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Effects of communication and cultural consequences on choices combinations in INPDG with four participants

Efectos de la comunicación y las consecuencias culturales en combinaciones de elecciones en un INPDG con cuatro participantes

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Resumen

En dos juegos de INPDG, cuatro personas eligieron una tarjeta verde o rojo de forma individual. El verde siempre produce el mejor resultado para las personas si todos los otros optaron por el rojo y el peor resultado si todos eligieron verde. Todos los que eligen las tarjetas rojas optimizan puntos. En ningún caso, ningún grupo elige rojo en condición A (Línea de base de 20 ensayos) Las metacontingencias se agregaron (consecuencias culturales de las combinaciones de opciones enVR2) y fueron manipulados a través estas 2 condiciones, la selección de por lo menos 3 tarjetas rojas (condición B), o por lo menos 3 tarjetas verdes (condición C). se permitió la conducta verbal en un grupo (GV), y para la última sesión del otro grupo (GNV), las opciones de estos grupos estabilizados todos de color rojo (o todo verde), dependiendo de la metacontingencia en vigor. Aunque los grupos sin la conducta verbal terminaron con tres de los cuatro participantes en la elección de color rojo, de acuerdo con la metacontingencia, los 4 participantes de ambos grupos llegaron a un consenso sobre la elección de color verde.

Palabras clave: Metacontingencias – Juego Del Dilema Del Prisionero – Conducta verbal.

Abstract

In two games of INPDG, four people chose a green or red card individually. The green one always produces the best outcome for individuals if all the others chose red and the worst outcome if all chose green. All who choose red cards optimize points. In no case any group choose red in Condition A (Baseline 20 trials). Metacontingencies were added (cultural consequences on VR 2 for various combinations of choices) and manipulated across the next 2 conditions, selecting for at least 3 red cards (B condition) or at least 3 greens (C condition). Verbal behavior was allowed in one group (GV), and for the last session of the other group (GNV); the choices in these groups stabilized on all red (or all green), depending on the metacontingency in effect. Although groups without verbal behavior ended with 3 of 4 participants choosing red in accordance with the metacontingency, all 4 participants in both groups reached consensus on choosing green.

Keywords: Metacontingencies – Prisoner's Dilemma Game – verbal behavior

The Prisoner's Dilemma Game (Prisoner's Dilemma Game – PDG) is a tool of applied mathematics to analyze how social interactions and their possible products can be quantified and predicted (Axelrod, 2006, Axelrod & Hamilton, 1981; Fiani, 2004). In this analogy of social interactions, combining responses from two or more organisms is what determines the products of this interaction. Thus, the product may be beneficial for all organisms to a greater or lesser magnitude, as it can provide differences in earnings between the group members.

Rachlin, Brown and Baker (2001) describe these possible relationships in terms of positive reinforcement and punishment. For these authors mutual positive reinforcement occurs when participants enter into an agreement on an optimal molar alternative, gaining similar magnitudes of reinforcement. The situation of punishment occurs when one of the participants receives reinforcements of greater magnitude than the others. Mutual punishment occurs when all participants choose the greater magnitude alternative available, but the combination of these responses produces equal and low magnitude reinforcement for all.

These descriptions corroborate the definition of social behavior for behavior analysis. Skinner (1953/2001) defines social behavior as the behavior of two or more people regard to one another or together related to a common environment. The concept of social behavior, therefore, involves the behavior of two organisms in which the responses of one of the organisms functions as a source of stimulation, antecedent or consequent, for the behavior of the other (De-Farias, 2005; Skinner, 1953/2001).

The studies of PDG with humans and nonhumans have shown control by the immediate consequence (molecular control) (Flood, Lenderman &Rapapport, 1983; Green, Price & Hamburger, 1995; Hall, 2003; Sanabria, Baker & Rachlin, 2003). This pattern has made some authors think of PDG as a tool for studying self-control.

Ever since the first experiments with games, the contact between participants was minimized or even prohibited because of the game features. Usually, the experimenter or a computer acted as the other player, and the experimental manipulation was conducted by means of this virtual member. In the current literature, this experiment is sometimes considered to be impersonal and distant to social situations of the natural environment. Furthermore, direct communication between all participants of the game has made the response of cooperation predominant (Kerr & Kaufman-Gilliland, 1994).

A number of studies have been conducted on the effect of communication on the responses of cooperation and coordination (e.g., Cronin, Kurian & Snowdon, 2005; Dugatkin & Alfieri, 1991; Dugatkin & Wilson, 2000; Mendras & Waal, 2000; Milinski, 1987; Milinski et al., 1997; Noë, 2006). Two lines of research with chimpanzees are very important to evaluate the role of communication in coordinating the responses. Both of them follow Crawford`s model (Cronin, Kurian & Snowdon, 2005; Dugatkin & Alfieri, 1991; Dugatkin& Wilson, 2000), in which two chimpanzees had ropes at their disposal and were given food only when both of them responded simultaneously. Mendros and de Waal (2000) presented a bar to pairs of monkeys. The bar was counterbalanced so that it could not be pulled by only one of the subjects, thus producing food. Later, the pair was separated by an opaque plate to prevent eye contact or by a translucent plate. Subjects coordinated less their responses in the presence of the opaque plate which led to the interpretation that communication is essential for the coordination of responses.

In PDG is necessary that less or no information is transmitted between the group members who require the separation of players in different cabins, eliminating the communication and ensuring to each player that there are other participants in the game. According to Mendros and de Waal (2000), this increases the responses frequency that produce unequal gains. Milinski (1987) and Milinski et al. (1997) showed that the mere presence of another organism increases the likelihood of the subject to cooperate, even when the other is just a reflection in the mirror of the experimental subject. Clements and Stephens (1995) and Stephens, Maclin and Stevens (2002) in order to test the cooperation between two organisms, connected two boxes of operant conditioning for pigeons. The cooperation of the subjects was named instrumental cooperation and it was the only pattern reinforced. Thus, isolated responses of a subject did not produce reinforcement. The instrumental cooperation was considered analogous to the response in the triple contingency - the interlocking responses or the instrumental cooperation produced reinforcement. The results showed that a cooperative pattern may be reinforced directly without the need of communication, since the two subjects were spatially isolated and did not communicate.

Data from researches that do not allow communication between human participants show a pattern of cooperative responses, although a longer time is required for the emission of such responses (Yi & Rachlin, 2004; Chen &Komorita, 1994; Chaudhuri, Sopher & Strand, 2002). Sanabria et al., (2003) presented data with pigeons showing a cooperative pattern in PDG which may suggest that, unlike what was stated in the field of social behavior, verbal behavior is neither necessary nor sufficient for the emergence of cooperative social behavior, but some accessory stimuli or contingencies are necessary to clarify the contingency in effect and to prevent the subjects from choosing the molecularly maximized magnitude alternative.

Another variable studied was the number of people involved in the PDG (Fox & Guyer, 1977; Yi & Rachlin, 2004). Research shows that the more people who are involved in the PDG the higher the individual competition. The main explanation is that such gains are calculated by an equation; and as an alternative always generate more points than the other, this alternative is molecularly most likely to be chosen.

Specifically the Yi and Rachlin study (2004) was the first behavior analytic PDG study with groups. The authors used five players in the procedure. Only one of the players was a real subject. The responses of the others were controlled by a computer according to solving strategies of the game. The procedure consisted of choosing between X and Y. X was the alternative with the possibility of higher earnings and Y was 7 points less than X. Two strategies were used, TFT and RANDOM. In TFT, all virtual participants begin the game choosing X. For each participant's response in Y, one of the virtual participants chose Y in the following trial. Thus, 4 consecutive responses in Y by the participant resulted in 4 virtual players choosing Y in the fifth trial. For the responses in X the same relationship was in effect. For each response in X by the participant, one of the virtual players would choose X in the following trial. The results were clear in showing that when the strategy was TFT participants increased the rate of choosing X, while when the RANDOM strategy was in effect (50% chance for each alternative on each trial) the rate of choosing Y increased. This can be due to the fact that choosing Y could produce more points regardless of their previous response.Then, choosing Y was an alternative to maximize points. Ortu, Woelz and Glenn (2008) replicated Yi and Rachlin (2004) in a metacontingency study using four actual participants.

Metacontingency is defined by Glenn (1986, 1989, 1991, 2004) as a process where a cultural consequence can select interaction patterns that are replicated within and across generations. Metacontingencies have three terms: the IBC (interlocking behavior contingency), where the responses of organisms function as antecedent or consequent for the response of the others; the aggregate product that is only an effect of the IBC; and the cultural consequence that is the responsible for the selection of IBCs and the aggregate product. The concept is based on the description of the third level of selection where there is a consequence that selects patterns of interaction of the group (Skinner, 1984). Some studies have been developed to produce data to support this concept. The data suggest that the cultural consequence has the function of selecting IBCs and the aggregate product (Nogueira, 2009; et al., 2010; Ortu, Woelz & Glenn, 2008; Vichi, Andery & Glenn, 2009).

In the study of Ortu et al., (2008), the combination of responses were the IBCs that produced the aggregate product, which was the sum of the individual consequences. (The sum was only possible as a result of a particular combination of participants` responses.) The cultural consequence was the presentation of the market gains or losses, which added or subtracted points for the group contingent on the aggregate product of the IBC. There were two conditions and the participants could communicate through a chat room throughout the experiment. In Condition A the target aggregate product was XXXX (all participants choosing the alternative X) and the cultural consequences were as follows: +10 points for the combination XXXX; 0 points for XXXY; -3.3 points for XXYY; -6.6 points for XXXY and -10 points for YYYY. The signs of plus and minus of the cultural consequences were inverted in Condition B. In almost 80% of the trials the most frequent IBC was the one that produced 10 points from the market only when the individual contingencies were inconsistent with the metacontingency (Condition B, in which it was necessary that everyone chose Y receiving a low amount of individual points in order to receive the greatest cultural consequence). After the achievement of the stability criterion of eight consecutive trials with the emission of the same combination in conditions A and B, fading of the cultural consequence was implemented. The fading procedure did not alter the frequency of IBC already selected in each condition. Thus, further exposure to the cultural extinction condition was necessary for participants to return to responding for individual gain.

This study is a systematic replication of Ortu et al., (2008) with the overall objective of investigating the effect of individual and cultural consequences on the coordination or the interlocked choices of participants in the Iterated n-players Prisoner's Dilemma Game (INPDG) with four players, which differs from pairs usually employed in the game. Among the specific objectives two variables are considered: (1) the cultural consequence and (2) the verbal interactions in brief intervals.

Method

Participants

Eight undergraduate students from five degree programs of *Universidade de Brasilia*: Nutrition, Pharmacy, Psychology, Wood Engineering and Information Science. The groups were arranged in such a way that the 4 participants did not know each other and were from different programs.

The average of participants was 24 with standard deviation of 6 (18 - 30 years old).

Instruments

There was a 90 cm height, 3m width table. There was a 3m length, 1 m height wooden divider on the table. Three Styrofoam dividers connected to the wooden dividers formed 4 separated individual places, allowing no visual contact; dividers were of 75 cm width and1 m height. The table and dividers were 2.5 m from a projection screen and this screen was 1m x 1m so that the participants could see it. There were chairs for each participant and experimenters. There was one laptop with Excel© to record the participants` choices, individual and cultural consequences, and a projector to show the sheet to the participants.

The task involved the choice by each participant of a red or green card on each trial. Each card was 14.85 cm length, 21 cm width.

Procedure

At the beginning each participant read and signed the informed consent which presented the general information and objectives about the task. By participating in the research the students could receive up to 5 points out of 100 in a class from the Basic Psychological Processes Department. Each hour of participation resulted in 0.5 points.

At the end of the experiment the individual and group points were exchanged for lottery tickets for a US$ 25.00 prize (R$ 40.00). The proportion was 100 points per ticket. Each participant had tickets of one specific color and the group ticket was of a different color. If one of the individual tickets was drawn, the participant associated with the ticket received the amount. If a group ticket was drawn the amount was equally divided among the 4 participants.

The 8 participants were divided in two groups: one with no communication (GNV) and one with short periods of communication (GV). In each session there were 4 participants and 3 experimenters. The participants did not see each other until the end of the experiment.

The instructions were given by the experimenters and each participant had a printed copy in front of them. The following general instruction was given:

> "You will participate in a study of learning in group. It is very important that you don't know each other, please don't try to discover the others. You will be asked to choose between 2 colored cards. Depending on the combinations of cards chosen you will receive different numbers of points and sometimes you will also receive points for the group which will be shared at the end of the study. Please don't talk to each other. Thank you."

For the GV group, the last sentence was changed for: "Please talk to each other only when the experimenters say that you can."

The following features of the game were used:

1. INPDG with 4 members.
2. Cultural consequence on a VR 2 schedule (the cultural consequence was presented on average every 2 trials).
3. The participants of the GV group could talk to each other for periods of two minutes between conditions.
4. In the first condition (Baseline) there was no cultural consequence and no communication for all groups.
5. The choices were simultaneous:

"*Please make your choice and pick one of the cards."*

6. The players saw the pay off for all group members. This research used equations to calculate the individual consequence (Yi & Rachlin, 2004).

$$(1)\ R = 4\ x\ Z \qquad (2) G = R + 7$$

Equation 1 calculates the individual consequence of players who picked the red card. R is the number of points received by the players who picked Red and Z is the number of players who picked Red. Thus, the participant who chooses Red will receive 12 points if 3 participants choose this option. Equation 2 shows G as the number of points received by players who picked Green and it is always 7 points more than the number of points received by the participants who picked Red. Thus, the participant who chooses Green will receive 19 points if all the other three participants choose Red. All the combinations, individual consequences, aggregate product (sum of individual points) and cultural consequences by condition are shown in Table 1.

There were 3 conditions and the sequence of presentation of the conditions was not the same for both groups. It depended on whether or not the group achieved the stability criterion in a particular condition and the number of trials the group took to achieve it. The stability criterion was the presentation of combinations that produced positive cultural consequence in 5 consecutive trials from a block of ten trials or in 60 trials in the same condition.

The conditions were:

Condition A –20 trials with no cultural consequence, only the INPDG with four members and individual consequences as calculated by the equations. This condition was used to evaluate patterns of combinations (IBCs) before the cultural consequence was implemented and it was used to determine the next condition. If there were combinations with at least 3 Reds, the next condition would be Condition B and if there were 3 or 4 Greens the following condition would be Condition C. This strategy was used to strengthen the target combinations and make it easier for the groups to contact the cultural consequence.

Condition B –Minimum of 10 trials. This condition lasted until the achievement of the stability criterion or until the 60th trial, whichever occurred first. In this condition there was a cultural consequence, called Market feedback, on a VR 2 schedule. This cultural consequence was positive if 3 participants had chosen red – RRRG (addition of 36 points to the group) or if 4 participants had chosen red – RRRR (addition of 60 points to the group). Thus, if in a trial with a programmed cultural consequence the combination of choices was RRRG, the Market feedback would be 36; and if it was RRRR, the Market feedback would be 60 points. There were also cultural consequences with subtraction of points from the group for the combinations RGGG (-36 points) and GGGG (-60 points). For the combination RRGG there was not any cultural consequence programmed.

Condition C- In this condition the target IBCs was inverted. Thus, the addition of points to the group by the Market was contingent on IBC combinations RGGG (addition of 36 points) and GGGG (addition of 60 points) and the subtraction of points was contingent on IBC combinations RRRG (subtraction of 36 points) and RRRR (subtraction of 60 points). The same criterion was used for the end of this condition (see Table 1).

Table 1 shows the combinations (IBCs) in the first column, the individual consequences based on the combinations in the second column, the aggregate product (the sum of individual consequences) in the third column and the cultural consequence in the fourth column.

Table1

Points received by the participants (individual points) and by the group (cultural consequence) in Conditions A, B and C according to the combinations of choices (IBCs).

Combinations of Choices	Individual	Aggregate	Cultural Consequence	
(IBCs)	Points	Product	Condition B	Condition C
RRRR	16/16/16/16	64	60	-60
RRRG	12/12/12/19	55	36	-36
RRGG	8/8/15/15	46	0	0
RGGG	4/11/11/11	37	-36	36
GGGG	7/7/7/7	28	-60	60

Results

Figure 1 shows the molecular distributions of aggregate products on the y-axis. Each aggregate product stands for a specific IBC as Table 1 shows. The experimental conditions are shown on the x-axis at the exact sequence presented in the experiment. In Condition B, the IBC RRRG (aggregate product = 55) produced 36 points and

the IBC RRRR (aggregate product = 64) produced 60 points. In Condition C, the IBC RGGG (aggregate product = 37) produced 36 points and the IBC GGGG (aggregate product = 28) produced 60 points. These combinations were the target IBCs.

It is possible to see that the GNV group (with no communication) shows more variability of IBCs. This group received more positive cultural consequences of 36 points in Condition C because one of the participants chose Green all the time. In the second and third sessions (third A – x-axis) the participants in the GNV group started to present the combination GGGG in Condition C and RRRG in Condition B. In the last session of this group (when communication was allowed – seventh A – x-axis) the most frequent IBCs and aggregate product were those which produced the highest number of points for the group. These data show the role of verbal behavior in the coordination of choices.

However, it is not possible to say that the verbal behavior was required for coordination since three participants from the GNV group coordinated their choices in a way that produced positive cultural consequences before communication was allowed. Furthermore, in the GV group (with constant communication) some participants chose Green in Condition A (without cultural consequence) even though this wasn`t a good option to optimize the individual points.

These data suggest that the coordination is an effect of the interaction between cultural consequences and communication. However, the cultural consequence alone was enough to produce some degree of coordination. In the group with communication the changing of IBCs was faster, avoiding losses of cultural consequences and quickly responding in accordance with the new condition. The more persistent pattern emitted by this group was GGGG (aggregate product = 28) in Condition C and RRRR (aggregate product = 64) in Condition B.

When the cultural consequence was withdrawn for the GNV group (second, fourth and sixth presentations of Condition A) there were still choices in Green, even after Condition B.

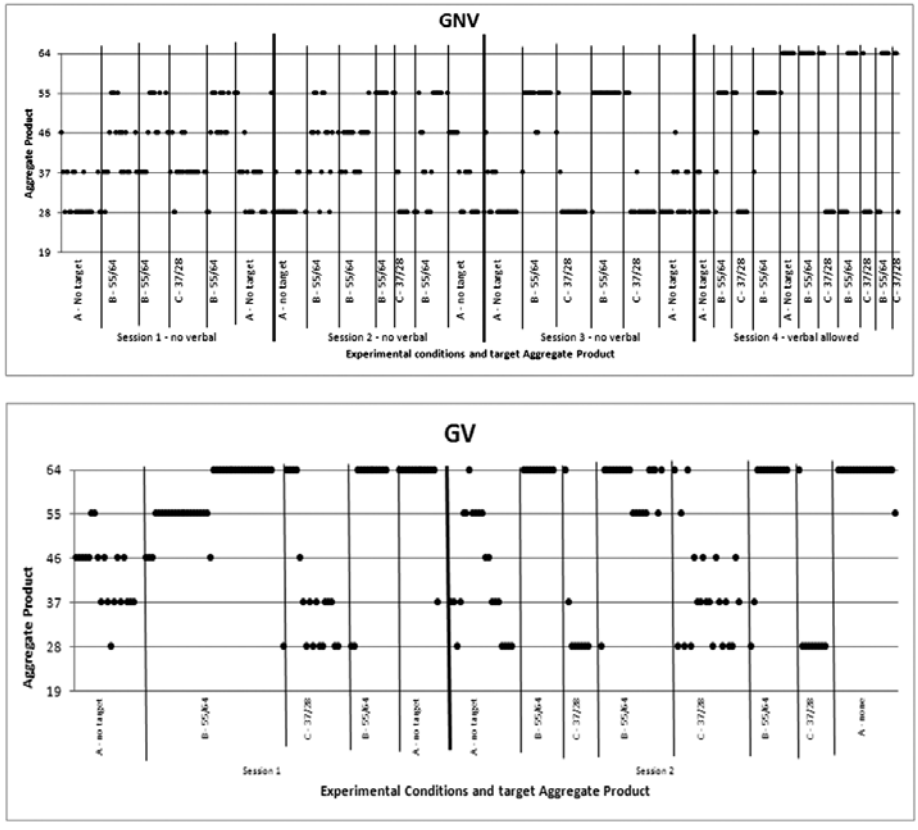

Figure 1. Aggregate products by trials in all experimental conditions.The value of the aggregate product is positively related to the number of Reds in a combination. Thus, when the aggregate product was 64, that means that all participants chose Red (64 = RRRR; 55 = RRRG; 46 = RRGG; 37 = RGGG and 28 = GGGG)

In the last presentation of Condition A for the GNV group (eighth presentation of Condition A, with communication) and in the last two presentations of Condition A for the GV group, the most frequent IBCs were RRRG and RRRR.

Figure 2 shows the relative distribution of IBCs on the y-axis and the experimental conditions on the x-axis. With the exception of the first three conditions in the first session of the GNV group, the most frequent IBCs were those which produced positive cultural consequence - GGGG and GGGR in Condition C; RRRR and RRRG in Condition B. It is possible to notice that in the GNV group the most frequent combination was the target IBC with three equal choices, while in the GV group and in the fourth condition of the GNV group the most frequent combinations were GGGG or RRRR. Approximately 70% of the IBCs were those which produced positive cultural consequence.

Figure 3 presents the molar earnings received from the Market until the end of the experiment. It is possible to notice that both groups have the same graph shape, with a higher percentage of positive cultural consequences in the GNV group (?) (68% in the GV group and 88% in the GNV group). The negative cultural consequence was the second highest bar. It is possible that the negative cultural consequence functioned as a discriminative stimulus for changing the IBCs because it produced losses for the group. The lower bar represents no cultural earnings or losses. It is noteworthy that in the GNV group the most frequent cultural consequence was 36 points for combinations with three equal choices, while in the GV group and the fourth session of the GNV group the most frequent cultural consequence was 60 points.

Discussion

More research is needed to support theoretical assertions in the field of metacontingencies. Skinner (1984) suggested a third level of selection where a consequence for the group selects interactions between members of groups rather than individual responses. Glenn (1986, 1988, 1989, 1991, 2004) presents the concept of a cultural consequence that is able to select interaction patterns that are replicated within and between generations.

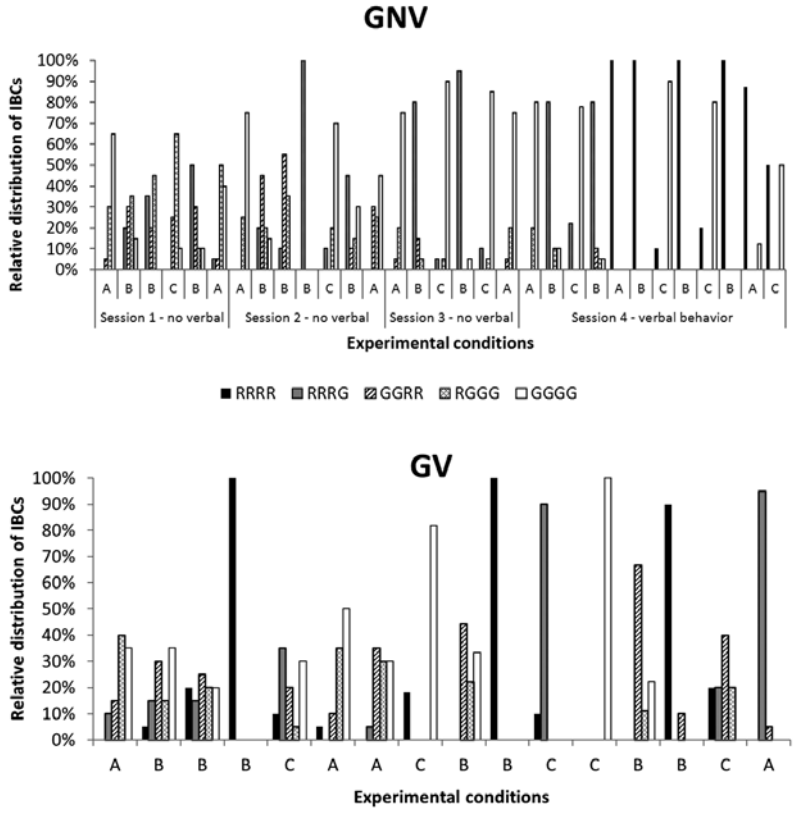

Figure 2. Relative distribution of the IBCs by condition. The frequencies of the IBCs were divided by the number of trials in each condition.

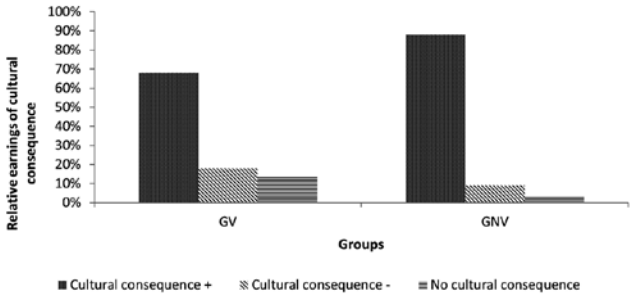

Figure 3. Molar distribution of cultural consequences

The goal of this experiment was initially to determine whether a cultural consequence could select interlocking behavioral contingencies patterns (IBCs) in an Iterated n-players Prisoner's dilemma game (INPDG). This game was chosen because of its feature of having concurrent choices where one choice produces more individual points than the other. However, the other choice produces more points for the group if all participants choose this option.

The data suggest that the cultural consequence selected combinations of choices (called here IBCs) even with the participants not seeing each other or communicating (GNV group). The cultural consequence was a coordinator choice to produce the target IBC and aggregate product that generated positive cultural consequences and avoided negative cultural consequences. These data are consistent with results of other experiments showing that cultural consequences can select IBCs, even though the coordinated pattern that is selected is disadvantagous for the individual (Ortu et al., 2008; Vichi , Andery & Glenn, 2009; Nogueira, 2009, 2010). In this experiment this situation was represented by Condition C in which to produce the biggest magnitude of cultural consequence (60 points for the group) the participants had to receive a small number of individual points (7 points).

However, the GV group and the fourth session of the GNV group suggest that the verbal behavior also functions to accelerate frequency of the target IBCs as well as producing fast change of the IBCs in accordance with changes in the experimental conditions.

Dugatkin and Reeve (1998) define communication as the relationship between the responses or clues emitted by an organism influencing the behavior of another organism. Those authors do not refer to verbal or vocal language but the interaction between the responses of two organisms. The same happens to the definition of IBCs. Two experienced fishermen who fish together do not need to vocally request a response from the other. Their nonverbal responses are enough to evoke responses that generate a cultural consequence. One fisherman pulling strongly a fishing rod is a discriminative stimulus for the other fisherman to help the first one pull in the fish.

Animal signs serve to facilitate and coordinate social interactions. These signs may relate to the external environment or to the social environment of specific groups (Dugatkin & Reeve, 1998; Maynard Smith, 1982). This confirms the previous assertion, but it describes a function of communication that had not been reported, that is, describing the individual and group contingencies. Likewise, none of the authors speak of linguistic behavior, but information exchange. When in danger, some animals position themselves or emit grunts under control of imminent danger in the external environment, which evokes responses of other group members to flee or protect them in a safe environment.

Specifically in the case of human animals both functions can be attributed to verbal behavior. Participants in the GV group and the fourth session of the GNV group accurately described the individual contingency and metacontingency in place. Even when the condition changes, the participants of the GV group choose in agreement with the description rather than the new condition metacontingency. The GV Group presents an interesting data in the fourth presentation of Condition B. One of the participants suggested that three participants should choose the red card and one participant should choose the green card in every trial and that they should alternate who would choose the green card, which offers the highest amount of individual points. This happened for 6 consecutive trials until another participant realized this was not the best strategy for getting more points and proved it to the others.

These data are consistent with experiments in the field of rule-governed behavior where the participants follow the rule even when the rule is inaccurate (Fonseca, 2008; Galizio, 1979, Ribes & Rodriguez, 2001; Rosenfarb et al., 1992) as well as with experiments in the field of cultural practices that use communication and analyze the verbal interactions of the participants showing the same effect (Baum et al, 2004; Baia, 2008, Leite, 2009). In these studies, it was noted that participants followed the rules

even if they were inaccurate, especially a type of rule called mythological which suggests a response without describing the contingency.

Finally, the interaction of the coordinating role of the cultural consequence and verbal behavior observed in this study was replicated by Nogueira (2009) showing that in groups in which the communication was allowed the proportion of IBCs that produced positive cultural consequences was higher than in groups without communication.

For future research on the role of verbal behavior in metacontingencies, we suggest manipulation of two types of individual consequences as well as a general and constant cultural consequence. Individual consequences would include those contingent on the verbal description of the participant`s future responses and those contingent on the responses themselves, similar to an experiment of correspondence say-do /do-say. The experiment would be a replication of this study. The question is whether there is functional independence between verbal and nonverbal behavior in metacontingencies. In each condition there would be two minor conditions, in which the first individual consequence would be for the participants` performance and the second one for their report of their individual performance. Sometimes the positive consequence would be contingent on an accurate report of their performance and sometimes on an inaccurate report. In another condition the target verbal report would be an accurate or inaccurate report emitted by the group. This suggestion follows the logic of say-do correspondence experiments as in Catania, Mathews and Shimoff (1982) and Torgrud and Holborn (1990).

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