Do Incentives Affect Routinized Behavior?

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Presentation schedule

- Introduction
- Rules of the game
- Game simulation (volunteer: Eizo Akiyama)
- Experimental design
- Data analysis
- Conclusion

1 Introduction.

Aim: investigate the emergence of coordination routines in a laboratory μorganization,
test the effect of different incentive structures on the routinization process.

Approach: routines observation is problematic.
Behavioral routines are stored in tacit memory $\Rightarrow$ a controlled laboratory environment allows the simulation of a minimal organization. Two experimental subjects have to be coordinated in order to resolve a problem.
A key property of many real and artificial contexts in which individuals cooperate to achieve a common goal is that of the variety and multiplicity of the possible solutions. Actors are able to devise many alternative ways to cooperate and solve the problems.

2 Organizations & routines.

The persistence of diversity among economic organizations has received a considerable amount of attention in the recent literature. One important source of diversity lies in path dependent features of organizational learning: similar organizations - for example, small firms competing within the same industry - can increase their differences over time if they respond with different strategies to environmental changes.

If we interpret the different ways in which firms respond to changes as the outcome of their different and idiosyncratic accumulations of knowledge, then learning - as a form of knowledge acquisition - becomes the key element in explanation of such differentiation.

In an Organization the knowledge - identified by the “automatic” practices and behaviors - is organized in routines.

One of most distinctive features in both individual and organizational learning is path dependency[a].

Path dependency and organizational routines are strictly correlated.

[a]Studies in different theoretical areas - technological change (Kauffman 1988, Brian Arthur 1988, 1989, Dosi and Kaniowsky 1994, David 1988, 1989), organizational learning (March 1981, Levitt and March 1988, Levinthal 1994), economic and institutional change (North 1991, Denzau and North 1994) - claim that path dependency plays a key role in explaining the evolution of, and differentiation among, economic organizations and institutions

3 Routine definition.

“Standard” definition:

> *“[routine] may refer to a repetitive pattern of activity on an entire organization, to an individual skill, or, as an adjective, to the smooth uneventful effectiveness of such an organizational or individual performance.”*

Nelson and Winter [page 97]

> *“Our general term for all regular and predictable behavior patterns of firms is ‘routine’. We use this term to include characteristics of firms that range from well-specified technical routines for producing things, through procedures for hiring and firing, ordering new inventory, or stepping up production of items in high demand, to policies regarding investment, research and development, or advertising, and business strategy, about product diversification and overseas investment. in our evolutionary theory, these routines play the role that genes play in biological evolutionary theory.”*

Nelson and Winter [page 14]

> *“We will regard a set of activities as routinized, then, to the degree that the choice has been simplified by the development of a fixed response to defined stimuli. If search has been eliminated, but a choice remains in the form of a clearly defined and systematic computing routine, we still say that the activities are routinized.’*

March and Simon [page 163]

“.. a relatively complex pattern of behavior (or the theoretical representation of such a pattern) triggered by a relatively small number of initiating signals or choices and functioning as a recognizable unit in a relatively automatic fashion...’

Winter 86 [page 165]

“The regular or routine features of encounters, in time as well as in space, represent institutionalized features of social systems. Routine is founded in tradition, custom, or habit, but it is a major error to suppose that these phenomena need no explanation, that they are simply repetitive forms of behavior carried out ‘mindlessly’. On the contrary, as Goffman (together with ethnomethodology) has helped to demonstrate, the routinized character of most social activity is something that has to be worked at continually by those who sustain it in their day-to-day conduct.”

Giddens 84 [page 60]

“By ‘organizational routines’ we mean patterned sequences of learned behavior involving multiple actors whoa re linked by relations of communication and/or authority.”

Cohen [page 555]

“Within the organization, we can consider as routine any procedure which provides for the execution of a specific task: it is therefore a procedure which solves a set of problems internal to the organization.”

Egidi [page 4]

“A routine is an executable capability *for repeated performance in some* context *that been learned by and organization in response to* selective pressure.”

SFI [page 33]

4 The TTTexperiment.

The Target The Two (TTT) experiment was invented by M.D.Cohen & P.Bacdayn [1994].
The rules of the game are the following:

- two players: *colorkeeper* and *numberkeeper*,
- 6 cards: $2_\heartsuit$, $3_\heartsuit$, $4_\heartsuit$ and $2_\clubsuit$, $3_\clubsuit$, $4_\clubsuit$,
- 4 cards are on the table, 1 belong to *colorkeeper*, 1 belong to *numberkeeper*,
- *colorkeeper* starts playing,
- at every turn one player can decide to exchange the card that he has in hand with one of the 4 cards on the table and then pass the turn to the other player, or pass directly the turn
- aim of the game: put the $2_\heartsuit$ in the TARGET position,
- *colorkeeper* can change his card with the card in TARGET iff the two cards share the same color,
- *numberkeeper* can change his card with the card in TARGET iff the two cards share the same number,
- the hand finishes when: the $2_\heartsuit$ is in TARGET, or the players use more than 20 moves, or they pass the turn 4 times in a row,
- $P_{ck} = P_{nk} = \frac{2000-(100 \cdot nm)}{2}$,
- Experiment: 42 hands, time limit: 40 mins.

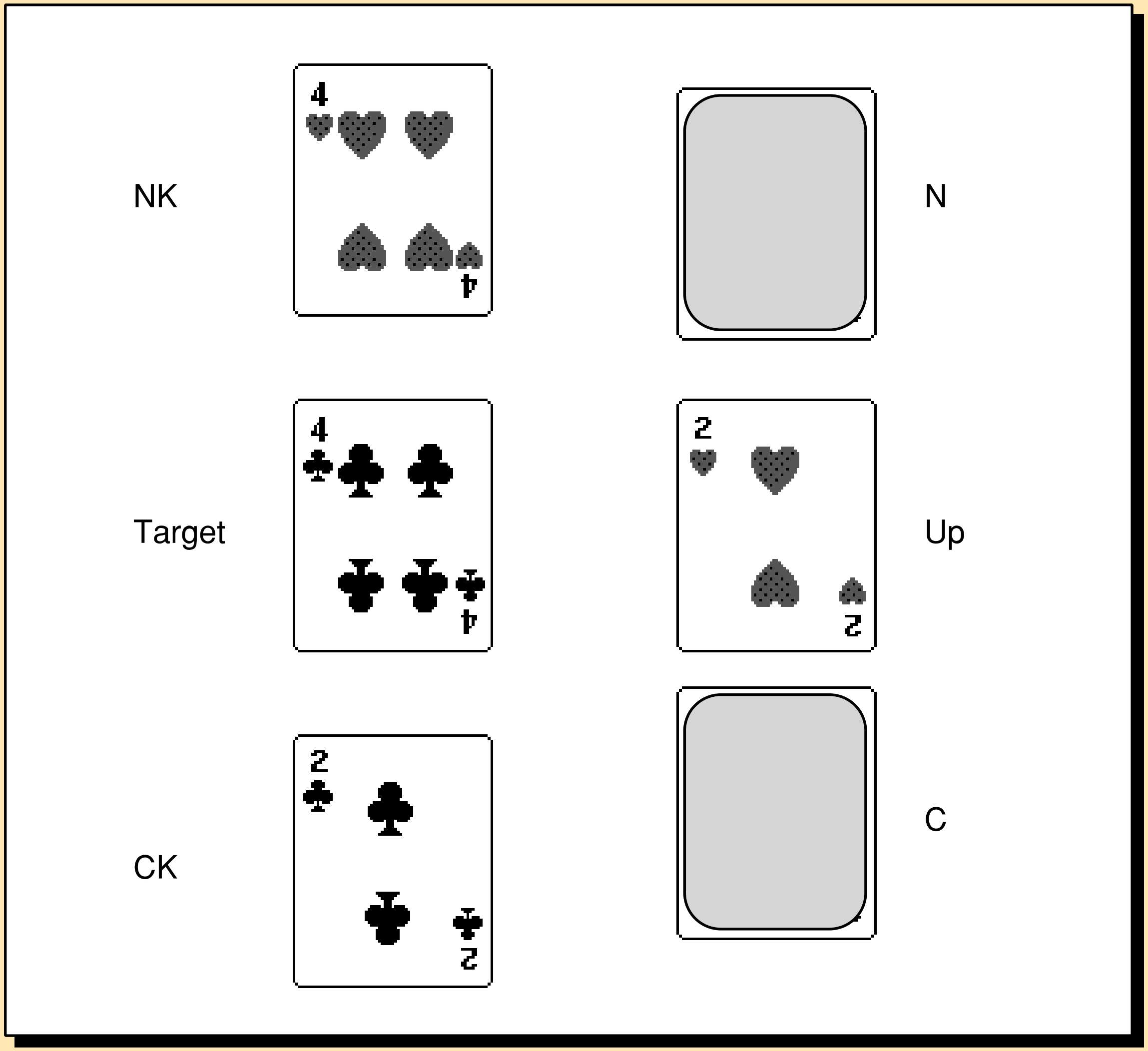


Figure 1: An example of cards distribution.

4.1 Subproblem space

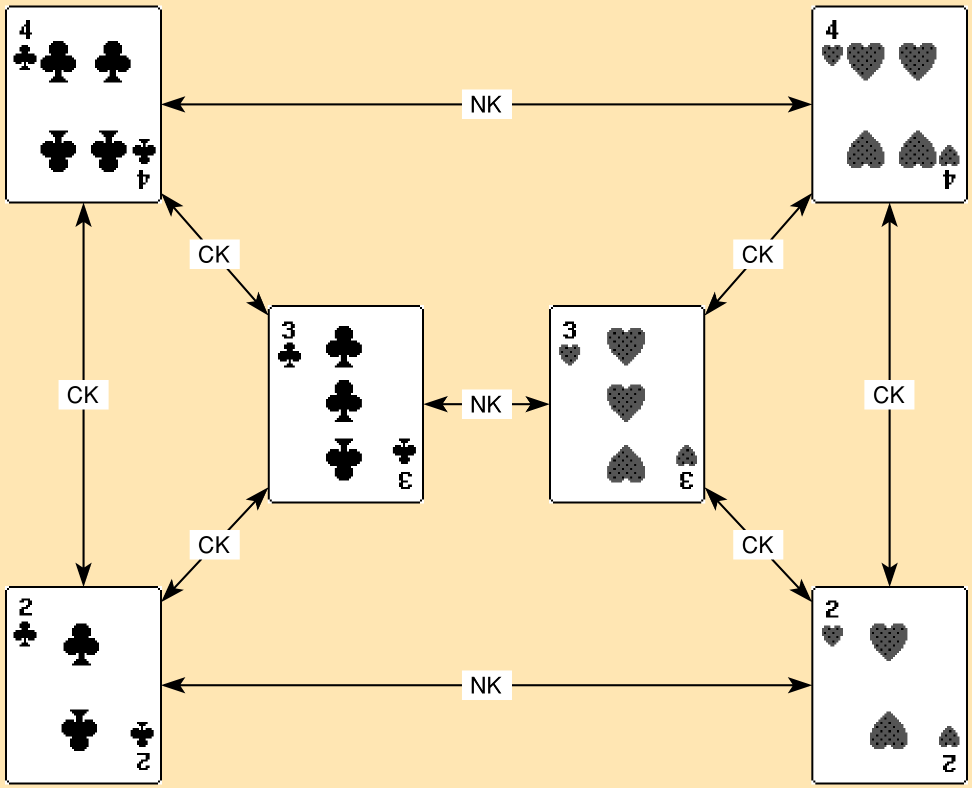
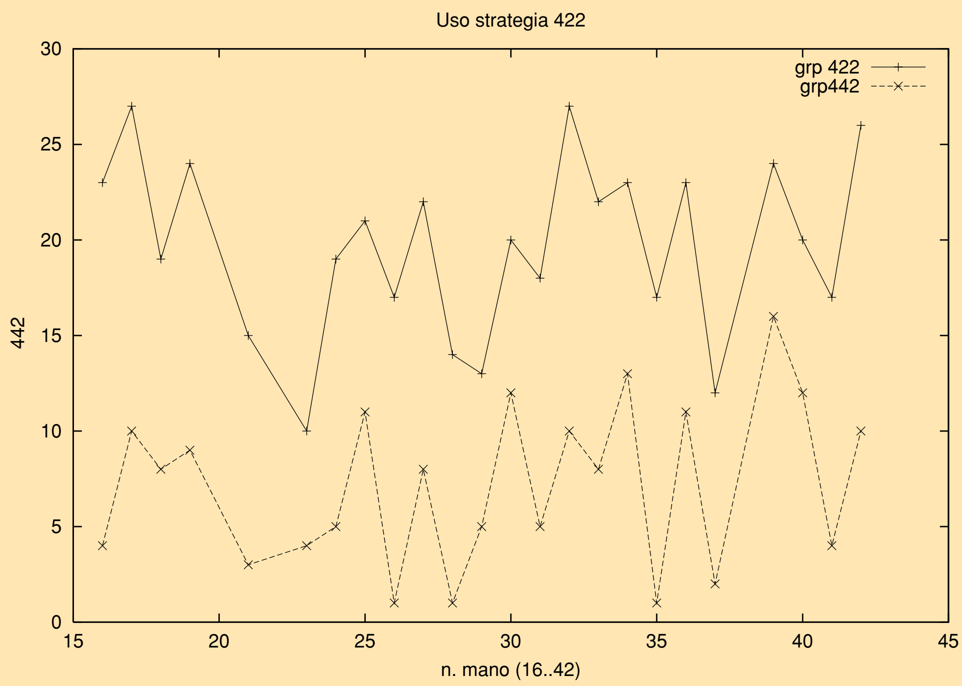


Figure 2: Game graph: each node represent a set of configurations that share the same card in TARGET.
The vertical links can be followed by the *numberkeeper*, the other links by the *colorkeeper*.

4.2 Routinized Behavior

The work of Egidi and Narduzzo show strong path dependency in the strategy space:



5 Experimental Design.

Aim: to study the effect of asymmetric incentive structure on agents behavior in a controlled environment

$$
\begin{aligned}
P_{ck} &= d \cdot p \cdot P_{tot} + (1-d) \cdot (1-p) \cdot P_{tot} \\
P_{nk} &= (d-1) \cdot p \cdot P_{tot} + d \cdot (1-p) \cdot P_{tot}
\end{aligned} \tag{1}
$$

with $P_{tot} = (1000 - 100 \cdot nm)$, nm number of moves, d is defined as follows:

$$
d = \begin{cases} 1 & \text{if } ck \text{ put } 2\heartsuit \text{ in target} \\ 0 & \text{if } nk \text{ put } 2\heartsuit \text{ in target} \end{cases} \tag{2}
$$

Methodology: comparison between a group (*unitn14*) exposed to asymmetric payoffs with a group exposed to symmetric payoffs (*unitn3*).

Hypothesis: we want to test the following hypothesis

H_1**:** asymmetric incentives allows subjects to explore a larger subspace of the strategy space.

H_2**:** if H_1 is true then we expect more efficiency in the group exposed to asymmetric incentives.

Experimental design structure:

exp. session	I[a]	*group*	*treatment* learning	test
unitn3	no	grp422	422 oriented $\longleftarrow [1..15] \longrightarrow$	mixed 422/442 $\longleftarrow [16..42] \longrightarrow$
	no	grp442	442 oriented $\longleftarrow [1..15] \longrightarrow$	mixed 422/442 $\longleftarrow [16..42] \longrightarrow$
unitn14	yes	grp422	422 oriented $\longleftarrow [1..15] \longrightarrow$	mixed 422/442 $\longleftarrow [16..42] \longrightarrow$
	yes	grp442	442 oriented $\longleftarrow [1..15] \longrightarrow$	mixed 422/442 $\longleftarrow [16..42] \longrightarrow$

[a] Asymmetric payoff in the “learning period”.

Table 1: Experiment structure.

6 Results...

6.1 Number of moves analysis.

The performance of the pairs belonging to the two groups is measured on the base of the number of moves used to resolve a hand. If the number of moves is low then the pair payoff is high .

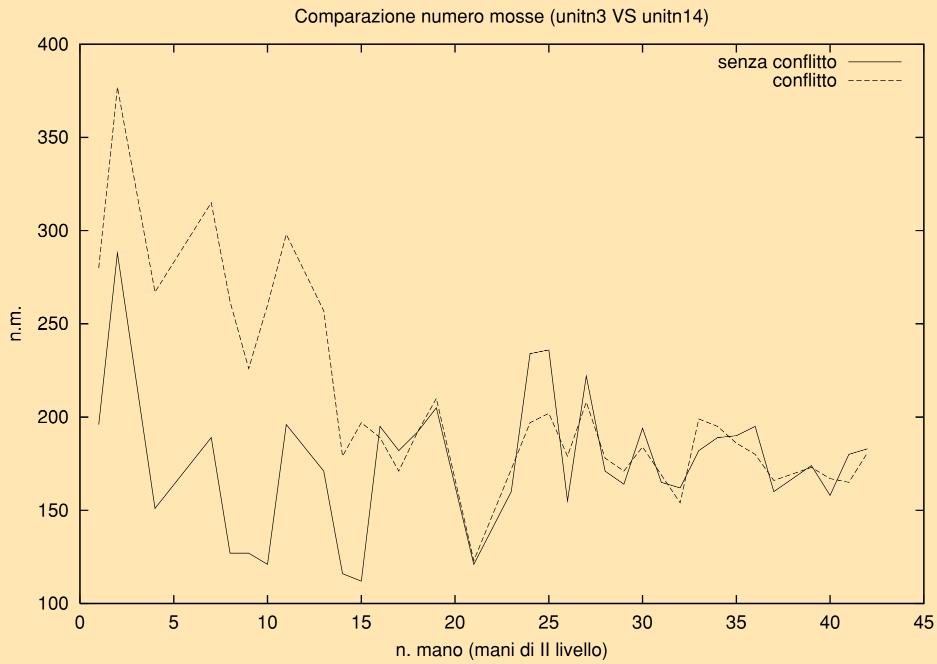


Figure 3: Aggregate number of moves per hand in the two groups.

Number of moves per hand

Group	$\sum x$	$\overline{x}$	S^2	*t-test*
unitn3 $[1..15]$	1794	163	52.77	$3.21 \cdot 10^{-08}$
unitn14 $[1..15]$	2918	265	54.77	

During the learning period the group with asymmetric payoff uses in the average a number of moves that is 40% greater than the other group.

Q: Is there an explanation for this difference? The first 15 hands can be easily resolved using the 442 strategy ⇒ *colorkeeper* put $2_\heartsuit$ in TARGET and in this way he will receive the 80% of the pair payoff.
It is plausible to hypothesize an *numberkeeper* anti–cooperative behavior. The *numberkeeper* can obstacle *colorkeeper*forcing an inefficient end of the hand, in the following way :

- number of moves $> 20 \Rightarrow P_{tot} = 0$,
- 4 pass moves in a row $\Rightarrow P_{tot} = 0$.

Looking the data we observe:

Not finished hands

Group	n.	perc.
unitn3 $[1 \dots 15]$	3	1%
unitn14 $[1 \dots 15]$	37	12,33%
unitn3 $[16 \dots 42]$	0	0
unitn14 $[16 \dots 42]$	4	0,5%

The *numberkeeper* oobstructionist behavior pushes *colorkeeper* to behave in a more “fair” way: the 37% of hands is closed by *numberkeeper* (*numberkeeper* put the $2_\heartsuit$ in TARGET) ⇒ non optimal strategy ⇒ worse performance.

During the test period of the experiment the difference between the average number of moves of the pairs per hand is not statistically relevant:

Number of moves per hand

Group	$\sum x$	$\overline{x}$	S^2	*t-test*
unitn3 $[16..42]$	4369	182	26.08	0,207
unitn14 $[16..42]$	4311	179	18.92	

It is interesting to compere the number of moves of the agents with the optimal number of moves along the 42 hands:

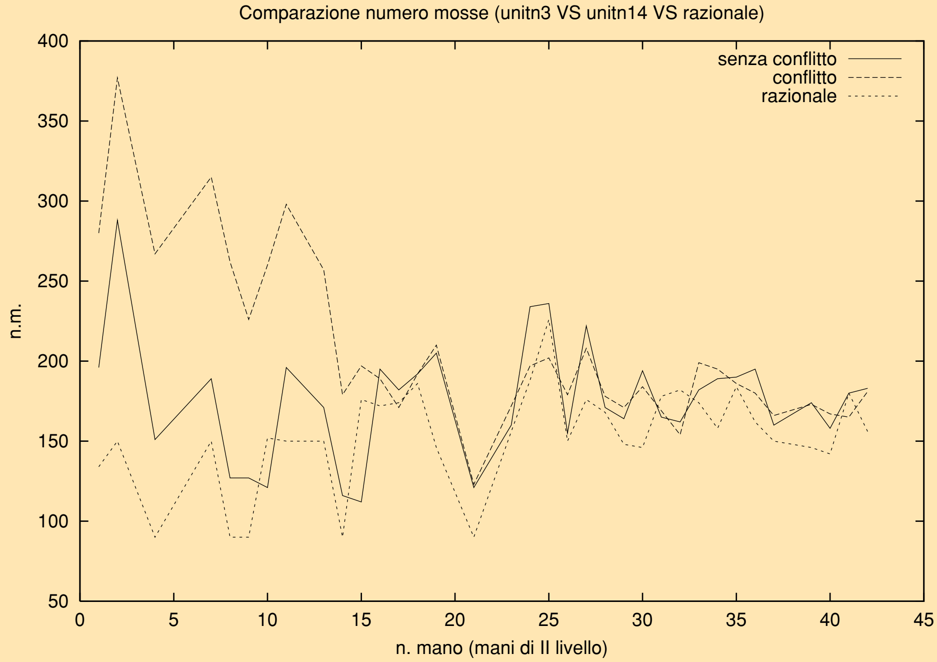


Figure 4: Aggregate number of moves of the two groups and optimal player.

6.2 Strategies Analysis.

We classified the behavior of the experimental pairs on the base of the followed path in the subproblem space. The following figure shows the optimal strategy for each hand. In the 25th hand the 442 and 422 strategy are equivalent.

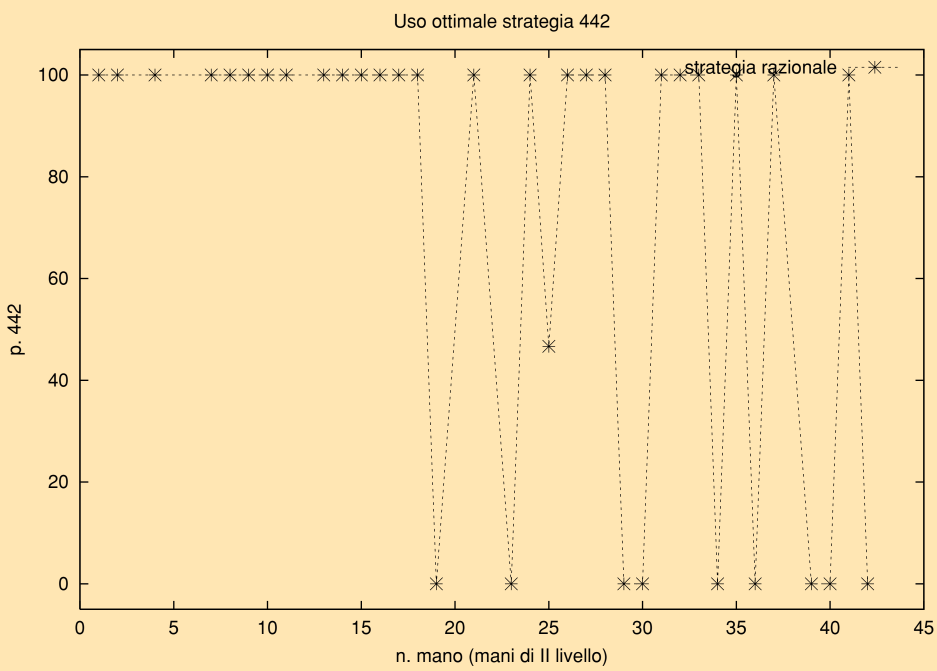


Figure 5: Optimal probability to play 442 stra tegy.

6.2.1 Learning period

The first 15 hands are resolved optimally using the 442 strategy.
Different incentive structure for the two groups:

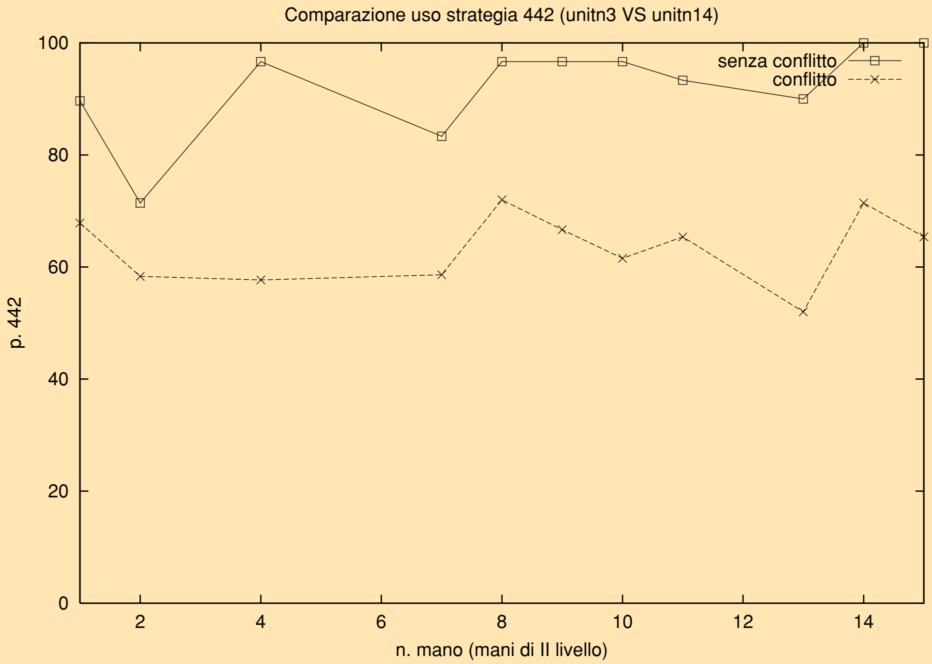


Figure 6: Use (percentage) of the 442 strategy during the first 15 hands

Use 442 strategy

Group	$\overline{x}$	S^2	*t-test*
unitn3 $[1..15]$	92,21	8,50	$1,05 \cdot 10^{-7}$
unitn14 $[1..15]$	63,35	6,25	

6.2.2 Control period

During the control period both groups are exposed to symmetric incentives.

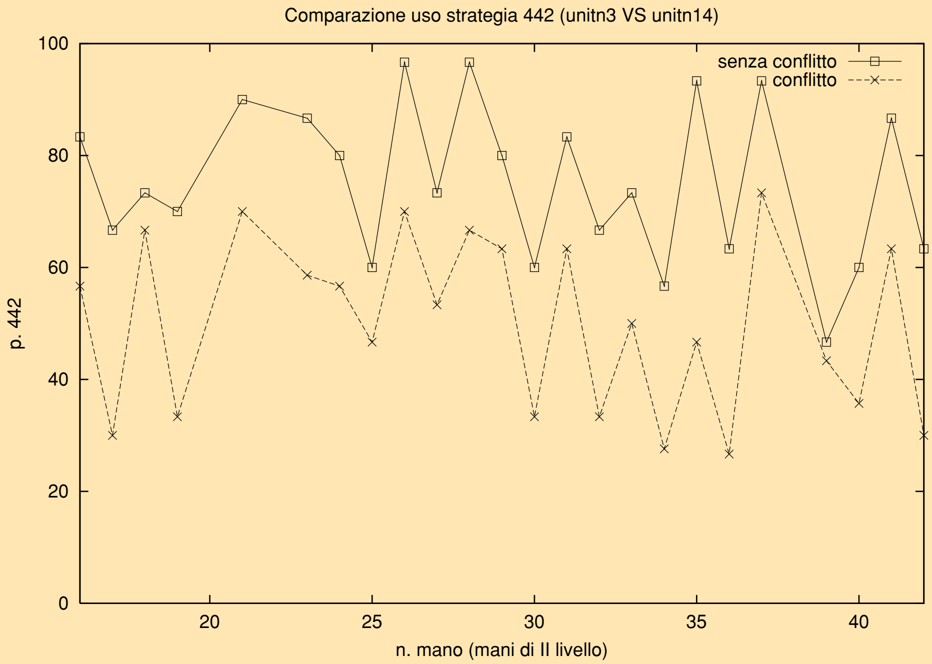


Figure 7: Use (percentage) of the 442 strategy during the last 27 hands.

Use 442 strategy

Group	$\overline{x}$	S^2	*t-test*
unitn3 $[16..42]$	75,13	14,07	$3,51 \cdot 10^{-12}$
unitn14 $[16..42]$	49,94	15,54	

6.3 Pairs distribution.

Distribution of pairs (support: use in percentage of the 442 strategy) during the learning period.

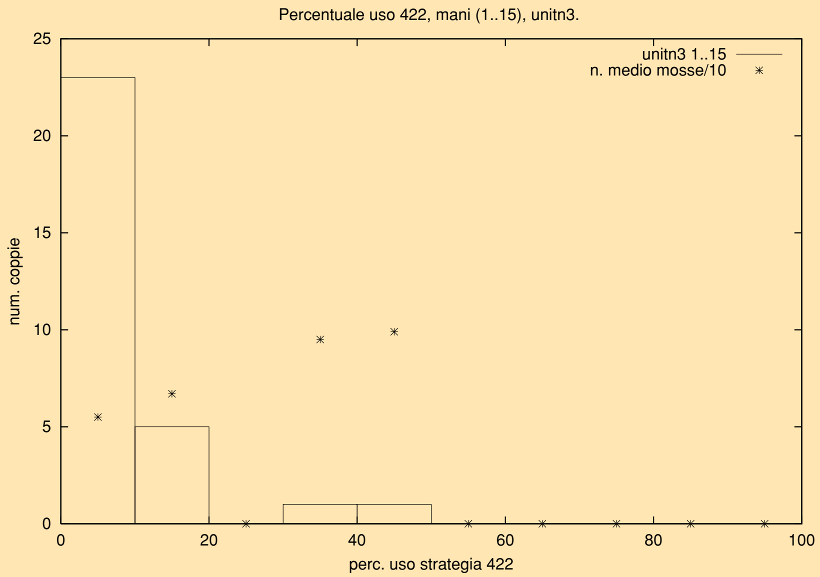


Figure 8: Pairs distribution: *unitn3* during [1..15].

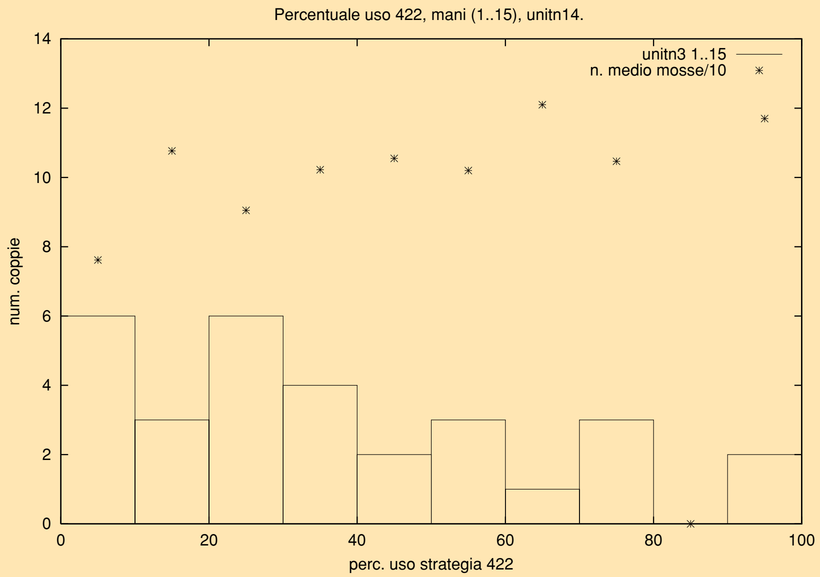
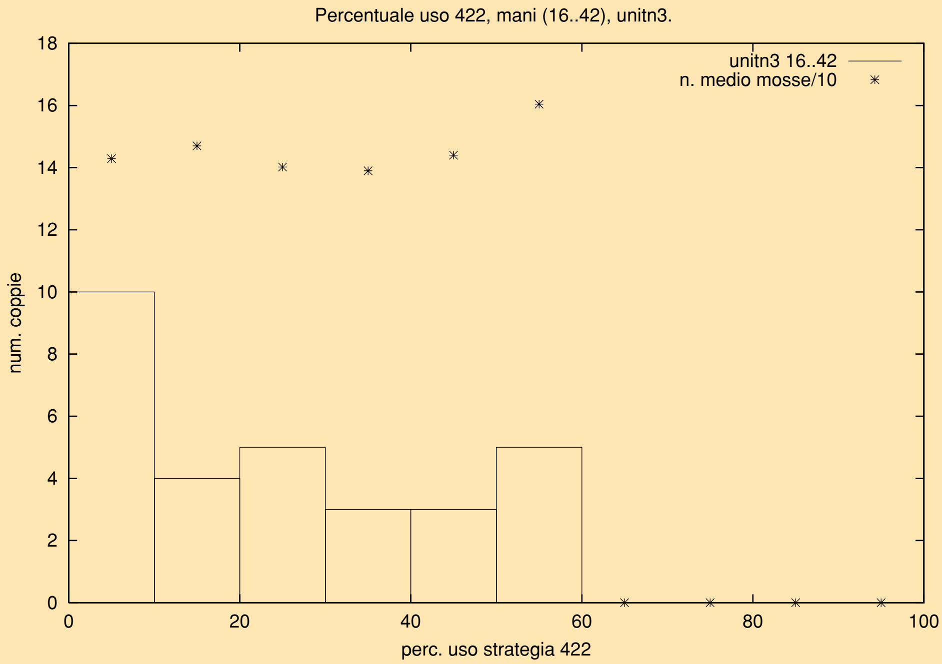
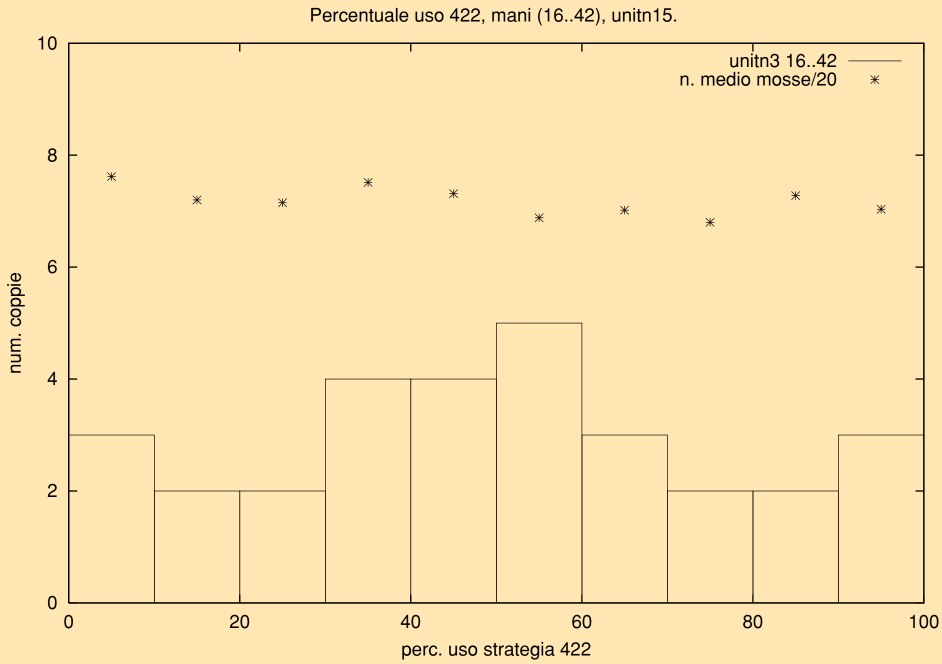


Figure 9: Pairs distribution: *unitn14* during [1..15].

Distribution of pairs (support: use in percentage of the 442 strategy) during the control period.



Pairs distribution: *unitn3* during [16..42]



Pairs distribution: *unitn3* during [16..42]

6.4 Couples distribution *unitn14*.

How does the behavior change when we switch the payoff structure?

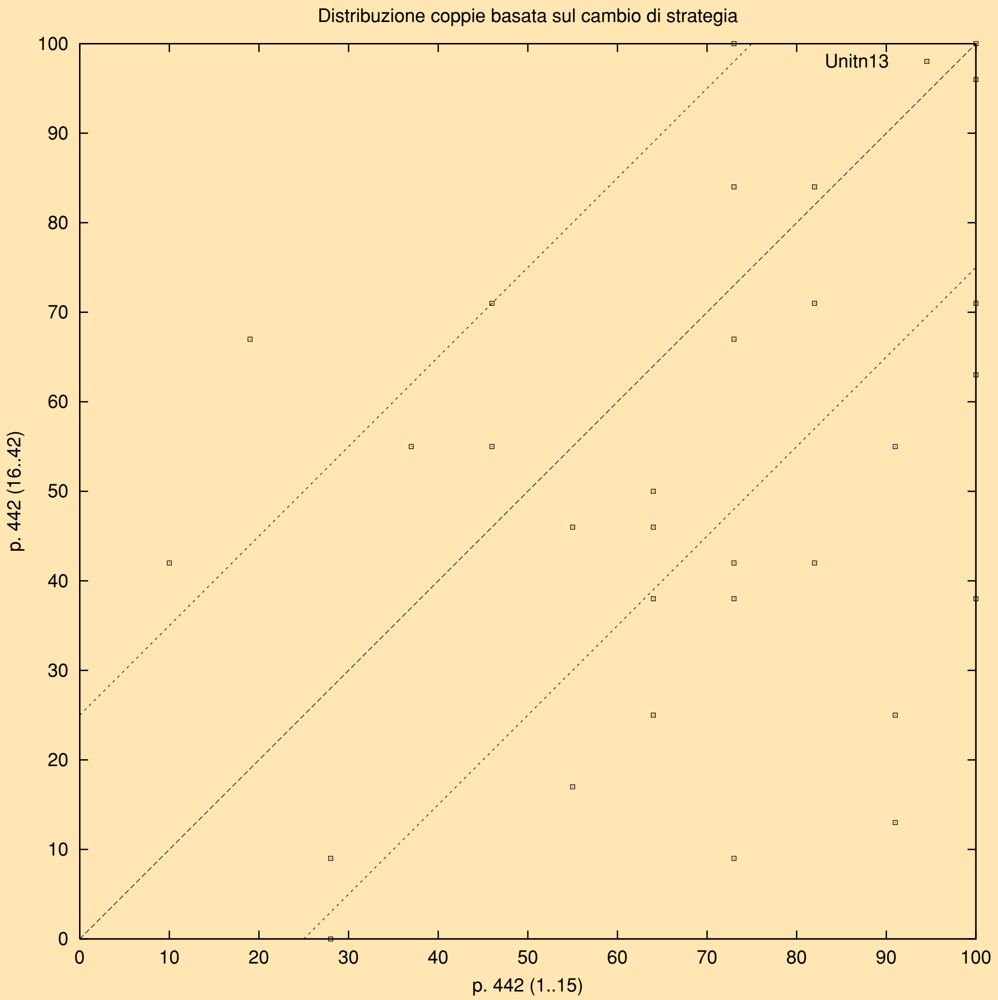


Figure 10: Every point of the scatter plot is a pair. On the abscissa the percentage of 442 strategy used in the learning period. On the ordinate the percentage of the 442 strategy used during the control period.

6.5 Coordination analysis.

If the $4_\clubsuit$ is in the TARGET then for *colorkeeper* the main cards are: $4_\heartsuit$, $2_\clubsuit$, $2_\heartsuit$. *colorkeeper* needs the $2_\clubsuit$ in order to reach the first subgoal and $2_\heartsuit$ to reach the second one. The $4_\clubsuit$ allows that *numberkeeper* reaches the first subgoal.

Target	card	CK	NK
$4_\clubsuit$	$2_\clubsuit$	▲	▽
	$2_\heartsuit$	⧫	⧫
	$4_\heartsuit$	▽	▲
$3_\clubsuit$	$2_\clubsuit$	▲	▽
	$2_\heartsuit$	⧫	⧫
	$3_\heartsuit$	▽	▲

The players can act in the following ways:

- to change the card that they have in hand with the card in TARGET: T.
- to change the card that they have in hand with the card in up: U.
- to change the card that they have in hand with one of the two covered cards: S.
- to pass: P.

In tab: results of the first 16 hands of the couple n.2

CK						NK					
Cond.	T	U	S	P	$\sum$	Cond.	T	U	S	P	$\sum$
▲,♦	4	0	1	0	5	▲,♦	1	0	2	0	3
▲,▽	0	0	0	0	0	▲,▽	1	0	0	0	1
▲,N	1	0	0	1	2	▲,N	4	0	3	0	7
♦,▲	0	0	0	1	1	♦,▲	0	1	0	0	1
▽,▲	0	0	0	0	0	▽,▲	0	1	1	0	2
N,▲	0	0	0	0	0	N,▲	0	0	2	0	2
♦,▽	0	0	1	1	2	♦,▽	0	0	0	0	0
♦,N	0	0	2	3	5	♦,N	0	0	0	0	0
▽,♦	0	2	4	0	6	▽,♦	0	0	3	0	3
N,♦	1	0	7	0	8	N,♦	0	0	6	1	7
▽,N	0	0	1	0	1	▽,N	0	0	2	0	2
N,▽	0	0	1	0	1	N,▽	0	0	0	0	0
N,N	0	0	3	0	3	N,N	0	0	1	0	1
$\sum$	6	2	20	6	34	$\sum$	12	4	40	7	63

7 Conclusions.

- The asymmetric payoff structure has a strong impact on the players strategies and on the player efficiency.
- The group exposed to asimmetric incentives explore the strategy space but the plyers are unable to exploit this knowledge during the part of the experiment with symmetric payoff. The couple lacks in coordination.

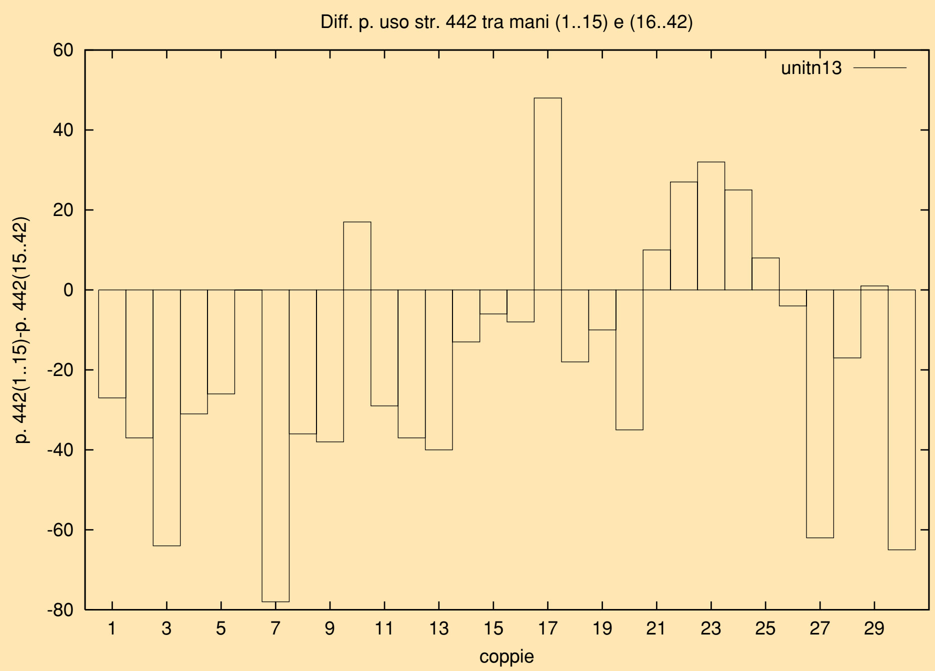


Figure 11: Differenza per coppia dell'uso della strategia 442 tra la prima e la seconda fase per coppia dell'epserimento *unitn14*

Azione	H	U	T	M_a^{-1}	U_a^{-1}	T_a^{-1}	M_b^{-1}	H_b^{-1}	U_b^{-1}	T_b^{-1}	M_a^{-2}	$\cdots$
T	$2\heartsuit$	#	$3\heartsuit$	#	#	#	#	#	#	#	#	#
P	#	#	#	U	$2\clubsuit$	$2\heartsuit$	#	#	#	#	#	#
C	$\cdots$											
$\vdots$	$\ddots$											

Table 2: Esempio di tabella *Condizione–Azione*

La forza f_i della *i*–esima regola r_i è calcolata nel modo seguente:

$$f_i = \sum_{j,j=1}^{n} w_j m(s_j, r_{i,j}). \quad (3)$$

La regola scelta sarà $r^\star$ alla quale corrisponderà un $f^\star$ tale che $f^\star = \max_i f_i$.