. In this case, player one wins more than player two;

- fair choice; players one and two split us the points, alternating the choice of the first number with the one of the second. In this case, they win a same amount;

- path dependent choice; the choices depend on the image, since the players learned to follow the image in the first game of the experiment[1]. In this case, players don't follow either the reward of himself or the one of the other. They choose following the images. By applying the model proposed by Bateson (1972), given the similarities in the problems to be solved, we could expect some kind of inertia between behaviors in the two games, but only if players developed a reinforced strategy in the first one. This is, in fact, a key point.

Both Bateson's learning one and two should be relevant here. Learning one suggests that in a given context, signaled by a context marker, agent should learn to perform a same choice. The problem is that of fixing a context. As in the real world there are no two identical situations, in our experiment the first game and the second one are not identical. The two contexts can't be considered similar if we do not restrict our attention, excluding part of the information. Learning two shows that agents can use classes of solution for different problems, and in this way reduce the need for a precise definition of the context. A context is a situation where a same action can be performed and eventually reinforced. Contexts need also to be recognized, so there should be some signal able to activate a specific strategy. A strategy reinforced in the first game, could also be applied in the second one, a battle of the sexes, presented as a repeated ultimatum game

In the second game, the most profitable option for the first player is to choose the first number (rational choice). In this way, he obtains seven point, if the second player accepts: according to the rational choice, the second player should accept, and win five instead to refuse and win zero. But, the second player could be willing to refuse this offer if it was perceived as unfair. The proposer could, therefore, react to this threat by accepting to win five point, or to alternate offers. A similar behavior could be expected by assuming the hypothesis of fairness. We did not neglect any of these possible effects. Yet our contention was that the decision would be related also to the treatment in which the first game was played and to the relevant experience acquired by the subjects.

The participants have played three different treatments in the first game. In the first one, to follow just the image was a good way to obtain a result; in the second treatment and in the third one it was not sufficient, since coordination had to

1 Accordingly with an idea of the acquisition of knowledge as a path-dependence process

happen on the lowest number and the image didn't give information about this. Moreover, while in the second treatment, a coordination on the highest numbers gave zero point, in the third one, it gave minus seven. So we can consider each of the three treatments as a different kind of possible training. Our aims is to observe the different effects of each of them on the second game.

We expect that during the first game, players in treatment one could learn to play the most (or least) frequent number in the image more than the others players. In fact, in treatment one players need to reach coordination in order to obtain a positive payoff, regardless on which number. Consequently, we expect that also in the second game they could go on looking at the image, as in the previous game, since in the previous game it has been a good strategy. So, they would be motivated to keep on choosing the most (or least) frequent number in the image also in the battle-of-the sexes game more often than players in the other treatments. Instead of just looking for the egoistic choice (or for an altruistic one) they would be influenced by the image. Therefore a learning spill-over process could exist.

The training effects on the battle of the sexes for the second and third treatments should be different. While in treatment one it is plausible that players learn to choose the most (or least) frequent number in the image, in the other two treatments this behavior is not rewarded. If players do not understand the correct rule (pick the lowest number), the rule "pick the most frequent number" should not be reinforced, at least not strongly (sometimes this rule could enable to score points, but not always).

In our model, both agents are influenced by their common training and the perceived fairness should depend on the way the first part was played. However, players from the first treatment should be more influenced by the image and, consequently, should select different kinds of equilibria[2] in part three and four of the second game (the battle of the sexes). In fact, in part three, the second choice (the less profitable for the proposer) was the one referring to the most frequent number. In part four, there should be an opposite situation as the first word refers now to the most frequent number. If players are influenced by the first game of

(Rizzello, 2004)

[2] The word "equilibria" is used when first players' proposals was accepted by the receivers, while "proposals" indicates offers which can be either accepted or not accepted.

the experiment, and so they follow the image, in part three, proposers should obtain lower scores than receivers. For the same reason, In part four, proposers are expected to get higher rewards.

The situation ought to be less clear for the other two treatments. The differences in the result of the third and fourth parts of the battle of the sexes should be less accentuated. In fact, in these treatments, players should better not look at the most frequent number in the image with the same intensity as in the first treatment.

As we can expect, if in the treatment one there is a clearly reinforced strategy of the kind: "pick the word of the most frequent number", we can expect that this same strategy will be used also in the second game, with an higher probability than in the other treatments. So agents can in some way spontaneously look at the second game as if it were a natural extension of the first, if a strategy had been reinforced. Therefore, according to our hypothesis, in treatment one there could be more proposals and equilibria on the word corresponding to the most frequent number. It could happen even if in the part three the proposer win less than receiver selecting the most frequent number in the image, and in the part four, receiver win less than proposer accepting the choice of the most frequent number. This result should be less pronounced in the other treatments.

5. Results and Discussion

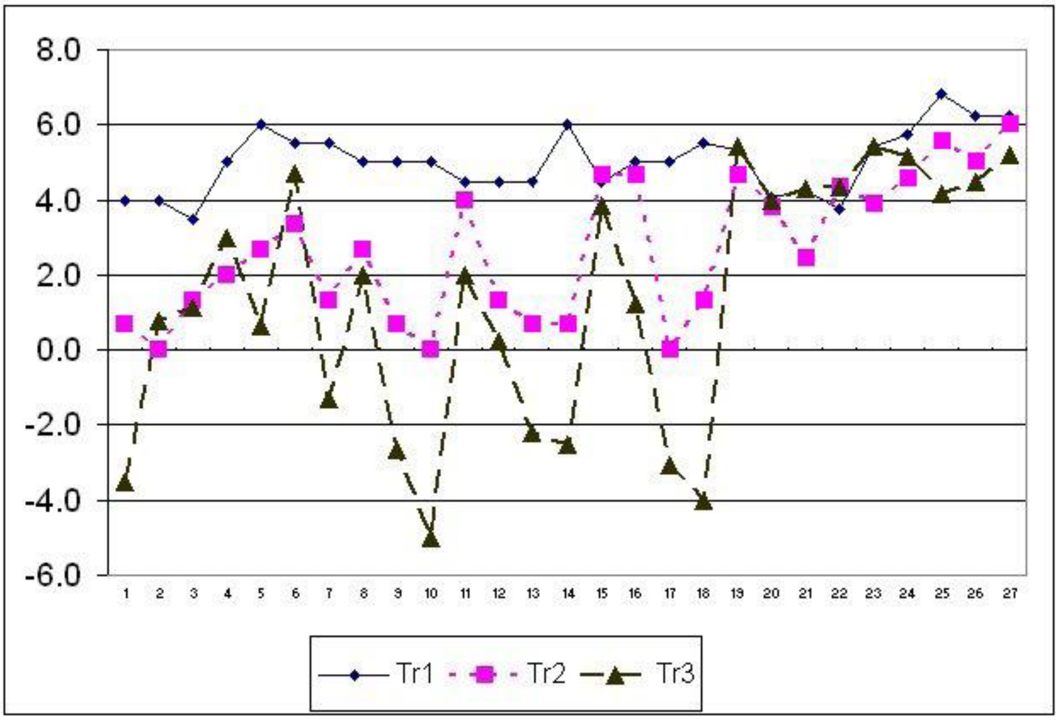
Graph 1 gives a first idea of the mean payoff for the first player[3] for each treatment during the whole experiment (the first game ends at round 18). In the first game the highest mean payoff was almost always achieved in treatment one, as expected, since coordination was easier (and could be achieved in different ways). A fast learning process can be observed here: from the fourth turn the percentage of subjects who coordinated with their partner increased and remained stable. It is evident that the image acquired a real powerful role: even though the players were not told about the need to find out a rule in order to coordinate, they might have related to the image and the most frequent number depicted in it suddenly became their focal point.

[3] Obviously the earnings of the two coupled players in the second game are highly dependent. So we decided to focus our analysis mainly on the first one. The mean payoff in the first game were identical for both players, since they won the same payoff in each turn.

Coordination in treatment two and three was more difficult: players from the second and third treatment won a lower mean payoff than players in the first treatment. There was no apparent and no clear trend emerged. In those treatments, the most frequent number in the image could still be the most focal one from a visual point of view, but this time the game was built upon a very specific rule, that is “coordinate on the lowest number”. This rule seemed to be difficult to identify. Maybe the image was too strong and captured the players' attention.
In order to compare how coordination took place in the different treatments, Table 5 shows the percentage of choice of the most frequent number for any treatment. A number could be either the most or the least frequent; in a single round a player can appear to choose an option just by accident. In other words: the lowest number could be chosen, but this could also be the most frequent. So an external observer cannot understand the decision criteria. Looking at the decisions taken in many following rounds, we reduced this problem as, throughout the game, the lowest number was independent from the most frequent. A slightly different and more reliable indicator of the same attitude is the sequence of turns in which any couple chooses the word corresponding to the most frequent number (or to the lowest one)[4].

[4] Let us consider, for instance, the first five rounds. Let us imagine that a couple selects the most frequent number at round three, four and five. It is possible to define a variable called repetition whose value is equal to zero in the first three rounds, while afterwords it takes the values one and two. We can compute a mean value for the given period and couple of this variable and divide it by five. In this way we have an indicator of the tendency to repeat a same choice in a given period. If a same choice is repeated by a same couple of players it is less probably a random choice. Using this index, we found the same tendency shown in table 5. Treatment one had the highest mean value (0.29 while treatment two had and index equal to 0.09 and treatment three had a value equal to 0.10).

Graph 1. First Player's mean payoff, for each turn of the first (turns 1-18) and the second part (turns 19-27) of the experiment



In the first treatment the percentage of choice of the most frequent number and of the sequences of choices were higher, as expected. The other treatments failed to understand their correct coordination rule. So their percentage of choice of the lowest number was not higher than that of treatment one.

Graph 1 shows also the mean payoff of player one in the second game. If we look at the first treatment, we notice that mean payoffs in the rounds from 24 to 27 were higher than the ones in rounds from 19 to 23. In the last five rounds there was a clear increase in this value. For the other two treatments the picture was quite less clear. Especially for the third group, there seemed to be no difference between what we called part three and part four of the second game. Table 6 allows a better analysis of the differences between the treatments, showing a series of indicators and two significance tests.

Table 5. Choice of the most frequent and lowest number in the coordination game: mean values per treatment

	Treatment 1	Treatment 2	Treatment 3	KW p-value	Test t p-value
Percentage of choice on the most frequent number	0.88	0.66	0.68	0.000	0.000
Percentage of choice on the lowest number	0.55	0.53	0.52	0.490	0.382

In the third period for the first treatment, players one often offered the less profitable number for themselves (the *word proposed corresponding to the most frequent number* - i.e. the second one - was higher for this group, even though the difference is not very significant). Notwithstanding this, they obtained the highest mean payoff, with respect the other two treatments. This can occur because treatment one is characterized by the lowest offers' rejection rate, and, then, by the highest number of equilibria. Table 6 shows that data about equilibria on the most frequent number, for the first treatment, are statistically significant both in period three and period four with a parametric and non parametric test.

Proposers from the first treatment choose the most frequent number 72% of the times and the proposals made were accepted 68% of the times. Instead, in treatments two and three, the first players were more likely to choose proposals which were the most profitable for themselves but not for the second player, and their proposals were more likely to be rejected as well: proposal for the most frequent number were 56% and 60% respectively in period three of the second and third treatments, while equilibria on the most frequent number decreased with respect the first treatment, being 35% and 42% respectively.

Table 6. Mean Values for some indexes in the battle-of-the sexes, player one.

Index	Treatment 1	Treatment 2	Treatment 3	KW p-value	Test t p-value
Proposals for the word corresponding to the most frequent number, period 3	0.72	0.56	0.60	0.125	0.094
Proposals for the word corresponding to the most frequent number, period 4	0.83	0.67	0.57	0.023	0.019
Equilibria on the proposals of the word corresponding to the most frequent number, period 3	0.68	0.35	0.42	0.003	0.001
Equilibria on the proposals of the word corresponding to the most frequent number, period 4	0.79	0.56	0.41	0.001	0.000
DIFF3	-0.36	-0.15	-0.15	0.231	0.201
DIFF4	0.65	0.28	0.04	0.003	0.001
DDIFF	1.01	0.43	0.19	0.010	0.003
Mean payoff for couples, period 3	5.08	3.56	3.40	0.000	0.000
Mean payoff for couples, period 4	5.63	5.00	4.71	0.119	0.159
Percentage of choices' confirmation for identical images between the coordination and the two steps battle-of-the sexes (turns 1-22; 4-27; 9-23; 12-26)	0.71	0.50	0.54	0.034	0.022

The first treatment is characterized by the highest frequency of choices on the most frequent number: this datum can be seen by looking at the *mean difference in the payoff among player one and player two in each pairs of subjects*. We call this variable DIFF, which is computed as:

mean value over all t, of: first player's payoff in turn t- pair's of subjects mean payoff in turn t.

If DIFF is negative, this means that the proposer's payoff is lower than receiver's. If, for example, a proposer always picks the first number (winning 7 points, while the receiver gets 5), DIFF is equal to 1. An opposite behaviour would determine a value equal to -1. Data in table 7 shows that in period three, proposers in all treatments won a lower mean payoff than the second player, as they offered many times the second word. The mean value of DIFF 3[5] was lower for the first treatment, but the difference was not significant from the other groups. In period four, all treatments jumped to a positive value of DIFF4, but now the first one had a significantly higher value. In treatment three, DIFF4 is almost equal to 0: there were virtually no differences between the two players. While in treatment one in most cases proposers picked the first number and receivers accepted it, in treatment three players tended to share the points almost equally and therefore behaved as if they were not relying so much on the most frequent object in the image.

The variable DDIFF measures the differences between DIFF in period four and DIFF in period three. Treatment one had the highest difference in DDIFF between the two periods. This is consistent with our prediction: players who had been used to look at the most frequent number in the image kept on doing so at a greater extent than others.

If we consider both players of any couple, and not just proposers, treatment one shows the highest mean payoff in the period three, as a result of a better capacity to coordinate, related to a shared representation of the game. In period four, players from the first treatment got again higher payoffs, but the differences are not very significant. The overall lower performance in treatments two and three

shows that players don't need to share common information for taking a decision.
The inertia between the two games can be tested in another way. Four images had been presented in the coordination game and were then repeated in the second part. Players in treatment one showed the greatest consistency, confirming the same choices in the two situations. Treatment one showed, moreover, the longest sequence of choices on the most frequent number, in both parts of the game, as they showed highest values for the same kind of decision in the first game.

Table 7. An analysis at the individual level: some correlation coefficients between choices in the two games

	tr 1	tr 2	tr 3
Correlation coefficient between the score in the first part of the game and the frequency of seven got in the second part by the first player in the third part of the game	-0.42 (0.09)	0.30 (0.31)	-0.26 (0.23)
Correlation coefficient between the score in the first part of the game and the frequency of seven got in the second part by the first player in the fourth part of the game	0.41 (0.10)	0.59 (0.05)	-0.27 (0.21)

The link between the behavior in the two games can be detected also at an individual level. In the first treatment, a well defined behavior is reinforced. Players who learn to pick the most frequent number get an higher score and should develop a stronger tendency to look at the image in the same way also in the second game. This same attitude is only partially reinforced in the second treatment and is not reinforced at all in the last one.
The correlation coefficient between the score in the first part of the game and the frequency of seven got in the second part by the first player in the third part of the game is negative and significant for the first treatment: first players who understood in a better way the game in the first part get a lower score in part three

[5] In Table 6 we defined as DIFF3 and DIFF4 the value corresponding to DIFF in period three and period four respectively.

and an higher one in part four. In the third group this coefficient is not significantly different from zero. So there is no such correlation where picking the highest number is not reinforced. In the second treatment (where picking the highest number where partially reinforced) the correlation is found just when it is convenient for the proposer. The same behavior is maintained in the two games only if it were initially reinforced.

6. Conclusions

This paper aimed at proposing new evidence on learning transfer from different contexts, starting from some insights proposed by Gregory Bateson (1972). This topic is not new in the literature, but it is quite neglected, so further evidence is needed to understand both its importance and field of application. Moreover, there is mainly the need of a general framework for modeling this phenomenon in order to understand when it occurs and which effect it determines. Among other possibilities, the steps based learning idea proposed by Bateson seems to be quite useful. First of all, it is quite general, as it can be applied to study both game theory and other decision settings. It helps, besides, in understanding the adaptive origin of the transfer of learning. It shows both the positive and negative elements of learning. It highlights the link between decisions and the environment and the problem of fixing an environmental context. It shows how a same environment can be perceived in different ways, because of different social reinforcement based on a selection of the information. This model makes it clear how in the real world agents need first of all to define in which decision context they are, screening all the variables and selecting some of them. Economics usually models human being as just interested to monetary incentives. So all other information can be excluded from analysis. The experimental literature showed that agents react also to other variables, as information. Therefore, studying how information is selected becomes a necessary task. The idea of context and context marker can help in understanding how this selection can occur and how apparently not relevant variables can be used because of learning. Bateson shows that this process can happen because of the same adaptation process (and therefore because of ecological rationality). So irrelevant information can be used even when they are irrelevant. Using fixed and abstract contexts, Economics excludes this possibility.

In our experiment, the treatment one, generates a reinforcement of the strategy played in the first game. This strategy is maintained in the second one because of a possible perception of similarities which seems to be weaker, or at least different, in the other treatments. So we can say that the reinforcement based on choosing the word of the most frequent element reinforces also the role of the image. The image is the context marker, while the most frequent object is the variable used for picking a word. Players learn to look at the image, searching for specific information. In the other treatments there is no shared information able to allow an easy coordination, as shown by the lower capacity to reach equilibria. The only shared idea could be a common expectation of the difficulty in getting a positive payoff. Sharing a rule can be, in a social context, good even if such a rule is not so profitable for the single agent. The overall better performance in treatment one can therefore be explained by a common representation of the game, lacking in the other treatments. In this experiment, learning two therefore can be seen as adaptive, because it allows for a common view of the game: in this game, learning two is the capacity to use a same strategy in different games. If we consider the proposer, fit of decision depends on the reply of the second player, and if the second player refuses choices different from the ones used in the first game, the two games can be seen as a unique context. So the kind of altruism found in this game is just the result of the representation of the game and even a demonstration of rationality. Given receivers' behavior, picking the less profitable word in period three can be seen as a rational strategy.

Appendix A: Instructions for the first part of the game

The instructions for the three treatments are reported below. In the original version of the experiment they were written in Italian. The English translation reported here is as faithful as possible.

Instructions for the first treatment:

You are supposed to fill in the next page with your first name and last name. Once you will click on the start button, the game will start with a certain number of turns. Throughout the duration of the experiment, the computer will pair you with another person in the lab, anonymously and randomly chosen. Your partner will be the same throughout the experiment. In each turn, each of you will see the same image and the same list of two words. The words will be the same for each member of the pair, but their order may be different between the partners because it is randomly generated by the computer in a different way for each player. Each of you has to choose a word. If you choose the same word, both of you will be awarded with 6 experimental points; if the options chosen are different, you will not score any points for that turn. You are not allowed to communicate in any way. In each turn you have three minutes of time to make your choice. After you have chosen, the computer shows the choices that you both made and the payoff results for both of you.

Instructions for the second treatment:

You are supposed to fill in the next page with your first name and last name. Once you will click on the start button, the game will start with a certain number of turns. Throughout the duration of the experiment, the computer will pair you with another person in the lab, anonymously and randomly chosen. Your partner will be the same throughout the experiment. In each turn, each of you will see the same image and the same list of two words. The words will be the same for each member of the pair, but their order may be different between the partners because it is randomly generated by the computer in a different way for each player. Each of you has to choose a word. If you both make the same choice selecting the word that fulfills a particular criterion, you will both obtain 6 experimental points. If partners make different choices, they will not score points in that turn. You are not allowed to communicate in any way. If you make different choices or you select the wrong word, you will both get zero payoff. The word that makes you win 6 points follows a specific logic that can be inferred while playing.

Instructions for the third treatment:

You are supposed to fill in the next page with your first name and last name. Once you will click on the start button, the game will start with a certain number of turns. Throughout the duration of the experiment, the computer will pair you with another person in the lab, anonymously and randomly chosen. Your partner will be the same throughout the experiment. In each turn, each of you will see the same image and the same list of two words. The words will be the same for each member of the pair, but their order may be different among the partners because it is randomly generated by the computer in a different way for each player. Each of you has to choose a word. The payoff in each turn depends on the choice you both made. According to your choices, you could win or lose experimental points. The points won or lost are identical for both of you. You are not allowed to communicate in any way.

Appendix B: Instructions for the second part of the game

Instructions in case the computer has randomly determined that you are player one

At this time the game has changed. A player one and two have been determined, randomly, by the computer: you are player one.
You are still paired with the same player as in the first part of the game: pairs will remain unchanged throughout the experiment.
You have to make a choice in the following double-choice options. Your choice will be transmitted at player two, who can see the same image and words as you. Player two can either accept or refuse the proposal made. If you choose the first number in the double-choice options, and player two accepts it, you will win 7 experimental points, and he or she will win 5 experimental points. If player two refuses, you will both win zero payoff. If you choose the second number in the double-choice option, instead, and if player two accepts it, you will win 5 experimental points and he or she will win 7 experimental points. If player two refuses the offer made, you will both get a zero payoff. You have three minutes to make a decision for each trial.

Instructions in case the computer has randomly determined that you are player two

At this time the game has changed. A player one and two have been determined, randomly, by the computer: you are player two.
You are still paired with the same player as in the first part of the game: pairs will remain unchanged throughout the treatments.
Player one has just chosen a word from the double-choice options (he or she can see the same words and numbers as you). You can accept or refuse his or her offer. If player one's proposal corresponds to the first number in the double-choice option, and you accept it, player one will win 7 experimental points, and you will win 5 experimental points. If you refuse it you will both obtain zero payoff. If player one's proposal, instead, corresponds to the second number in the

double-choice option, and you accept the offer, you will win 7 experimental points, and player one will win 5 experimental points. If you refuse, you will both obtain zero payoff.

You have three minutes to make a decision for each trial.

References

Axelrod, R. (1984). *The Evolution of Cooperation*, Basic Books, New York.

Bateson, G. (1972). *Steps Toward an Ecology of Mind*, Ballantine Books, New York.

Bowles, S. (2004). *Microeconomics: behaviour, institutions, and evolution, Russell Sage Foundation*, New York; Princeton University Press, Princeton, Oxford.

Cabrales A. , Nagel R. , Armenter, R. (2007). Equilibrium Selection through incomplete information in coordination games: an experimental study. *Experimental Economics*, 10, 221-234.

Camerer C. F. (1998). Mental representations of games. Working Paper. California Institute of Technology.

Camerer C. , Knez M. (2000). Increasing cooperation in prisoner's dilemmas by establishing a precedent of efficiency coordination in games, *Social Science Working Paper* 1080, Division of Humanities and Social Sciences, California Institute of Technology.

Camerer C. F. (2003). *Behavioural Game Theory: Experiments in Strategic Interactions*. Princeton University Press, Princeton.

Eckel C. C. , Wilson R.K. (2007). Social learning in coordination games: does status matter? *Experimental Economics*, 10, 317-329.

Egidi M. , Narduzzo A. (1997). The Emergence of path-dependent behaviours in cooperative contexts. *International Journal of Industrial Organization*, 15(6), 677-709.

Harsanyi J. , Selten R. (1988). *A general theory of equilibrium selection in Games*, MIT Press, Cambridge, MA.

Henrich J. (2000). Does Culture Matter in Economic Behaviour? Ultimatum Game Bargaining Among the Machiguenga of the Peruvian Amazon, *The American Economic Review*, 90(4), 973-979.

Henrich J. , Boyd R. , Bowles S. , Camerer C. , Fehr E. , Gintis H. , Mc Elreath R. (2001). In search of Homo Economicus: Behavioural Experiments in 15 small-scales societies", *The American Economic Review*, 91(2), pp. 73-78.

Hoffman E. , McCabe K, Shachat K, Smith V.L. (1994). Preferences, property rights and anonymity in bargaining games, *Games and Economic Behaviour***,** 7, 346-380.

Hoffman E. , McCabe K. , Smith V.L. (2000). The impact of exchange context on the activation of equity in ultimatum games", *Experimental Economics* 3, 5-9.

Larrick R.P. , Blount S. (1997). The claiming effect: Why players are more generous in social dilemmas than in ultimatum games", *Journal of Personality and Social Psychology*, 72, 810-825.

Mehta J. , Starmer, C. , Sugden, R. (1994). The Nature of Salience: an Experimental Investigation of Pure Coordination Games, *The American Economic Review*, 84(3), 658-673.

Rizzello S. (2004), "Knowledge as a Path-dependent Process", *Journal of Bioeconomics* 6: 255-274

Schelling T. (1960). *The Strategy of Conflict, Harvard University Press*, Cambridge, MA.

Smith, V.L. (2008). *Rationality in Economics: Constructivist and Ecological Forms*, Cambridge University Press, Cambridge.

Sugden, R. (1995). A Theory of Focal Points, *Economic Journal*, 105(430), 533-550.

Sugden, R. (1998). "The Role of Inductive Reasoning in the Evolution of Conventions", *Law and Philosophy,* 17(4), 377-410.

Sugden R, Zamarrón I.E. (2006). Finding the key: the riddle of focal points, *Journal of Economic Psychology*, 27, 609-621.

Tversky A. , Kahneman D. (1981). The framing of Decisions and the Psychology of Choice. *Science,* 211(4481), 453-458.

Warglien M., Devetag M.G., Legrenzi, P. (1999) I modelli mentali dei giochi: focalizzazione e rappresentazioni selettive, *Sistemi Intelligenti*, 11, 85-112.

Witt, U. (2003). *The Evolving Economy: essays on the evolutionary approach to economics*. Edward Elgard, Cheltenham.

Acknowledgement

A first version of this paper was presented at IMEBE conference 2009. We would like to thank Giuseppe Attanasi for his interesting comments and meaningful insights.
The software was realized by Cesare Tibaldeschi.
Massimo Giornetti provided some linguistic comments and corrections on a first English draft of this paper. All possible errors are ours.
This paper was partially founded by the *Fondation Les Treilles*.