Revista Mexicana de Análisis de la Conducta
ISSN: 0185-4534
ISSN: 2007-0802
editor@rmac-mx.org
Sociedad Mexicana de Análisis de la Conducta
México

Sampaio, Angelo Augusto Silva

Verbal interaction promotes cooperation in an iterated prisoner's dilemma game: a multiple baseline metacontingency experiment

Revista Mexicana de Análisis de la Conducta, vol. 46, no. 2, 2020, July-, pp. 259-292
Sociedad Mexicana de Análisis de la Conducta
México

DOI: https://doi.org/10.5514/rmac.v46.i2.77883

Revista Mexicana de Análisis de la Conducta • Mexican Journal of Behavior Analysis
2020 | Núm. 2 • Diciembre | No. 2 • December | Vol. 46, 259 - 292
http://dx.doi.org/10.5514/rmac.v46.i2.77883

VERBAL INTERACTION PROMOTES COOPERATION IN AN ITERATED PRISONER'S DILEMMA GAME: A MULTIPLE BASELINE METACONTINGENCY EXPERIMENT

LA INTERACCIÓN VERBAL PROMUEVE LA COOPERACIÓN EN EL JUEGO DEL DILEMA DEL PRISIONERO ITERADO: UN EXPERIMENTO SOBRE METACONTINGENCIAS CON MÚLTIPLES LÍNEAS DE BASE

Angelo Augusto Silva Sampaio[1]
Universidade Federal do Vale do São Francisco and Universidade de São Paulo

---

1. Angelo A. S. Sampaio, Colegiado de Psicologia, Universidade Federal do Vale do São Francisco, and Instituto de Psicologia, University of São Paulo. https://orcid.org/0000-0001-7154-0862.
This research was part of the author's doctoral thesis presented to the University of São Paulo, with Marcelo Frota Lobato Benvenuti as advisor. The present work was funded by a doctoral scholarship from CNPq, Conselho Nacional de Desenvolvimento Científico e Tecnológico—Brazil, and by grants 2008/57705-8 from FAPESP and 573972/2008-7from CNPq to Instituto Nacional de Ciência e Tecnologia sobre Comportamento, Cognição e Ensino (INCT-ECCE). The data were presented at the 42th Annual Convention of the Association for Behavior Analysis International in Chicago, IL, in May 2016. The author wishes to thank: Thomas Woelz for programming the software used to collect data and for all the help with its usage; Carla Suarez, César Nascimento, Cíntia Corrêa and Natália Marques for assistance with data collection; the participants of the study, without whom this work could not have been possible; and Fábio Baia for comments on previous versions of the text.
Correspondence concerning this article should be addressed to Angelo A. S. Sampaio, Universidade Federal do Vale do São Francisco, Av. José de Sá Maniçoba, Centro, Petrolina - PE, Brazil 56304-917. E-mail: angelo.sampaio@univasf.edu.br. Telephone: +55 (87) 2101-6868.

Abstract

Some metacontingency experiments were based on cooperation procedures such as the iterated prisoner's dilemma game (IPDG), but dismissed earlier results on cooperation as pertaining only to operant (not cultural) selection and did not control verbal interactions among participants. The present study evaluated the effects of verbal interactions on participants' choices in an IPDG. Three sets of four university students played in four networked computers (screened by panels) and were exposed to conditions with or without permission to use a virtual chat room in a multiple baseline design. Without verbal interaction, choices varied, but tended to be all-defect. Once verbal interaction was allowed, choices quickly shifted and stabilized in all-cooperate on almost all trials. An IPDG can be interpreted as programming a metacontingency in which the higher payoff for the group (a cultural consequence) selects participants' choices of the cooperative alternative (a culturant). As the cooperation literature had similarly found, verbal interactions among participants even through virtual chat room promotes the selection by the higher payoff. Metacontingency and cooperation procedures such as the IPDG are indistinguishable and their results must be evaluated together.

Keywords: Cooperation, Cultural Selection, Metacontingency, Communication, Rule-Governed Behavior.

Resumen

Algunos experimentos sobre metacontingencia se han basado en procedimientos de cooperación como el juego del dilema del prisionero iterado (IPDG), pero descartaron resultados anteriores sobre cooperación como pertenecientes únicamente a la selección operante (no cultural) y no controlaban las interacciones verbales entre los participantes. El presente estudio evaluó los efectos de las interacciones verbales en las elecciones de los participantes en un IPDG. Tres grupos de cuatro estudiantes universitarios jugaron un IPDG en cuatro computadoras en red (apartados por paneles), y estuvieron expuestos a condiciones con o sin permiso para usar una sala de chat virtual en un diseño de múltiples líneas de base. Sin interacción verbal, las opciones variaban pero tendían a ser todos eligiendo traición. Una vez que se permitió la interacción verbal, las opciones cambiaron rápidamente y se estabilizaron en todos eligiendo cooperar en casi todas las tentativas. Un IPDG puede interpretarse como la programación de una metacontingencia en la que la recompensa más alta para el grupo (una consecuencia cultural) selecciona las elecciones de los participantes de la alternativa cooperativa (un culturante). Como la literatura de cooperación había encontrado de manera similar, las interacciones verbales entre los participantes, incluso a través de la sala de chat virtual, promueven la selección por la mayor recompensa. Los procedimientos de metacontingencia y cooperación como el IPDG son indistinguibles y sus resultados deben evaluarse juntos.

Palabras clave: cooperación, selección cultural, metacontingencia, comunicación, comportamiento gobernado por reglas.

Programming an operant contingency[2] involves scheduling an environmental change (e.g., the presentation or removal of a stimulus) depending on the occurrence of a response of a single organism (Mechner, 2008; Skinner, 1969; Todorov, 1991). For instance, removing a difficult task demand depending on the occurrence of a child's verbal response (request). The effects of scheduling an operant contingency can be interpreted as the selection of a response class (i.e., an operant) by its consequences (Catania, 2007; Skinner, 1981). Increases in the rate of requests by the child can be interpreted as the selection of this operant by the removal of the difficult task. When programming an operant contingency or assessing its effects, one employs a unit of analysis (the operant) pertaining to a single individual.

2. Also termed R-S contingency, behavioral contingency or individual contingency.

The concept of metacontingency, by its turn, addresses a dependency relation between interrelated responses *of more than one individual* and a common consequence (Glenn, 1986; Glenn et al., 2016). In that sense, programming a metacontingency involves scheduling an environmental change depending on the occurrence of responses from more than one organism (Baia & Sampaio, 2019). The two basic elements of a metacontingency are a culturant and a selecting consequence (Glenn et al.). A culturant involves interlocking behavioral contingencies (IBC), the recurring responses from one individual that produces stimuli (antecedent or consequences) for another individual and can be measured by their aggregate product (AP), that is, an outcome that depends on more than one individual. A culturant is viewed as analogous to the response class in an operant contingency. Contingent modifications on the environment that are able to modify those culturants are viewed as selecting consequences – analogous to the consequences in an operant contingency. To distinguish between consequences in operant contingencies and consequences in metacontingencies, the later has sometimes been called *cultural* consequences (e.g., Baia & Sampaio; Vichi et al., 2009). One example of a metacontingency is the assembling of a puzzle by three friends (IBC) resulting in a completed puzzle (that functions simultaneously as AP and cultural consequence) (Glenn et al.). The effects of programming a metacontingency can be interpreted as the selection of interrelated responses of more than one individual—a kind of *cultural* selection. When programming a metacontingency or assessing its effects, one employs a unit of analysis (the culturant) pertaining to multiple individuals—a supraindividual unit of analysis. Note that a culturant is not an arbitrary collection of otherwise isolated responses, but a functional unit composed of responses from multiple individuals that depend on one another to be emitted, and that are jointly controlled by a selecting consequence.

Metacontingency terminology may be somewhat recent, but the phenomena involved have been studied for quite some time in cooperation studies. Indeed, Hunter (2012) discussed the pioneer cooperation experiment conducted by Azrin and Lindsley (1956) as a metacontingency arrangement. Azrin and Lindsley defined cooperation as nearly simultaneous and coordinated responses by two children that sat by a table facing each other and chose to insert a stylus into one of three holes (IBC), measured by a circuit closure (AP). In some experimental conditions, cooperation produced a single jellybean presented to both children (cultural consequence), what increased and maintained the coordinated responses (culturant). Another cooperation task described by Hunter as a metacontingency arrangement was the one developed by Schmitt and Marwell (1968), in which pairs of undergraduate students could pull plungers. If both plungers were pulled within 3.0 s to 3.5 s apart from each other (IBC), a circuit closure (AP) produced one penny to each participant (cultural consequence). This task was very similar to the one employed in the more than 30 experiments that Marwell and Schmitt (1975) conducted and analyzed with what they called a molar approach, that is, treating "*pairs* of individuals (groups), not the individuals themselves, as our units of analysis." (p. xii)

Many metacontingency experiments tried to disentangle operant and cultural selection employing different experimental tasks (e.g., Guimarães et al., 2019; Saconatto & Andery, 2013; Smith et al., 2011; Toledo et al., 2015). Interestingly, some of these experiments (Costa et al., 2012; Hunter, 2012; Morford & Cihon, 2013; Ortu et al. 2012) employed tasks based on the prisoner's dilemma (PD)—a methodological strategy that has been used for decades in cooperation studies (Marwell & Schmitt, 1972; Rapoport & Chammah, 1965; Sally, 1995). The PD is a mathematical model employed in Game Theory to represent certain reciprocal interactions among agents (individuals, groups, organizations, countries etc.; Poundstone, 1993; Rasmusen, 2007). First applied in Economics, this model's name derives from a fictitious situation in which two individuals are arrested, but without conclusive evidence. The police isolate the prisoners in separate rooms and offers both the chance to confess and turn state's evidence, thus reducing the time that each would likely be sentenced to (e.g., 7 years). Prisoners cannot communicate and the sentence for each will depend on the choices of both. Each prisoner can accept the offer (defect) or not (cooperate with the other prisoner). If both cooperate, the two will have a 4-years reduction in sentence; if both defect, their sentences will be reduced in just 3 years; and if just one defects, the accused will have no sentence reduction while the defector will have a 7-years reduction and be set free (Table 1). Regardless of what the other prisoner chooses, defecting is always more advantageous than cooperating. However, both know all the possible results and that if both defect, they will produce a poor payoff. On the other hand, mutual cooperation produces a good result, however, if one prisoner cooperates, he/she risks obtaining no payoff in case the other defects[3].

Table 1

A Prisoner's Dilemma Payoff Matrix

		Prisoner B	
		Cooperate	**Defect**
Prisoner A	Cooperate	4 (upper right) / 4 (lower left)	7 (upper right) / 0 (lower left)
	Defect	0 (upper right) / 7 (lower left)	3 (upper right) / 3 (lower left)

Note. Each prisoner can defect or cooperate with the other. The combination of their choices determines how many years will be removed from both sentences. In the matrix's split cells, lower left sections present Prisoner A's sentence reduction and upper right sections present Prisoner B's sentence reduction.

3. The specific values of each possible payoff in a PD can vary. According to Axelrod and Hamilton (1981), Rapoport and Chammah (1965, chap. 1) and Szilagyi (2003), a PD is defined by two conditions that express the relationships between the agents' payoffs: (a) the payoff for defection given that the other cooperates (e.g., 7-years sentence reduction) is larger than the payoff for cooperation given the other cooperates (e.g., 4-years reduction), which in turn is larger than the payoff for defection given the defection of the other (e.g., 3-years reduction), and this, finally, is larger than the payoff for cooperating given the other defects (e.g., no sentence reduction) in other terms: $D|C > C|C > D|D > C|D$; and (b) the payoff for cooperating given the other cooperates is greater than half the sum of the payoffs for cooperating given a defection and for defecting given a cooperation in other terms: $C|C > [C|D + D|C] / 2$. Any situation in which two agents interacting can produce payoffs that meet these conditions can be called a PD.

The classic experimental procedure for studying the PD follows the fictional situation after which the dilemma was named: (a) two individuals, (b) without communication and (c) without knowledge of the choice of the other, (d) make a single choice. In experiments with human participants, the payoffs are usually points exchanged for money. Experiments using the PD, however, have manipulated (a) the number of participants, (b) the possibility of communication, (c) access to the choices of others, (d) the repetition of choices, among several other variables (*see* reviews by Balliet, 2010; Bicchieri & Lev-On, 2007; Chaudhuri, 2011; Dawes, 1980; Sally, 1995). When choices in a PD are repeated, we have an *iterated prisoner's dilemma game* (IPDG).

Ortu et al. (2012) conducted the first experimental study with an IPDG-based task employing metacontingency terminology. They aimed to distinguish the effects of metacontingencies from those produced by what would be operant contingencies and to determine the necessary conditions for metacontingencies to control culturants. In each of five experiments, a distinct set of four undergraduate students (quartet) worked simultaneously on computers connected in a network, without visual contact between them, but with the possibility of exchanging written messages through a virtual chat room. Participants were asked, at each trial, to click on one of two "buttons" on the computer screen (designated as X, the cooperation alternative, or Y, the defection alternative) to receive points exchanged for money. In baseline conditions—interpreted by Ortu et al. as involving only operant contingencies—participants played an IPDG in which cooperating (clicking on X) produced "the number of participants cooperating on the trial" times 4 points; and defecting (clicking on Y) produced "the number of participants cooperating on the trial" times 4, *plus* 7 points (*see* Table 2, two leftmost columns).

Table 2

Combinations of Choices, IPDG Payoffs, Cultural Consequences and Total Points on the Trial in Ortu et al.'s (2012) Study

Choices	IPDG Payoffs	Cultural Consequence (*and Total Points on the Trial*)			
		All-Cooperate Condition		All-Defect Condition	
		Points	Total	Points	Total
XXXX	X = 16	+10	X=26	-10	X=6
XXXY XXYX XYXX YXXX	X = 12, Y = 19	0	X = 12, Y = 19	-7	X = 5, Y = 12
XXYY XYXY YXXY XYYX YXYX YYXX	X = 8, Y = 15	-4	X = 4, Y = 11	-4	X = 4, Y = 11
XYYY YYXY YXYY YYYX	X = 4, Y = 11	-7	X = -3, Y = 4	0	X = 4, Y = 11
YYYY	Y = 7	-10	Y = -3	+10	Y = 17

Note. The first row presents a trial in which all participants choose X (cooperate); the second row, one in which only one participant chooses Y (defect); and so forth. The IPDG Payoffs are the points each participant choosing X or Y earned on a trial with the choices at the left. The same values were employed in the present experiment. Cultural consequences (termed market feedbacks by Ortu et al., 2012) and total points on the trial are displayed for Ortu et al.'s (2012) conditions with feedback market maximum set at 10 points.

Ortu et al. (2012) maintained this IPDG in effect throughout their whole study. But in the experimental conditions, in addition to the IPDG, there were also consequences called market feedback: a same amount of points (positive, negative or zero) presented to all participants and which depended on the number of participants who cooperated on the trial. For instance, in an All-Cooperate experimental condition (termed XXXX by Ortu et al.): If all participants chose X, each would earn 10 more points; if no participant chose X, 10 points were subtracted from each; if one, two or three participants chose X, they all received feedback with intermediate values (*see* Table 2, third column from the left). In the All-Defect experimental condition (termed YYYY by Ortu et al.), consequences were reversed, with the addition of 10 points if no one chose X, the subtraction of 10 points if everyone chose X etc. (*see* Table 2, fifth column from the left). The magnitude of the market's feedback was manipulated in some experiments by changing its maximum value. In the previous example, the maximum value was 10 points. Ortu et al. interpreted the scheduling of the market feedback as a metacontingency.

On the experimental conditions' trials, thus, participants earned points from both IPDG payoff and market feedback. Note that, while many metacontingency experiments (e.g., Franceschini et al., 2012; Smith et al., 2011; Vasconcelos & Todorov, 2015; Vichi et al., 2009) solely programmed one metacontingency, Ortu et al. (2012) superimposed the manipulated metacontingency—the dependency relation between the number of cooperating participants and the market feedback value—to an IPDG constantly in place[4].

Ortu et al. (2012) included baseline conditions in the beginning and end of all their experiments, except Experiment 1. One of the stated purposes of introducing baseline conditions was to assess if the IPDG alone would produce consistent choices by the participants. Baselines were terminated "according to the experimenter's judgment of stability" (Ortu et al., 2012, p. 117). Results showed that cooperative choices tended to increase in the initial baselines of Experiments 2, 3, 4 and 5, and were quite frequent in the final baselines of Experiment 5 and, in some extent, Experiments 2, 3 and 4, but all-cooperate

4. If one considers the total points per trial earned by each participant (*see* Table 2, fourth and sixth columns from the left), most of the experimental conditions by Ortu et al. (2012) does not meet the criteria that define a PD. We could say that the market feedback alters participants' earnings in such a way as to "solve" the dilemma. This applies to all experimental conditions with maximum market feedback greater than or equal to 5. When the maximum is 4 (e.g., in Ortu et al.'s Experiment 5), total points represent a PD only in the All-Defect Condition. With maximum values less than or equal to 3 (e.g., in Ortu et al.'s Experiment 5), total points always constitute a PD.

(XXXX) choices frequency was not as high as on the final trials of All-Cooperate experimental conditions.

Ortu et al. (2012) concluded that their five experiments "demonstrate a distinction between operant contingencies, which affect the behaviour of individuals, and metacontingencies, which affect interlocking behavioral contingencies in which multiple individuals participate." (p. 120) The operant contingencies they refer to are "the individual contingencies embedded in the [IPDG] game itself" (p. 118). Ortu et al. support this interpretation of an IPDG as involving only operant contingencies by referring to results from previous studies and comparing their own baseline and experimental conditions results:

> the findings of previous studies using prisoners' dilemma game are general to our setup; the individual contingencies embedded in the game itself do not reliably produce either XXXX or YYYY [all-cooperate or all-defect choices]. The reliable production of these products under conditions of market feedback show that patterns unlikely to proceed from individual interactions alone can be produced through the application of a cultural consequence. (Ortu et al., 2012, p. 118)

However, another interpretation of the contingencies involved in their IPDG baseline condition is possible. Firstly, the points produced by each participant in an IPDG depend not only on their own choice, but also on the choices of the other participants. For instance, one participant may repeatedly choose the same option (e.g., Y, i.e., defection), but produce different payoffs depending on the other participants' choices (e.g., 7, 11, 15 or 19 cents, as depicted in Table 2). As Ortu et al. recognized, in their study the payoffs are "interdependent consequences" (Schmitt, 1998 cited by Ortu et al., 2012, pp. 113, 114).[5] So the magnitude of the consequence presented for a participant's response also depends on the responses of other participants—constituting, therefore, IBC. Secondly, when choices are iterated and participants can communicate with each other, previous choices and verbal stimuli

5. According to Schmitt (1998), interdependent consequences are those that depend on the behavior of another individual. Some social behaviors involving such consequences are cooperation, competition and exchange.

produced by other participants may function as antecedents or consequences for the following choices—another way in which operant contingencies can interlock in this situation. Finally, the total cents produced by a quartet on a trial varies depending on the quartet's choices (in Ortu et al.'s study, between 28 and 64 points). Since this value depends on the responses of more than one individual and can affect them, it can constitute a cultural consequence. In short, an IPDG like the one programmed by Ortu et al. involves IBC and cultural consequences and can be interpreted as a metacontingency.

In this experimental situation, the systematic production of all-cooperate choices—the combination of choices producing the highest total points per trial—would be an evidence that this consequence affects the quartet's choices. Despite Ortu et al. (2012) claiming an IPDG do not reliably produce all-cooperate choices, innumerous studies included in reviews of the IPDG experimental literature attest to that possibility (Balliet, 2010; Bicchieri & Lev-On, 2007; Chaudhuri, 2011; Dawes, 1980; Sally, 1995). These reviews point out that many parameters are relevant to the production of cooperative choices: iterated choices, group size, payoff matrix, detailed experimental instructions etc. One of these variables that greatly contributes to the production of cooperative choices in PD is communication (or verbal interaction) among participants. The meta-analyses by Balliet (2010) and Sally (1995) and the review by Bicchieri and Lev-On (2007) exemplify the vast PD experimental literature that demonstrated the facilitating effect of communication on cooperation. This communication effect has been predominantly studied in face-to-face interactions, but experiments that employed computer-mediated communication or texting also found more cooperation in these conditions compared to no communication conditions (Balliet, 2010; Bicchieri & Lev-On, 2007). Thus, the verbal interaction through virtual chat room in Ortu et al.'s (2012) study, can be a critical variable for the production of unanimous cooperation.

In fact, participants interacting verbally introduce a whole range of antecedents and consequences potentially relevant to the responses emitted during the task. A participant can, for example, reinforce or punish with verbal stimuli the behavior of another participant, can describe the contingencies in force or issue various types of instructions that affect the behavior of others. It is no coincidence that both the PD literature (Balliet, 2010; Bicchieri & Lev-On, 2007) and metacontingency studies (e.g., Glenn, 1989; Sampaio et al., 2013; Smith et al., 2011) emphasize the relevance of this variable.

Thus, the present study evaluated whether an IPDG can produce unanimous cooperation (all-cooperate choices) and what are the effects of verbal interaction on this cooperation. Its first specific objective was to answer if the IPDG programmed by Ortu et al. (2012) is, as stated by these authors, unable to reliably produce unanimous cooperation (X choices only). Given the results of other IPDG experiments and its interpretation as a metacontingency, the hypothesis was that that statement would not be sustained. To answer this question, quartets of participants were exposed to the same IPDG as Ortu et al., without any manipulation of gains or superimposed market feedback. In addition, considering the evidence of how verbal interaction between participants can affect cooperation, the present study also sought to evaluate the effects of verbal interaction on choices in an IPDG. The hypothesis regarding this objective was that verbal interaction would promote cooperation, as suggested by the experimental PD literature (Balliet, 2010; Bicchieri & Lev-On, 2007; Sally, 1995). Considering the possibility of verbal interaction having an irreversible effect in the short time of a single experimental session (Bicchieri & Lev-On, 2007), the present study exposed each quartet to one condition without and one condition with verbal interaction. In order to assess the effects of the number of trials before the start of verbal interactions, it varied this number among quartets—employing therefore a non-concurrent multiple baseline design between quartets to assess the effects of verbal interaction.

Method

Participants

Thirteen male and three female graduate or undergraduate students from varied courses (not Psychology) at the University of São Paulo, with ages between 19 and 40 years (M = 24.4; SD = 5.0), were recruited through posters on campus and messages in a social network. They were asked to participate in a "decision-making" study and informed that they could earn around R$ 10. They were grouped into four quartets according to their schedule availability. Participants in each quartet were not acquaintances. The study was previously approved by an Institutional Review Board and before the experimental session all participants signed an Informed Term of Consent. Immediately after the experimental session, quartets were debriefed and the specific objectives of the study were discussed.

Setting, Equipment and Materials

The study was conducted in a room on campus, where each participant, seated on a chair, performed the experimental task on a laptop on top of a table. Snacks and juice were available to participants at their tables, for consumption during the experimental session. The four tables of the participants were arranged side by side, leaning against the same wall of the room, screened by large panels that prevented visual contact between the participants. Behind the participants' tables, on a table with two chairs, the experimenter and a research assistant supervised data collection and manipulated in real-time the experimental conditions using another laptop. All laptops were connected in a network, running the same software used by Ortu et al. (2012) (developed by Thomas A. R. Woelz) for the presentation of experimental conditions and data recording. During the study, the experimenter filled out a paper register form to check if the previously established stability criteria for condition change were met.

Procedure

Each quartet participated in one single experimental session. Upon arriving for the session, each participant was asked to remain silent and directed to the chair in which they remained throughout the session. Participants did not see or talk to each other before or during the experimental session. After the last participant sat in front of his laptop, the experimenter read the initial instructions out loud:

> You are owners of a company. The amount of money you will make depends on how well you do during the experiment. At the end of your participation, you will earn one third of the earnings displayed at the computer. You are allowed to communicate with each other exclusively through your computers.

The first two sentences of the initial instructions were used by Ortu et al. (2012). The third sentence was included to adequate the points' value to the local currency's value and to the ethical requirements for human research in the country. The last sentence was also used by Ortu et al. but was replaced in three of the quartets by "*You cannot communicate. Use the chat room on the left only if you need to communicate with me*".

The experimental task was the same employed by Ortu et al. (2012) in their baseline conditions. At each trial, participants had 15 s to choose between clicking the letter X or letter Y displayed on the screen. A countdown timer showed the remaining time for the choice. Participants could choose in any order (e.g., anyone could be the first to choose). The choice of each participant was immediately presented on the screen to all participants (e.g., "Player 1 (X)" or "Player 1 (Y)"). When one or more participants did not choose in time, the computer made a random choice for each one, but the choice was presented to the quartet in the same way as when the participant him/herself chose. After everyone had chosen, their choices and the points won by each were visible to everyone for 4 s. IPDG points had the same values used by Ortu et al. (Table 2).

Following Ortu et al.'s (2012) procedure, during the 9 s inter-trial interval each participant screen presented three "buttons" labeled

"Kick Player [n]", each button referring to one of the other members of the quartet. Each participant could click on one of these buttons. If three participants clicked the button to remove the same participant, that participant was kicked on the next trial. The trials with one kicked player run as a 3-player IPDG, with the kicked player always receiving 0 point. The remaining three participants received 7 or 12 points if they had chosen all-defect or all-cooperate, respectively. A participant who chose to cooperate alone received 4 points, with the remaining two defecting participants receiving 11 points. When two participants cooperated, they received 8 points, and the defecting member received 15 points. If one or more participants did not click on the buttons during ITI, the next trial initiated with no differential consequences programmed.

At the left side of the screen, a virtual chat room allowed participants to send messages visible to all of them. The chat room remained active during all conditions, including when participants were not allowed to use it—in this case, the participants only used it to address the experimenter. The experimenter viewed in real time all messages sent and also responded when participants requested something (e.g., more snacks or juice).

Experimental Conditions and Design

The quartets were exposed to Ortu et al.'s (2012) baseline condition (i.e., only the IPDG points were presented, without any market feedback) in a nonconcurrent multiple baseline design across quartets in which the permission to interact through the chat room was manipulated. Quartet 1 was allowed to use the chat room throughout the entire experimental session (Chat condition). Quartet 2 was initially exposed to a condition in which they were not allowed to use the chat room (No Chat condition). When their choices had stabilized in the initial condition, they were allowed to verbally interact. Quartet 3 was only allowed to use the chat room after the number of trials required for Quartet 2's choices to stabilize in the Chat condition and after their own choices had stabilized in the No Chat condition. Quartet 4 was allowed to use the chat room after the number of trials required for Quartet 3's choices to stabilize in the Chat condition and after their own choices had stabilized in the No Chat condition. The No Chat condition was presented first because verbal interactions can produce changes in choices that are impossible to reverse in a single experimental session. To signal the permission to use the chat, the experimenter sent, through the chat room itself, the instruction (similar to that employed by Ortu et al., 2012): "From now on, you can communicate with each other exclusively through your computers."

Ortu et al. (2012) did not clearly define the criteria for finishing their baseline conditions. In the present study, all experimental conditions were finished only after stability criteria were met: in three consecutive 10-trial blocks, the percentage of all-cooperate and all-defect choices by the quartet did not successively increase or decrease (i.e., no trend) or vary more than 40% (i.e., small bounce). The 40% value was established based on the results of pilot studies. Trial blocks were not signaled to the participants. For checking the stability criteria, trials with a kicked player in which the three remaining participants choose all-X or all-Y were considered as all-cooperate or all-defect choices, respectively. During the session, in the end of each trial, the experimenter visualized the participants' choices on his own laptop and recorded in the paper register form if the quartet produced consensual choices. Each experimental session lasted a maximum of 2 h and ended after 280 trials or when choices had stabilized in the Chat condition.

Data Analyses

The percentage of all-cooperate and all-defect choices in 10-trial blocks was calculated with and without the trials that included a kicked player. No relevant differences in the overall results were found, so kicked player trials where all three remaining participants choose all-X or all-Y were considered as all-cooperate or all-defect trials, respectively. A separate analysis of the percentage of trials per block in which each participant was kicked was conducted.

The trials with one or more computer-generated random choices were also included in the percentages of all-cooperate and all-defect choices since they were rare and generally irrelevant to overall results. The frequency of trials with computer-generated random choices per trial block was calculated and is presented when relevant. The frequency of chat entries for each trial block was also calculated, and chat entries with explicit instructions directed at other participant(s) identified.

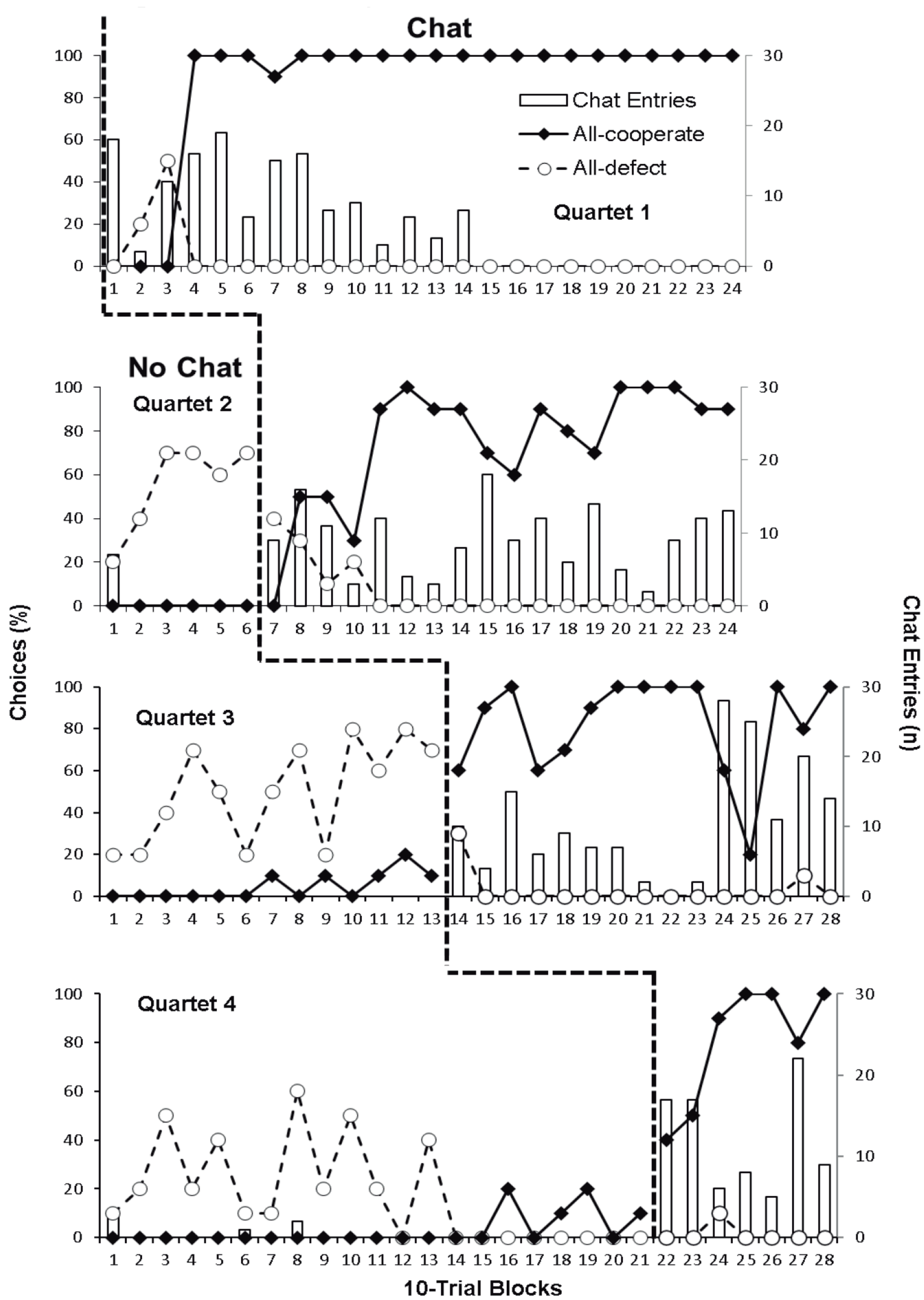
Results

Figure 1 presents the percentages of all-cooperate (all-X) and all-defect (all-Y) choices, and the frequency of chat entries, for each quartet, in 10-trial blocks. Quartet 1, allowed to interact through the chat room from the beginning, quickly started to choose all-cooperate in a near exclusive fashion, and kept responding that way until the end of the session. The first trial with all-cooperate choices was immediately preceded by an instruction from Participant 4 (on trial 30): "everybody [sic] x." This quartet stopped using the chat room starting from block 15 and was the only quartet to not interact verbally for more than one block after being allowed to do so. Quartet 1 had only four trials with a kicked participant, all of them in the initial four blocks. There were also 12 trials with computer-generated choices. On the first nine trials, Participant 2 choice time expired because he wrote his choices in the chat room instead of clicking on the button. The remaining three trials involved different participants expiring their choice time on different trial blocks.

The choices of Quartet 2 in the initial No Chat condition stabilized in 70% of all-defect and 0% of all-cooperate choices. After been allowed to verbally interact, this quartet chose all-cooperate for the first time in the second 10-trial block, immediately after Participant 6's instruction (on trial 73): "people, let's choose x everybody to see what happens". Next, Quartet 2's percentages of all-cooperate choices remained between 90% and 100%, with the exception of a drop during blocks 15 and 16, and another drop in blocks 18 and 19. Quartet 2 had 26 trials with one kicked participant—Participant 8 alone been kicked 18 times

Figure 1

Chat Entries, All-Cooperate and All-Defect Choices



Note. Percentage of all-cooperate and all-defect choices and frequency of chat entries, in 10-trial blocks, with communication via a virtual chat room allowed or not.

by his partners on nine different trial blocks. Some chat entries suggest that on most of these trials participants were trying to figure out the effect of kicking one participant on their earnings—with Participant 8's consent. There were 24 trials with computer-generated choices. Similar to Quartet 1, on the first three trials Participant 5 choice time expired because he wrote his choices in the chat room, but he also did not click on any button during the next six trials. At the end of block 15, the participants asked and discussed among themselves what would happen if one or more participants did not choose. Several trials followed in which at least one of the participants did not choose in time, causing the computer to make the choice: two attempts in block 15; three, both in blocks 16 and 17; one, in block 18; and three more, in block 19. These computer-generated random choices produced the drops in all-cooperate choices on theses trial blocks seem in Figure 1. At the end of block 19, after two participants emitted instructions for everyone to cooperate, the quartet returned to unanimous cooperative choices.

Quartet 3's choices in the No Chat condition stabilized at 70% of all-defect and 10% of all-cooperate. In the first block in the Chat condition, the percentages of all-defect and all-cooperate choices basically reversed (for respectively 30% and 60%). The first trial with all-cooperate choices was immediately preceded by Participant 12's writing "let's try everybody clicking on x…" on trial 133—to what Participant 9, at the same trial, replied "yes everybody [sic]". Next, all-cooperate choices stabilized close to 100%, while there was only one more trial with all-defect choices. The exceptions were a drop in the percentages of all-cooperate choices during blocks 17 and 18, and another drop in blocks 24 and 25. Quartet 3 had 48 trials with a kicked participant, 25 of which involved Participant 10. Until block 17, kicks were mainly concentrated in Participant 11 (with 14 kicks; Participants 9, 10 and 12 had 2, 3, and 7 kicks, respectively), but with a maximum of three times in a single block. On block 17, however, after some all-cooperate trials, Participant 10 started six consecutive defect choices. During that, on trial 173, Participant 11 wrote: "I think that [Participant 10] wants to be kicked/ Easier/ Who does different, will be kicked." Then, starting at the same trial, Participant 10 was kicked for 12 consecutive trials. On the trial in which she could choose again, Participant 10 defected once more, which led the rest of the quartet to kick her for another 10 trials in a row. After such a punishment, always accompanied by supporting verbal interactions, she resumed cooperating and no participant was kicked until the end of the session.

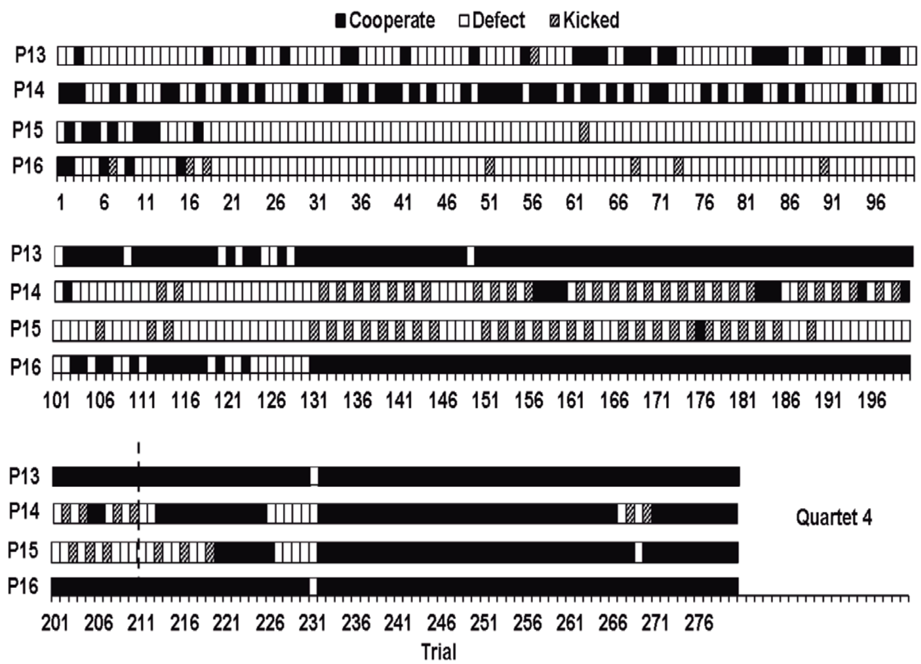
Quartet 3 also produced 21 trials with computer-generated choices. Fourteen such random choices produced the diminished all-cooperate choices in blocks 24 and 25. As in Quartet 2, verbal interactions related to what would happen if one or more participants did not choose in time preceded and followed these 14 trials. At the end of block 25, verbal interactions described the contingencies involved in not choosing and involved instructions to return to all-cooperate choices.

Quartet 4 produced between 10% and 60% of all-defect choices until block 13 and then 0% until the end of the No Chat condition. All-cooperate choices remained at 0% until block 15, then varied between 20% and 0% until the end of this first condition. The changes in choices between blocks 14 and 21 followed a pattern that can be seen in Figure 2: Participants 13 and 16 cooperated almost exclusively, while Participants 14 and 15 mostly defected and were alternately kicked. This quartet had only two trials with computer-generated choices, but a total of 80 trials with one kicked player, Participants 14 and 15 being kicked 36 times each, mostly between blocks 14 and 21. This attempt by Participants 13 and 16 to force the others to cooperate produced the first all-cooperate choices, but always with Participant 14 or 15 kicked. This strategy, however, did not led Participants 14 and 15 to cooperate systematically. Only in the Chat condition did all-cooperate choices quickly increase and stabilize at 100%, while all-defect choices remained at 0% (Figure 1). On the second trial after verbal interaction was allowed (trial 212), Participant 16 suggested "Choose X"; Participant 14 stated "Let's all choose x / Should give 16 to everyone"; to which Participant 16 replied "Yes". On the next trial (213), with Participant 15 kicked, Participant 14 began to systematically cooperate. Participant 15 continued to choose Y and to be kicked until trial 219

(Figure 2), when Participant 14 encouraged: “come on [Participant 15]”. Participant 15 replied “ok / x”. Still on trial 219, Participant 13 also encouraged him: “Try it once to see what happens”. From the next trial on, Participant 15 also began choosing X systematically.[6]

Figure 2

Trial-by-Trial Cooperate and Defect Choices in Quartet 4



Note. Trial-by-trial cooperate (X) and defect (Y) choices by the participants (P13, P14, P15 and P16) from Quartet 4. Striped squares indicate trials were the participant was kicked. The upper panel presents choices on the first 100 trials, the middle panel, on trials 101 to 200, and the lower panel, on trials 201 to 280. The vertical dashed line marks the beginning of the Chat condition, in which participants could interact through the virtual chat room.

6. Trial by trial choices and kicked players for Quartets 1, 2 and 3 are presented in Supplementary Figures S1, S2 and S3, respectively.

Discussion

The results clearly demonstrate that verbal interaction among participants rapidly promotes reliable unanimous cooperative choices in a 4-player IPDG, confirming the study's hypotheses. When not allowed to use the chat room—and regardless of the number of trials on that condition—, the quartets rarely chose to unanimously cooperate and *all four* members of a quartet never choose to cooperate on the same trial. When allowed to verbally interact, however, the percentages of all-cooperate choices stabilized in 100% or 90%. The experiment's multiple baseline design allows one to affirm that this rapid and strong effect of verbal interaction on cooperative choices is replicable between quartets and is not due to the time of exposure to the experimental task or to the No Chat condition. As the results from baseline conditions in Ortu et al.'s (2012) study suggested, but contrary to what these authors stated (p. 118), therefore, an IPDG can reliably produce cooperative choices by all members of the quartets when verbal interaction occurs.

These results corroborate the well-established effect of "communication" in promoting cooperation in social dilemmas, including the IPDG (Balliet, 2010; Bicchieri & Lev-On, 2007; Sally, 1995). The results also corroborate the findings by Bicchieri and Lev-On that cooperation remains high and stable as long as communication persists and even after trials with little cooperation. Two limitations of the studies on the effects of communication on cooperation analyzed by Balliet and by Bicchieri and Lev-On were: (a) studies with small number of trials (a mode of 10 and a maximum of 101 in the experiments analyzed by Balliet; and a maximum of 31 in the experiments reported by Bicchieri & Lev-On); and (b) experimental conditions that allowed only few opportunities for communication among participants. The present experiment, on the other hand, involved (a) 240-plus trials for each quartet and (b) opportunity for continuous communication—expanding the findings to a single-subject design with larger exposure to experimental conditions and more intense communication. PD experiments, therefore, must always consider the effects of verbal interaction.

In the No Chat conditions, there was no trial with all-cooperate choices in Quartet 2, while Quartets 3 and 4 produced all-cooperate choices in only six trials each, but always with one kicked participant—what earned the quartet a total of only 36 points. Thus, the quartets never produced four cooperative choices on the same trial, which would have produced the highest total points for the quartet (64). This seems crucial for all-cooperate choices having not been established in the conditions without verbal interaction. Quartets simply did not come into contact with the consequence of higher magnitude programmed for cooperation.

Thus, the effect of verbal interaction seems to have been mainly on the initial establishment of cooperation. In fact, besides the lack of four-participants all-cooperate choices in the No Chat condition, the percentages of all-defect trials actually increased during this condition for Quartets 2 and 3. And even when two participants systematically tried to induce the other players to cooperate, this did not happen. These results corroborate Marwell and Schmitt's (1972), who compared dyads and triads exposed to an IPDG for 100 trials, without communication. These authors employed an initial training of the participants to guarantee the first occurrences of all possible combinations of choices and exposure to their respective consequences. Eight out of 12 dyads cooperated systematically at the end of the study, against only two out of 12 triads. Dyads or triads who began to cooperate systematically did not stop doing so. The difference between dyads and triads was, therefore, due to differences in establishing—rather than maintaining—cooperation. When compared to dyads, fewer triads cooperated systematically due to the punishment of cooperative choices for occasional defections by other participants—more likely to occur in larger groups. These results suggest the mechanism by which verbal interaction favored the establishment of cooperation on the quartets of the present study: avoiding punishment of cooperative choices by unannounced defections.

In fact, the effects of the Chat condition were probably determined by verbal instructions emitted by participants for the whole quartet to cooperate. These instructions occurred in all quartets before the first trials with four cooperative choices and probably signaled that cooperating would not be punished by defections in the following trials. After the first instance of four cooperative choices, the consequences of higher magnitude for the quartet (64 points) strengthened those choices. The instructions for the whole quartet to cooperate seem to exemplify what Bicchieri and Lev-On (2007) called "promises" or "commitment production", the critical characteristic of face-to-face communication that, according to these authors, would facilitate cooperation. Although not involving face-to-face communication, the present results showed strong and rapid effects of what Bicchieri and Lev-On called "computer-mediated communication" on cooperation. To more accurately weight the influences of verbal interaction (and particularly of group-directed instruction) and the exposure to higher-magnitude consequence in the kind of procedure employed in the present study, future research could include and evaluate the effects of an initial training phase with forced exposure to all possible consequences (cf., Marwell & Schmitt, 1972).

Marwell and Schmitt's (1972) results (and others, cf. Balliet, 2010; Dawes, 1980) also suggest group size as an important variable in IPDG cooperation. Generally, the larger the group, more defection is to be expected. In light of that, the present results with quartets attests to the powerful influence of verbal interaction in the production of cooperation. Probably, verbal interactions become more and more important to the establishment and maintenance of cooperation with larger and larger groups. This has obvious implications for the functioning of workgroups and organizations, for instance.

There was less choice variability during Chat conditions on Quartet 1 than in all other quartets. However, the choices by Quartet 2, which was exposed to the No Chat condition during six blocks, varied more than those of Quartets 3 and 4, which were exposed to this condition during 13 and 21 blocks, respectively. Thus, regardless of duration, the mere exposure to the No Chat condition favored that one or more participants defected or did not choose in time in the Chat condition. The exact processes involved in such an effect are not clear and can be explored in the future. What seems understandable is the fact that, since this alteration in choices reduced the points earned by the quartet, it was punished by the other participants—either verbally or by putting the participant on hold—what finally led to all-cooperate choices been produced again.

The present results could have been influenced by the option of kicking one player and to computer-generated choices. Kicking a player was less frequent in Quartets 1 and 2, in which it had mainly an exploratory function, and was employed more often by Quartets 3 and 4, mainly with a punishment function. Three participants had to coordinate their kick choices to effectively remove another participant from the next trial, what was often done with some kind of verbal coordination via the chat room. These interactions constitute IBC that assisted in the regular production of all-cooperate choices, but that were not the focus of the present analysis. The computer-generated choices could have had a similar function in aiding the production of all-cooperated choices by increasing the variability and the contact with different consequences. Since they were not analyzed by Ortu et al. (2012) and were not manipulated in the present study, they were also not the focus of the present work. Future studies could follow up on this respect, for instance by instructing participants on how kicking one player works and by including an option to dismiss the kick choice to minimize exploratory choices.

The present results also suggest contrasts and similarities between the experimental procedures and theoretical propositions referring to cooperation and metacontingency. Would an IPDG involve only a set of operant contingencies, unable to produce unanimous cooperation? Or would it involve a metacontingency, in which total points per trial could select combination of choices such as unanimous cooperation? The IPDG points are jointly generated by more than one individual and affect the subsequent choices of those involved—they can therefore be characterized as cultural consequences. In addition to this interlocking of the operant contingencies involved in the choices, a participant's previous responses and verbal instructions also generate antecedent and consequent (social) stimulation for the other participants, configuring the set of choices in a trial as an instance of a culturant. In this perspective, therefore, an IPDG programs a metacontingency: if certain combinations of choices are emitted (culturant), then certain points are presented to the group (cultural consequence).

The metacontingencies programmed in most experiments conducted by behavior analysts (e.g., Saconatto & Andery, 2013; Sampaio et al., 2013; Smith et al., 2011; Toledo et al., 2015; Vasconcelos & Todorov, 2015) are simpler than the metacontingency programmed in an IPDG. In the typical programmed metacontingency, a given culturant produces a cultural consequence in the form of identical points for all participants; all other culturants do not produce any consequences or produce only the affirmation that the participants have won nothing. In the IPDG, on the other hand, different culturants generate cultural consequences with different magnitudes and sometimes in the form of identical points for everyone (if all-cooperate or all-defect), sometimes in the form of unequal points for the participants (all other combinations of choices). These variations inherent in IPDG programmed metacontingencies can be a challenge to the experimental analysis of the behavioral mechanisms involved in its effects (Locey et al., 2013; Silverstein et al., 1998; Yi & Rachlin, 2004), but the orderliness of the present results shows that a molar analysis is possible. The establishment of cooperation in situations like the ones in the present experiment is greatly facilitated by verbal interactions among participants, especially the ones involving instructions to the whole group. The validity of this result does not depend on a detailed understanding of how all relevant behavioral processes come into play—what strengthens an interpretation like Glenn's (2003, 2004) regarding another (cultural) level of selection by consequences. The culturant, the unit of analysis in this case, encompasses the behavior of several individuals, but does not necessarily need to be reduced to a collection of individual behaviors.

Such an analysis, however, needs to be careful. To consider only the quartet's total points per trial, for example, may explain the increase in unanimous cooperation—which produces the highest possible total gain (64 points). But it does not explain the increase in unanimous defection—which produces the lowest possible total gain (28 points)—observed in conditions without verbal interaction. Even if the effects of the 64 points are disregarded, because it was never produced, three cooperative choices and one defection always produced 55 points for the quartet, a much higher value than the 28 points produced by unanimous defections. Thus, in addition to verbal interaction, another relevant variable to understand IPDG results is the (in)equitable distribution of points among participants in each trial. As unfavorable inequitable points in cooperative tasks can be aversive for many participants (Marwell & Schmitt, 1975), the total points produced by quartets involving inequity may actually have smaller selecting effects than those involving equity. In fact, the only combinations of choices that produced equal points for all participants were all-cooperate and all-defect—the most frequent combinations in all quartets. Although some experiments on metacontingency involved inequitable points (e.g., Vichi et al., 2009), the vast majority employed equal gains and none directly compared these two possibilities. Future studies should delve more deeply in this aspect of metacontingency procedures.

In sum, our experiment demonstrated how verbal interaction among participants facilitates the establishment of cooperation in an IPDG. This result corroborates the importance of communication highlighted in the literature on the PD (Balliet, 2010; Bicchieri & Lev-On, 2007) and also pointed out by metacontingency experiments (Smith et al., 2011; Sampaio et al., 2013). The IPDG can be understood as programming metacontingencies and can be used, therefore, to investigate selection by consequences at the cultural level without the need to overlap it with another metacontingency (e.g., presentation of market feedbacks; Costa et al., 2012; Morford & Cihon, 2013; Ortu et al., 2012). Being clear about the differences and similarities between the procedures used in the study of cooperation with prisoners' dilemmas and in the study of cultural selection with metacontingencies allows advances in one area to be more easily used by the other.

Conflict of Interest: The author declares that he has no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

References

Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *Science, 211* (4489), 1390-1396.

Azrin, N. H. & Lindsley, O. R. (1956). The reinforcement of cooperation between children. *Journal of Abnormal and Social Psychology, 52,* 100-102.

Baia, F. H., & Sampaio, A. A. S. (2019). Distinguishing units of analysis, procedures, and processes in cultural selection: Notes on metacontingency terminology. *Behavior and Social Issues, 28*(1), 204-220. https://10.1007/s42822-019-00017-8

Balliet, D. (2010). Communication and cooperation in social dilemmas: A meta-analytic review. *Journal of Conflict Resolution, 54*(1), 39-57. https://10.1177/0022002709352443

Bicchieri, C. & Lev-On, A. (2007). Computer-mediated communication and cooperation in social dilemmas: An experimental analysis. *Politics, Philosophy & Economics 6*(2), 139-168. https://10.1177/1470594X07077267

Catania, A. C. (2007). *Learning* (Interim 4th ed.). Sloan Publishing.

Chaudhuri, A. (2011). Sustaining cooperation in laboratory public goods experiments: A selective survey of the literature. *Experimental Economics, 14,* 47-83. https://10.1007/s10683-010-9257-1

Costa, D., Nogueira, C. P. V., & Vasconcelos, L. A. (2012). Effects of communication and cultural consequences on choices combinations in INPDG with four participants. *Revista Latinoamericana de Psicología, 44* (1), 121-131.

Dawes, R. M. (1980). Social dilemmas. *Annual Review of Psychology, 31*, 169-193.

Franceschini, A. C. T., Samelo, M. J., Xavier, R. N., & Hunziker, M. H. L. (2012). Effects of consequences on patterns of interlocked contingencies: A replication of a metacontingency experiment. *Revista Latinoamericana de Psicología, 44*(1), 87-95.

Glenn, S. S. (1986). Metacontingencies in Walden Two. *Behavior Analysis and Social Action, 5,* 2-8.

Glenn, S. S. (1989). Verbal behavior and cultural practices. *Behavior Analysis and Social Action, 7,* 10-15.

Glenn, S. S. (2003). Operant contingencies and the origins of cultures. In K. A. Lattal, & P. N. Chase (Eds.), *Behavior theory and philosophy* (pp. 223-242). Klewer Academic/Plenum.

Glenn, S. S. (2004). Individual behavior, culture, and social change. *The Behavior Analyst, 27,* 133-151.

Glenn, S. S., Malott, M. E., Andery, M. A. P. A., Benvenuti, M., Houmanfar, R., Sandaker, I., & Vasconcelos, L. A. (2016). Toward consistent terminology in a behaviorist approach to cultural analysis. *Behavior and Social Issues, 25,* 11–27. https://10.5210/bsi.v25i0.6634.

Guimarães, T. M. M., Picanço, C. R. F., & Tourinho, E. Z. (2019). Effects of negative punishment on culturants in a situation of concurrence between operant contingencies and metacontingencies. *Perspectives on Behavior Science, 42,* 733–750. https://10.1007/s40614-019-00224-z

Hunter, C. S. (2012). Analyzing behavioral and cultural selection contingencies. *Revista Latinoamericana de Psicología, 44*(1), 43-54.

Locey, M. L., Safin, V. & Rachlin, H. (2013). Social discounting and the prisoner's dilemma game. *Journal of the Experimental Analysis of Behavior, 99,* 85-97. https://10.1002/jeab.3

Marwell, G., & Schmitt, D. R. (1972). Cooperation in a three-person prisoner's dilemma. *Journal of Personality and Social Psychology, 21*(3), 376-383.

Marwell, G. & Schmitt, D. R. (1975). *Cooperation: An experimental analysis*. Academic Press.

Mechner, F. (2008). Behavioral contingency analysis. *Behavioural Processes, 78*, 124–144. https://10.1016/j.beproc.2008.01.013

Morford, Z. H., & Cihon, T. C. (2013). Developing an experimental analysis of metacontingencies: Considerations regarding cooperation in a four-person prisoner's dilemma game. *Behavior and Social Issues, 22*, 5-20. https://10.5210/bsi.v22i0.4207

Ortu, D., Becker, A. M., Woelz, T. A. R., & Glenn, S. S. (2012). An iterated four-player prisoner's dilemma game with an external selecting agent: A metacontingency experiment. *Revista Latinoamericana de Psicología, 44*(1), 111-120.

Poundstone, W. (1993). *Prisoner's Dilemma*. Anchor Books.

Rapoport, A., & Chammah, A. M. (1965). *Prisoner's dilemma: A study in conflict and cooperation*. University of Michigan Press.

Rasmusen, E. (2007). *Games and information: An introduction to game theory* (4th ed.). Blackwell Publishing.

Saconatto, A. T., & Andery, M. A. P. A. (2013). Seleção por metacontingências: Um análogo experimental de reforçamento negativo [Selection by metacontingencies: An experimental analog of negative reinforcement]. *Interação em Psicologia, 17*(1), 1–10. https://10.5380/psi.v17i1.26779

Sally, D. (1995). Conversation and cooperation in social dilemmas: A meta-analysis of experiments from 1958 to 1992. *Rationality and Society, 7*(1), 58-92. https://10.1177/1043463195007001004

Sampaio, A. A. S., Araújo, L. A. S., Gonçalo, M. E., Ferraz, J. C., Alves Filho, A. P., Brito, I. S., . . . Calado, J. I. F. (2013). Exploring the role of verbal behavior in a new experimental task for the study of metacontingencies. *Behavior and Social Issues, 22*, 87-102. https://10.5210/bsi.v22i0.4180

Schmitt, D. R. (1998). Social behavior. In K. A. Lattal & M. Perone (Eds.), *Handbook of research methods in human operant behavior* (pp. 471-505). Plenum Press.

Schmitt, D. R. & Marwell, G. (1968). Stimulus control in the experimental study of cooperation. *Journal of the Experimental Analysis of Behavior, 11,* 571-574.

Silverstein, A., Cross, D. Brown, J., & Rachlin, H. (1998). Prior experience and patterning in a prisoner's dilemma game. *Journal of Behavioral Decision Making, 11,* 123-138. https://10.1002/(SICI)1099-0771(199806)11:2<123::AID-BDM283>3.0.CO;2-5

Skinner, B. F. (1969). *Contingencies of reinforcement: A theoretical analysis*. Appleton-Century-Crofts.

Skinner, B. F. (1981). Selection by consequences. *Science, 213,* 501–504. https://10.1126/science.7244649

Smith, G. F., Houmanfar, R., & Louis, S. J. (2011). The participatory role of verbal behavior in an elaborated account of metacontingency: From conceptualization to investigation. *Behavior and Social Issues, 20,* 122-146. https://10.5210/bsi.v20i0.3662

Szilagyi, M. N. (2003). An investigation of N-person prisoners' dilemmas. *Complex Systems, 14,* 155–174.

Todorov, J. C. (1991). O conceito de contingência na Psicologia [The concept of contingency in Psychology]. *Psicologia: Teoria e Pesquisa,* 7(1), 59-70.

Toledo, T. F. N., Benvenuti, M. F. L., Sampaio, A. A. S., Marques, N. S., Cabral, P. A. A., Araújo, L. A. S., . . . Moreira, L. R. (2015). Free Culturant: A software for the experimental study of behavioral and cultural selection. *Psychology & Neuroscience, 8,* 366–384 https://10.1037/pne0000016

Vasconcelos, I. G. & Todorov, J. C. (2015). Experimental analysis of the behavior of persons in groups: Selection of an aggregate product in a metacontingency. *Behavior and Social Issues, 24,* 111-125. https://10.5210/bsi.v.24i0.5424

Vichi, C., Andery, M. A. P. A., & Glenn, S. S. (2009). A metacontingency experiment: The effects of contingent consequences on patterns of interlocking contingencies of reinforcement. *Behavior and Social Issues, 18*, 41-57. https://10.5210/bsi.v18i1.2292

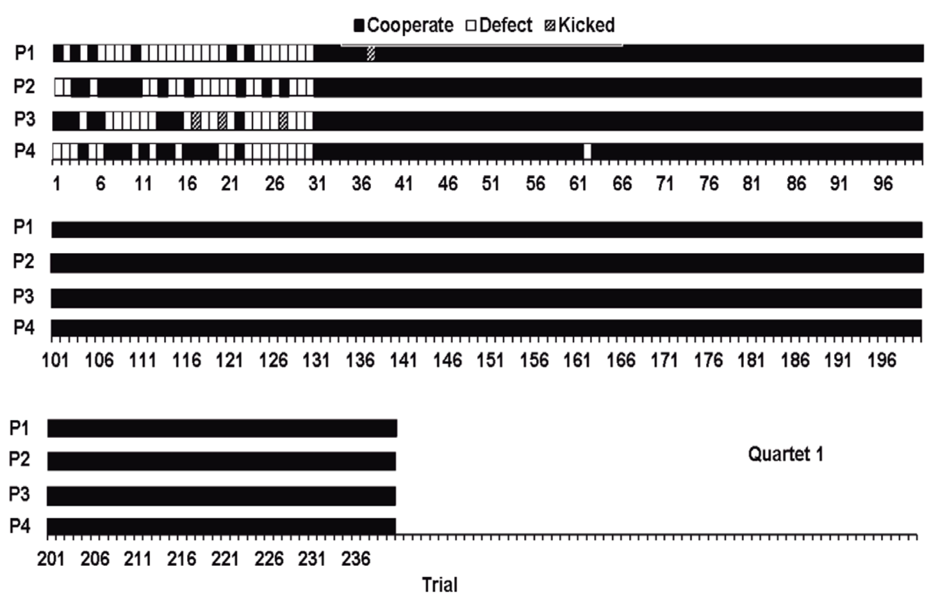
Yi, R. & Rachlin, H. (2004). Contingencies of reinforcement in a five-person prisoner's dilemma. *Journal of the Experimental Analysis of Behavior, 82*, 161-176. https://10.1901/jeab.2004.82-161

Received: September 30, 2020
Final Acceptance: December 3, 2020

Verbal Interaction Promotes Cooperation in an Iterated Prisoner's Dilemma Game: A Multiple Baseline Metacontingency Experiment

Supplementary Figures

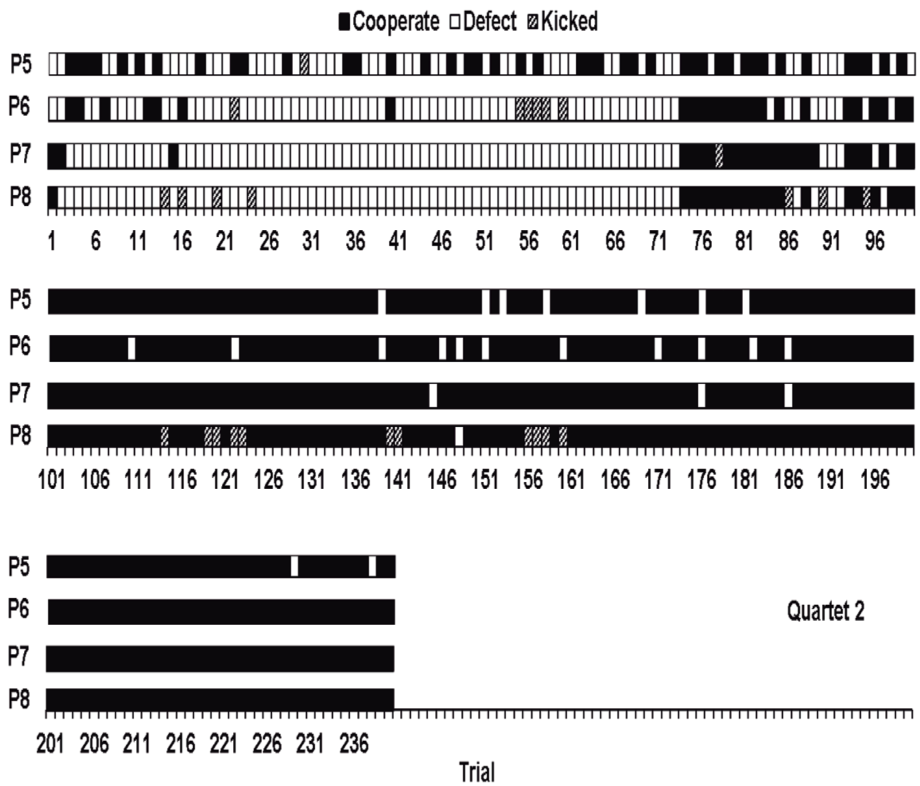
Figure S1
Trial-by-Trial Cooperate and Defect Choices in Quartet 1



Note. Trial by trial cooperate (X) and defect (Y) choices by the participants (P1, P2, P3 and P4) from Quartet 1. Striped squares indicate trials were the participant was kicked. The upper panel presents choices on the first 100 trials, the middle panel, on trials 101 to 200, and the lower panel, on trials 201 to 240. The vertical dashed line marks the beginning of the Chat condition, in which participants could interact through the virtual chat room.

Figure S2

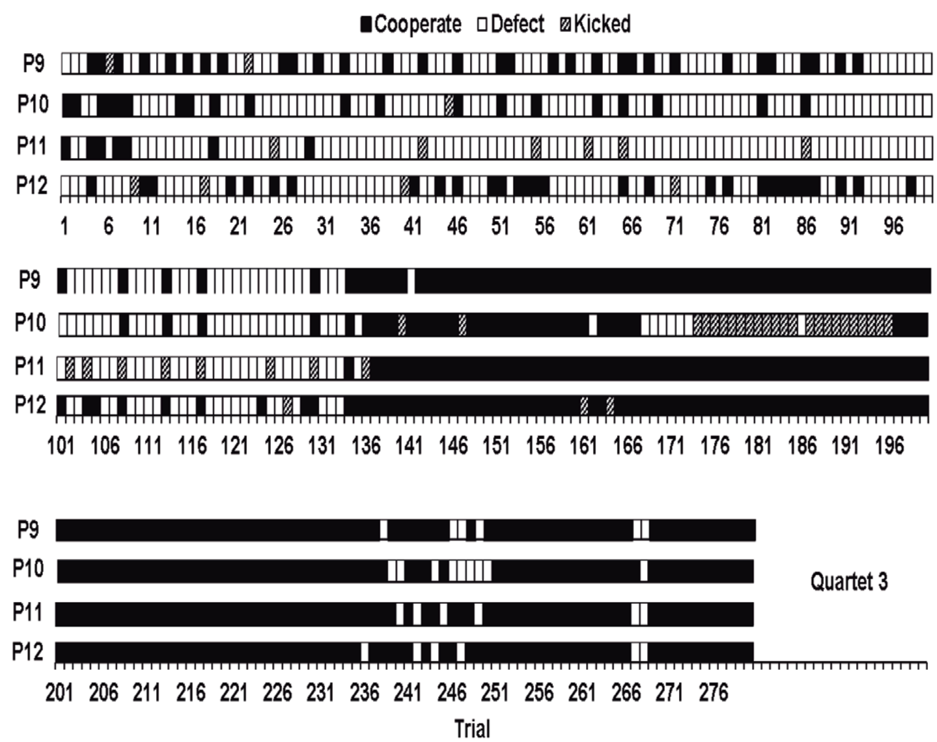
Trial-by-Trial Cooperate and Defect Choices in Quartet 2



Note. Trial by trial cooperate (X) and defect (Y) choices by the participants (P5, P6, P7 and P8) from Quartet 2. Striped squares indicate trials were the participant was kicked. The upper panel presents choices on the first 100 trials, the middle panel, on trials 101 to 200, and the lower panel, on trials 201 to 240. The vertical dashed line marks the beginning of the Chat condition, in which participants could interact through the virtual chat room.

Figure S3

Trial-by-Trial Cooperate and Defect Choices in Quartet 3



Note. Trial by trial cooperate (X) and defect (Y) choices by the participants (P9, P10, P11 and P12) from Quartet 3. Striped squares indicate trials were the participant was kicked. The upper panel presents choices on the first 100 trials, the middle panel, on trials 101 to 200, and the lower panel, on trials 201 to 280. The vertical dashed line marks the beginning of the Chat condition, in which participants could interact through the virtual chat room.