# AN EXPLORATION OF COOPERATION DURING AN ASYMMETRIC ITERATED PRISONER'S DILEMMA GAME

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Researchers investigated how the contingent delivery of a cultural consequence on target culturants in an asymmetric iterated prisoner's dilemma game (IPDG) affected players' choices. The asymmetric IPDG creates an analogue to income disparities created by wage gaps and other cultural practices that create wealth inequalities between different members of the population and allows researchers to explore how these inequalities affect cooperation between players. Six undergraduate students divided into three dyads participated in an ABABCDCD reversal design. An asymmetric IPDG was arranged in Condition A and C such that one player received a greater number of points regardless of the second participants' selections - analogue to contingencies that produce income inequalities from wage gaps. In Condition B and D, a metacontingency was arranged such that delivery of a cultural consequence (CC; bonus points equally distributed among the dyad) was contingent on the oscillating production of target aggregate products (AP) across two consecutive cycles. When participants' coordinated responding and contacted the target AP→ CC relation, the wage gap was reduced. However, individual contingencies are in direct competition for the "wealthier" player, reducing the probability of cooperative responding. Results showed the CC selected certain oscillations between target APs resulting in a decrease of a point disparity between the players while also establishing equal points between the players during certain conditions.

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# INTRODUCTION

The science of behavior analysis has developed with an interest in how a natural science of behavior can contribute toward the creation of a better world (e.g., Skinner 1948, 1953, 1971, 1987). This focus has often manifested itself in calls to increase behavioral scientists' attention to addressing social issues (Cihon & Mattaini, 2019; Dixon et al., 2018; Mattaini, 2019; Mattaini & Cihon, 2019). Many have suggested that attempts to apply behavioral science to mitigate social issues requires an analysis and reorganization of social and cultural contingencies and the creation of interventions that affect a large number of people and systems (Biglan, 1995; Holland, 1978; Glenn & Malott, 2004; Mattaini, 2013). As behavioral scientists look more closely at the most pressing social issues (e.g., poverty, climate change, corruption, wage disparities, educational disparities), we need to identify the contingencies that are responsible for invoking and sustaining the behaviors and practices that contribute to such issues. Some have suggested that understanding the contingencies that evoke and sustain cooperative behaviors can aid in both addressing large social issues and creating a more ideal society (Picketty, 2014; Vugt et al., 2000). The contingencies that produce cooperation are important for a culture or society to flourish. In order to one day arrange such contingencies throughout society, we must first identify and understand the different contingencies that are in place during cooperation.

Cooperation is a social phenomenon that is observed in many different situations. It can be observed when a group of individuals work collectively during a hunt with the goal of catching prey. It is also observed when different members of the medical community collaborate and engage in behaviors that may lead to a vaccine. Although cooperation is common, the definitions of cooperation vary greatly across disciplines. In its most familiar form, cooperation is understood to be the actions that several individuals engage in together with common effort.

Some researchers have suggested that cooperation occurs when, "each individual willingly acts in a manner that contributes to the others' welfare," (Diekmann & Lindenberg, 2001, p. 1). Others have considered cooperation as, "the coordination of multiple individuals toward a goal that benefits the entire group" (Moskowitz & Piff, 2017, para. 1). Khamis et al. (2016), for example, posit that cooperation is not a simple behavior nor is it a specific pattern of behaviors; rather, cooperation is, "a situation in which a set of actions and consequences are taken [sic] place in order to achieve a certain goal" (para 4.). Despite the variations in definitions of cooperation, they contain common elements. Cooperation 1) involves more than one person, 2) persons engage in more than one behavior, and 3) the outcome of one individual's behavior is dependent on another individual's behavior. A strength of studying cooperation from a behavioral perspective is the attention is focused on the identification and investigation of the interlocking contingencies between the cooperating individuals as well as the consequences of the cooperation or the common outcomes that are achieved through cooperation.

Several groups of researchers from various disciplines (e.g., behavior analysis, psychology, economics, etc.) have conducted experimental analyses of cooperation. Of immediate relevance to the current investigation and summarized below are: 1) early behavioral analytic experimental studies, 2) experimental work conducted outside of behavior analysis by psychologists and economists, and 3) recent experimental work in behavior analysis that brings the two approaches together alongside principles of culturo-behavior science (see Cihon & Mattaini, 2019).

Some early behavior analytic work has focused on understanding and developing cooperation in human and nonhuman organisms (Azrin & Lindsley, 1956; Cohen, 1962; Schmitt & Marwell, 1968; Skinner, 1962). Azrin and Lindsley (1956), for example, explored cooperation between two children. They designed an apparatus in which a table was partitioned in two halves, separated by a wire screen. The table contained three holes and a stylus on each side of the table. The children were told that each of them could place the stylus in any of the holes in front of them and that they could eat jelly beans while they were in the room but they could also take them home if they preferred. The children were also told that they could engage in any game they wanted. Then, the experimenters left the room. Azrin and Lindsley defined cooperation as, "the children placing their stylus in opposite holes of each other within 0.04 sec of each other" (p. 100) and jelly beans were provided contingently on responses that met this definition. The results suggested that cooperation occurred at a higher frequency during conditions in which reinforcement was in effect as compared to conditions of extinction. Azrin and Lindsley's work served as the basis for subsequent behavioral research on cooperation.

Skinner (1962) extended the exploration of cooperation with non-human organisms. He placed two pigeons in two compartments that were joined by a glass partition. Each compartment contained three buttons arranged in a vertical line and a food dispenser that was located under the buttons. The buttons were programmed to operate in pairs (one of the three buttons from one compartment and the parallel button in the other compartment). The pair of buttons that were operational was randomized across conditions. Reinforcement was contingent upon the pigeon's pecking of both operating buttons within 0.10 sec of one another. Skinner (1962) defined cooperation as, "discovering the operating button pair and pecking both buttons at the same time" (p. 532). Throughout the experiment, Skinner (1962) observed that one pigeon from each pair assumed the role of a leader. Namely, one pigeon explored which button was operational while the other pigeon pressed the parallel button. The reinforcement contingent on the pecking of the operating buttons within the specified time both developed and maintained cooperation between the pigeons.

Cohen (1962) extended the experimental analysis of cooperation, employing a new preparation that explored how cooperation might develop differently between different members of a social environment. Specifically, Cohen explored social interactions between the participant (Justin) and different family members, between Justin and a friend, and between Justin and a stranger. The experimental arrangement included two rooms that shared a wall and a sliding plexiglass window. Each room contained an operant conditioning panel with a mounted stimulus light, a plunger that functioned as a manipulandum, and a small bin in which reinforcers were delivered. Cohen situated one participant in each of the adjacent rooms in front of the conditioning panel. Once in the rooms, the participants explored the conditioning panel and the plunger. Reinforcement was delivered contingent on a number of different combinations of responses and was delivered either to only one of the participants or to both participants. One combination of responses, defined as social responses, consisted of a plunger pull by one of the participants that was followed within 0.5 sec by a plunger pull from the other participant. Another combination of responses, defined as non-social responses, included those in which the second plunger pull occurred more than 0.5 sec after the first. Cohen defined cooperation as, "behavior in which both subjects are involved and in which both subjects are reinforced" (p. 700). The results showed that cooperation was more frequent when the second participant was Justin's friend, a stranger, or his mother, and the non-cooperative responses were more frequent when the other participant was Justin's sister. The results also showed that Justin engaged in leadership behavior, engaging in the first plunger pull, when the second participant was one with whom he had previous leadership history outside of the experimental setting. This study showed that cooperation is established and maintained differently with different members of one's social environment and that the history of reinforcement outside of the laboratory setting can affect the patterns of cooperation seen in experimental settings.

Schmitt and Marwell (1968) extended Cohen (1962). They noted that with Cohen's preparation there was a possibility that accidental responses, those made by both players at the same time, could be interpreted as non-social responses. In order to address this, Schmitt and Marwell added a delay between the two responses such that the second participant's response had to occur between 3 and 3.5 sec after the first participant's response. There were five experimental conditions in which either timeout lights or response lights were made available or unavailable. The timeout light was illuminated for 0.5 sec and then followed by reinforcement for cooperative responses or was illuminated for 2.5 sec and then followed by a loud tone for non-cooperative responses. Once a participant made a response, the response light in the opposing participant's room was illuminated. The results showed that the frequency of cooperative responses was higher in conditions in which both the timeout and response lights were available and in conditions in which only the response lights were present. The study showed that the response lights served as discriminative stimuli for cooperative behaviors, highlighting that salient stimuli increased the probability of cooperative responses. The response lights were established as a discriminative stimuli during a history of reinforcement in which the second player engaged in a response that occurred within the required time constraints that was followed by reinforcement.

The early experimental work on cooperation highlighted two important contributions of a behavioral perspective on cooperation. First, the interresponse time between each participant's response was an important dimension for researchers studying cooperation to account for in their experimental strategies and tactics. Second, the researchers provided reinforcement contingent on cooperation or the combination of the participants' responses and there were no programmed consequences for the participants' individual responses. These findings informed the current study by highlighting how the process of reinforcement could be used to investigate and maintain behavior of more than one individual.

In addition to these early behavioral studies on cooperation, a number of behavioral researchers have also explored cooperation with strategies derived from social dilemma games. Social dilemma games allow for the manipulation of both individual and shared consequences (Cooper et al., 1996; Rapoport & Chammah, 1965; Selten & Stoecker, 1986). Stemming from game theory, social dilemma games have been used to explore many different social phenomena. The preparations typically consist of games played by two or more players. They involve a set of rules from which players can choose certain strategies based on the information that is present when they are making their choice and the results obtained once they have made a choice (Camerer & Fehr, 2004). Each player's choice is always dependent on the other player's choice. Social dilemma games operate on the assumption that each player will choose in a way that maximizes their individual gains and that players will plan their future responses based on the opposing player's responses (Camerer & Fehr), a concept known as Nash Equilibrium. Nash Equilibrium suggests that each player develops a strategy that serves as the best response to the opposing player's strategy, forming an equilibrium (Camerer & Fehr) and resulting in the highest possible payoff.

Social dilemma games such as the prisoner's dilemma game, the public goods game, the ultimatum game, and the dictator game have been used to explore a number of different social phenomena including cooperation (Cihon et al., in press), variations in interlocking behaviors

(Todorov & Vasconcelos 2015), the overuse of common pool resources (e.g., water, fishing grounds, forest, pastures; Nogueira & Vasconcelos, 2015), and ethical self-control or responding in ways that produce delayed consequences favoring the group  at the expense of receiving smaller magnitude reinforcing consequences for individuals within the group (Borba et al., 2017).

One of the social dilemma games most widely used in the study of cooperation is the Prisoner's Dilemma Game (PDG). A typical PDG involves two players who can engage in one of two possible responses (cooperate or defect). In the traditional sense, the PDG uses hypothetical prison sentences as the outcomes for each player. For its use in behavioral studies, each of the player's responses results in points that are awarded to each player. The points or the corresponding payoff for each participant depends on the other player's selection. The points are derived from a payoff matrix (see Figure 2) that is composed of the outcomes for each player's response. Cooperation and defection responses are usually made by pressing one of two keys on a computer keyboard, each associated with a different outcome (Cooper et al., 1996). If both players cooperate, they both receive the same number of points. If one player cooperates while the other player defects, the player who defects receives a greater number of points than the player who cooperates. If both players defect, they both receive the same number of points but the points are less than those that would have been awarded if they had both cooperated.

Typically, the PDG is conducted as a "one shot game" such that the players have only one opportunity to cooperate or to defect. When studying cooperation, one shot (one turn) PDGs do not provide the opportunity to observe cooperative behavioral patterns over time. In an attempt to address this limitation, some researchers have given players the opportunity to respond with respect to each other on more than one occasion (or across multiple cycles); this experimental strategy is known as the iterated prisoner's dilemma game (IPDG). The IPDG produces higher averages of cooperative responses than one shot games (Cooper et al. 1996). Rapoport and Chammah (1965), for example, conducted a study in which participants engaged in an IPDG with over 300 repeated trials. They found that mutual cooperation occurred in 53% of all dyads and more than 23% of the mutual cooperation occurred in the last 25 trials of the IPDG. These results suggest that the overall probability of mutual cooperation increases as the number of trials or iterations of the game increases. However, Selten and Stoecker (1986) suggested that in IPDGs with fewer trials, the mutual cooperation that is seen in the earlier trials eventually decreases in the later trials.

Several behavioral scientists have utilized the IPDG along with principles from culturo-behavior science in the attempt to understand the variables that influence cooperation and the conditions under which cooperation is most likely to occur (Morford & Cihon, 2013; Ortu et al., 2012). Extending Skinner's (1981) discussion of the third kind of selection and Glenn's (1986, 1988, 2004) metacontingency to the laboratory, many culturo-behavior scientists have found social dilemma games like the IPDG to be helpful in studies focused on the identification of the basic mechanisms regarding cooperation. Such research focuses on how interdependent behavior between two or more individuals (interlocking behavioral contingencies; IBCs) that result in an aggregate product (AP) are selected by cultural contingencies (CCs); the recurrence of the IBCs and AP under selection contingencies has been labeled a culturant. The contingent relation between the IBCs, their AP, and the CC are the basic components of Glenn's metacontingency (cf., Glenn, 1986, 1988, 1991, 2004; Glenn & Malott, 2004; Glenn et al., 2016). Glenn's metacontingency has set the occasion for a number of interpretive (e.g., Agbota et al., 2017; Todorov, 2009) and experimental analyses (e.g., Borba et al., 2017; Camargo & Haydu, 2016;

Carvalho et al., 2017; Morford & Cihon, 2013; Ortu et al., 2012; Saconatto & Andery, 2013; Toledo et al., 2015; Vichi et al., 2009; also see Cihon et al., in press for a review) that have started to increase behavior scientists' understanding of how culturants (IBC+AP; Glenn et al., 2016; Hunter, 2012) are selected by the environment.

Ortu et al. (2012) was the first experimental analysis of the metacontingency that utilized the IPDG. They evaluated the effects of a CC on the IBCs and APs for several groups of participants in five different experiments. Each group was made up of four participants. The payoff matrix throughout the study was arranged such that the points awarded for each individual's response was dependent on the number of participants who defected or cooperated within the group of four. A metacontingency procedure was imposed on this payoff matrix. A different CC was made contingent on AP production. The CC consisted of point delivery for the group or a point loss for the group. Depending on the condition, the players earned money for the group if one of the two target APs was produced (XXXX or YYYY). Losses of money were based on deviations from the production of all Xs or all Ys depending on the condition. The results of the five studies showed that the CC selected and maintained various culturants. During one of the experiments, the CC selected the culturant that benefited the group even though the operant contingencies were arranged in such a way that they produced a higher payoff for some individuals in the group. This sequence of studies provided evidence that the culturant is a unit of analysis that can be selected in its own right even under conditions in which there is competition between the CCs and individual operant contingencies that maintain the IBCs.

Similarly, Costa et al. (2012) explored the role of communication in an IPDG with a metacontingency manipulation. They used a payoff matrix similar to that of Ortu et al. (2012) and divided participants into two groups. One group of participants were not allowed to talk to one another until the last session of the experiment. The other group of participants was allowed to talk to one another for 2 mins between conditions. The results suggest that the CC selected coordinated[1] responses in both conditions; however, coordination occurred faster in those conditions in which communication was allowed between conditions. These results further support the selective effects of the CC on culturants even when such coordination results in a smaller payoff for some of the individuals in the group.

The experimental work conducted using a metacontingency arrangement in an IPDG contributes to the behavioral analysis of cooperation in two ways. First, the findings support the notion that the culturant (IBCs + AP) are a functional unit that can be selected by a CC. Second, these studies indicate that CCs select a culturant even if operant contingencies produce a higher individual payoff for defection rather than cooperation. These findings are important to the study of cooperation because they identify measurable effects on a functional unit consisting of many individuals. Although cooperation can result in outcomes that are considered good for some individuals, cooperation can also result in outcomes viewed as bad or negative for other individuals. By first identifying and manipulating the critical variables of cooperation, we are able to determine the contingencies that establish and maintain this social phenomenon before addressing the effects that it might have on the environment outside the laboratory. The culturant as a functional unit and a CC as a selective variable serve as critical variables during cooperation.

However, if we shift our focus to the world outside the laboratory setting, social interactions rarely result in equal outcomes for all persons involved as do the payoff matrices most commonly employed in the experimental research conducted to date. However, we still see

[1] Coordination or the interlocking behaviors investigated in Costa et al. (2012) are consistent with the behaviors defined as cooperation in Ortu et al. (2012).

cooperative behaviors even in conditions in which there are unequal outcomes for the individuals engaging in the cooperative IBCs. This may be seen when individuals work together on several scientific projects although not all scientists receive the same recognition for their work. It can also be seen when individuals of different genders with the same job position work cooperatively on a project while receiving different pay. Some researchers have attempted to understand cooperation in conditions with unequal outcomes for each player using an asymmetric IPDG.

As the PDG and the IPDG aim to understand player's choices and cooperation, the payoff matrix is designed to allow both players to have equal maximum payoffs as well as equal defecting payoffs. The asymmetric IPDG uses a payoff matrix similar to that used in the PDG and the IPDG; however, the payoffs for cooperation and defection are adjusted such that the payoff for one player is sometimes greater than that of the other player. This manipulation to the payoff matrix allows one player to receive a higher payoff even if both players choose to cooperate. The asymmetric IPDG has allowed economists to establish patterns of cooperation and defection and to make predictions as to how players will respond under such unequal or asymmetric conditions (Ahn, 2007; Beckencamp et al. 2007; Robinson & Goforth, 2004).

Some research conducted using an asymmetric IPDG has suggested that the percentages of cooperation in asymmetric games are lower than those found in symmetric PDGs (Ahn, 2007; Croson, 1999; Sheposh & Gallo, 1973). Ahn (2007), for example, manipulated the traditional IPDG payoff matrix to reflect two different asymmetric conditions. They compared cooperation in symmetric (traditional IPDG) or asymmetric payoff conditions, how cooperation is affected during symmetric and asymmetric games when players make selections simultaneously, and how the order of which player made the first selection affected cooperation in symmetric and asymmetric games. The results suggested that in games which players chose simultaneously, cooperation during conditions with asymmetric payoffs was much lower than in conditions with symmetric payoffs. The results also suggested that players with the highest payoff were less likely to cooperate if they made the first selection but during the second asymmetric condition, players with the lower payoff were more likely to cooperate if they made the first selection.

Similarly, Sheposh and Gallo (1973) showed that asymmetric PDGs produced less cooperation as compared to symmetric PDGs. Their results also showed that players receiving a lower payoff engaged in the cooperation response less often than players receiving a higher payoff. Croson (1999) showed that cooperation was higher in symmetric games (77.5%) than in asymmetric games (55%). The confluence of these studies suggests that that unequal or asymmetric conditions have a negative impact on cooperation, particularly as compared to levels of cooperation seen in equal or symmetric conditions.

However, behavior analysts have not yet explored how the metacontingency might affect cooperation in asymmetric IPDGs which construct conditions in an asymmetric or unequal way, perhaps more consistent with the world outside of the laboratory. Such an experiment might help behavior scientists to better understand how unequal conditions contribute to or disrupts cooperative behavior. If it is possible to determine the effects of unequal conditions on cooperation, behavior scientists might be able to determine contingency arrangements at the individual and/or cultural level that will promote cooperative behavior in conditions in which disparities are prevalent.

In the current study, experimenters alternated between an asymmetric IPDG and an asymmetric IPDG with a metacontingency manipulation. Cooperation was defined slightly differently than in previous research such that cooperation was not based on a single response by each player during each cycle. Cooperation was defined as the oscillation between two target

APs across two consecutive cycles. This required the individuals to engage in IBCs that resulted in one target AP during one cycle and in IBCs that resulted in a second target AP in the following cycle. The payoff matrix was made to favor one participant for the first half of the experiment and was then made to favor the opposing participant for the second half of the experiment. The specific research questions addressed were: 1) what are the effects of asymmetric conditions on cooperation? 2) Does cooperation as defined by oscillations between target APs over two consecutive cycles occur during asymmetric conditions? 3) Can cooperation as defined by oscillations between target APs over two consecutive cycles be selected during an asymmetric IPDG?

# METHOD

## Participants

Undergraduate students were recruited from a large state university located in the southwest region of the United States in one of two ways: in-person announcements in undergraduate behavior analysis courses (recruitment flyers were also given out during each classroom announcement; see Appendix A) or through a cloud-based participant management system (SONA). The SONA system provided students with the opportunity to view experiments being conducted by faculty and to volunteer to participate in one or more of the experiments for extra credit for courses in which they were enrolled.

Students who signed up to participate in the research via the SONA system were compensated with one SONA credit for every 30 minutes of participation; course instructors determined the exchange value for SONA points toward the students' final grades. Students who did not enroll through the SONA system were compensated $5 for every 30 min of participation. All participants were also compensated $0.001 for each point earned during the experiment.

Once at least two individuals had expressed interest in participating, the experimenter contacted them to coordinate an overlapping session time as the experiment required at least two participants to be present at the same time. Six students volunteered and were divided into three dyads. Before the start of every experimental session, the researcher handed each participant a consent form (see Appendix B) and explained and clarified all content within the consent form with each participant. Each participant signed the consent form before beginning the experiment.

## Setting, Materials, and Equipment

The experiment took place in a 4.5m x 3m room on the university campus. The room contained one large table, several chairs, and three desktop computers. Only the researcher and the participants were present during experimental sessions. The program was run on one Dell Optiplex 9020 desktop computer that was connected to three widescreen LCD monitors. Each monitor was placed on top of a rectangular table and each participant was seated in one of three available chairs that were placed in front of a computer monitor. Each participant also had a keyboard that they used to make responses throughout the experiment. Participants faced the opposite direction from each other such that they were unable to see each other's monitors, and therefore, each other's choices. Both player's computer screens displayed a table that depicted the points each player earned individually as well as the group points - those earned as a function of the players' coordinated responses. A green and a yellow button were also displayed on each side of the table (see Figure 1).

The researcher was seated in front of a third computer monitor and keyboard, adjacent to both participants. The researcher operated all three monitors with a program created in Microsoft Excel® 2016 that was designed to run across the three monitors. This program was designed to run both an IPDG and an asymmetric IPDG and allowed the researcher to deliver points contingent on any selection participants made individually as well as contingent upon the AP formed by the participants' coordinated responses (further described below).

## General Task

Two individuals, or one dyad, participated during each experimental session. Participants were read a set of instructions before the onset of the experiment:

> In this game, you are colleagues working in the same workplace. Throughout this game, you will earn money that will depend on the selections you make. At the beginning of each cycle, each of you will select either Green or Yellow by typing specific keys on the keyboard placed under your computer screen. Instructions on which key selects what color is placed on a piece of paper in front of you. Each of you will make one selection once per cycle. I will instruct you when it is your turn to choose. After each player has made their selection, you will receive points that will be displayed on the table located on the computer monitor in front of you. This will constitute one completed cycle. The left

> side of the table is designated for Player 1 and highlighted by the blue cells. The right side of the table is designated for Player 2 and highlighted in light blue. The table will depict the selection made by both players, the points that are earned during each cycle, and the cumulative (or total) points earned by each player. The points that will appear at the bottom of the table, highlighted in the yellow cells, are points that can be earned by both players. The upper yellow cell titled (Group points this cycle) shows the points earned by both players each cycle. The bottom yellow cell titled (Total group points) are the cumulative (or total) points earned by both players. These points will be evenly distributed to both players at the end of the game. The entire game will consist of several pay periods. Each pay period will consist of numerous cycles. You are allowed to talk to each other during any part of the game. Thank you for your participation. Are there any questions before we begin?

After the instructions had been read, each participant was asked to make a selection. Players could select either green or yellow by pressing Alt + the key that was previously programmed for either the green or yellow response option. The players made their choices successively (e.g., Player 1 made their choice between green and yellow; then, Player 2 chose between green and yellow). The participants could not see the opposing participant's selection until after both players had made their selections and the researcher delivered the points contingent on each individual's response. The sequence of responses, first Player 1 and then Player 2, along with the delivery of both the individual and group points, was defined as one cycle.

Each cycle allowed the opportunity for four possible aggregate products (APs): Green-Green (GG) was produced when both players selected green; Green-Yellow (GY) was produced if Player 1 selected green and Player 2 selected yellow; Yellow-Green (YG) was produced if Player 1 selected yellow and Player 2 selected green; or Yellow-Yellow (YY) was produced if both players selected yellow. The researcher delivered individual points to each player after both participants had made their selection and delivered group points to both players in certain conditions. The number of individual points each player received depended on the combination of both players' selections (i.e., the AP; see Figure 3 and 4). During conditions when group points were delivered, the group points were evenly distributed among the players and were added to the total individual points each player had accumulated.

In summary, each cycle consisted of the following steps: (a) the researcher instructed Player 1 to make a selection, (b) Player 1 selected green or yellow, (c) the researcher instructed Player 2 to make a selection, (c) Player 2 selected green or yellow, (d) the researcher delivered the individual points to each participant, and (e) during certain conditions, the researcher delivered a CC (group points). At the end of each condition, the researcher informed players of their cumulative individual and group points for that condition and reset the players' points (both individual and group) before starting the next condition.

At the end of the experimental session (8 conditions), the researcher informed players of the cumulative individual and group points earned over the duration of the entire experiment. Additionally, the researcher provided each player with a summary of their SONA credits earned (when appropriate) and the money they had earned.

### Asymmetric IPDG Favoring Player 1 (Condition A)

In Condition A, participants responded to an asymmetric IPDG. During this condition, Player 1 received a greater number of points for their selections regardless of the selection made by Player 2 such that this condition "favored" Player 1. This experimental strategy allowed Player 1 to accumulate a greater number of points than Player 2, creating a point disparity between the players over the duration of the condition. The condition was terminated after 50 cycles.

### Asymmetric IPDG Favoring Player 1 with Cultural Consequence (Condition B)

In Condition B, a metacontingency was arranged such that a CC was delivered when the players oscillated between two target APs across two consecutive cycles (GG and GY or GY and

YY). The oscillation between the target APs gave the players the opportunity to decrease, or even eliminate the point gap that would be produced given the programmed contingencies in an asymmetric IPDG. The condition was terminated after the players produced 10 consecutive CCs.

### Asymmetric IPDG Favoring Player 2 (Condition C)

Condition C was arranged with the same contingencies for each player as those organized in Condition A; however, in Condition C, Player 2 was favored instead of Player 1. The condition was terminated after 50 cycles.

### Asymmetric IPDG Favoring Player 2 with Cultural Consequence (Condition D)

In Condition D, the metacontingency was again in effect, similar to Condition B but continued in the context of the asymmetric IPDG that favored Player 2. Additionally, the CC was contingent upon the players' oscillation between GG and YG or YG and YY (different target APs than in Condition B) across two consecutive cycles. The condition was terminated after the players produced 10 consecutive cycles.

## Dependent Variables

The dependent variable was the oscillation or the switch from one target AP to a second target AP across two consecutive cycles (see Figures 5 and 6). The oscillation between the two target APs could decrease or even eliminate the point disparity created by the asymmetric IPDG. The oscillation between target APs during conditions in which the asymmetric IPDG favored Player 1 was 1) a switch from the AP of GG to the AP of GY from one cycle to the next or 2) a switch from the AP of GY to the AP of YY from one cycle to the next. When the asymmetric IPDG favored Player 2, the oscillation between target APs was defined as a switch from GG to YG or from YG to YY across cycles.

The individual contingencies for each player's selection of green or yellow were dependent on the other player's selection, thus comprising the IBCs. The resulting change in the environment or the product of their IBCs was the AP, in this case the combination of Green or Yellow. The IBCs and their resulting AP across two consecutive cycles constituted a culturant or the target oscillations.

## Independent Variables

The independent variable manipulation consisted of the delivery of the CC (i.e., group points) contingent upon the oscillation between the target culturants in each experimental condition.

## Experimental Design

Each dyad underwent the sequence of conditions ABABCDCD. The ABABCDCD design was arranged to counterbalance the unequal point distribution across participants, allowing both participants to experience conditions in which they were favored or compromised with respect to the individual point contingencies. The return to baseline between each experimental condition allowed the researcher to see the effects of the introduction of a CC on cooperative responding in comparison to each experimental condition. Condition A was baseline when Player 1 was favored while Condition C was baseline when Player 2 was favored. This sequence of conditions allowed for an analysis of how unequal point distribution affects cooperation by observing the frequency of cooperation responses as defined by the researchers (oscillations) that occurred during asymmetric conditions as well as the frequency of oscillations that occurred in conditions with a CC that could result in equal point distribution across two consecutive cycles.

## Data Collection and Analysis

All data collected were automatically recorded as participants were responding in Microsoft Excel® 2016. During each cycle, each player's selection (green or yellow), the AP, the cumulative individual points, the cumulative group points, and any CC delivery were automatically recorded.

Following the experiment, the APs produced during each cycle were graphed and compared across each condition. Additionally, the CCs that were delivered in both B and D conditions were superimposed on the AP graph in order to show if and when the target oscillations between the target APs occurred. Then, the instances in which a CC would have been delivered in the A and C conditions were added to the graph. This was done to more clearly depict if the target oscillations were occurring prior to the onset of the conditions in which the CC was delivered contingent upon the target oscillation patterns. Finally, the cumulative individual points for each player in each condition were graphed in order to depict the effect of the CC on the resultant point disparities between players consistent with the asymmetric IPDG.

# RESULTS

The results for each of the three dyads are depicted in Figures 7 through 12. Figures 7, 9, and 11 show the individual selections and the APs produced by each dyad during each condition. The target oscillations are shown by either an open square or triangle. The open squares depict the target oscillations that occurred during conditions where the CC was not delivered; the open triangles depict the target oscillations that occurred during conditions when the CC was provided contingent on the oscillations. Figures 8, 10, and 12 show the cumulative points earned by each player during each condition. The distance between the two data paths reflects the point disparity (e.g., a wider space between the two data paths indicates a greater point disparity throughout the experimental condition).

The results for Dyad 1 are depicted in Figures 7 and 8. During Condition A, the distribution of APs was as follows: GG was produced five times, GY was produced on 15 occasions, YG was produced 10 times, and YY was produced on 20 occasions. The data show an intermittent oscillation between GY and YY throughout the condition that occurred on 16 out of 50 cycles as depicted by the open squares. During Condition B, the distribution of APs was as follows: GG was produced 15 times, GY was produced on 14 occasions, YG was produced once, and YY was produced on two occasions. The players consistently oscillated between GG and GY throughout Condition B.

In the return to Condition A, GG was produced nine times, GY was produced on 10 occasions, YG was produced 14 times, and YY was produced on 18 occasions. The players did not oscillate consistently between any of the target APs during this condition. In the return to Condition B, GG was produced twice, GY was produced 12 times, YG was never produced, and

YY was produced on 12 occasions. The data show the players consistently oscillated between GY and YY throughout the majority of Condition B.

In Condition C, the distribution of APs was as follows: GG was produced six times, GY was produced on 20 occasions, YG was produced eight times, and YY was produced on 17 occasions. The data show the oscillation between YG and YY on two occasions toward the middle of Condition C and the oscillation between YG and YY became more consistent toward the end of the condition. The distribution of APs in Condition D was as follows: GG was never produced, GY was produced on two occasions, YG was produced eight times, and YY was produced on eight occasions. The players consistently oscillated between YG and YY throughout Condition D.

In the return to Condition C, the distribution of APs was as follows: GY was produced 12 times, GY was produced on five occasions, YG was produced 15 times, and YY was produced on 19 occasions. The data show a consistent oscillation between YG and YY at the onset of the return to Condition C, followed by intermittent oscillations between GG and YG toward the middle of Condition C. Toward the end of the condition, the oscillation between YG and YY resumed. In the return to Condition D, the AP distributions were as follows: GG was never produced, GY was produced on three occasions, YG was produced six times, and YY was produced on 10 occasions. The oscillation between YG and YY was consistent throughout the last half of Condition D.

Figure 8 depicts the cumulative points earned by each player in Dyad 1 across all conditions. The separation of the data paths depicts the point disparity between the players throughout each experimental condition. The results for conditions favoring Player 1 show that the point disparity was greatest in conditions that did not include a CC (Condition A: Player 1 =

510 points and Player 2 = 270 points; Condition A': Player 1 = 582 points and Player 2 = 228 points, respectively) and were less salient in conditions in which the CC was contingent upon the target AP oscillations (Condition B: Player 1 = 339 points and Player 2 = 279 points) and nearly non-existent in the second B condition (Player 1 = 204 points and Player 2 = 192 points).

The results for conditions (Condition C) in which Player 2 was favored also show a greater point disparity in conditions that did not include the CC (Condition C: Player 1 = 183 points and Player 2 = 633 points; Condition C': Player 1 = 309 points and Player 2 = 495 points, respectively) and a lesser point disparity in conditions with the CC (Condition D: Player 1 = 120 points and Player 2 = 156 points; Condition D': Player 1 = 102 points and Player 2 = 180 points, respectively). The greatest point disparity was shown during Condition C. However, in Condition C' a small disparity between the players is shown toward the middle of the condition which then increases for the remainder of the condition. Additionally, in the return to Condition D, a small point disparity between the players persisted throughout the condition.

Figure 9 and 10 show the results for Dyad 2. During Condition A, the distribution of APs was as follows: GG was produced 10 times, GY was produced on 20 occasions, YG was produced eight times, and YY was produced on 12 occasions. The data show the players oscillation between GY and YY occurred intermittently throughout the condition such that the oscillation occurred in 15 out of 50 cycles. During Condition B, the distribution of APs was as follows: GG was produced 13 times, GY was produced on 15 occasions, YG was produced seven times, and YY was produced on 15 occasions. The oscillation between GY and YY occurred consistently toward the end of the condition.

In Condition A', GG was produced nine times, GY was produced on 29 occasions, GY was produced four times, and YY was produced on eight occasions. The oscillation between GG and GY occurred intermittently until the middle of the condition and then did not occur again for the remainder of the condition. In Condition B’, GG was produced once, GY was produced on 13 occasions, YG was produced once, and YY was produced on eight occasions. The players oscillated between GY and YY on only two occasions during the first half of the condition but were oscillating between GY and YY consistently toward the end of the condition.

In Condition C, the distribution of APs was as follows: GG was produced twice, GY was produced on 26 occasions, YG was produced 15 times, and YY was produced on eight occasions. The players oscillated between YG and YY intermittently for the first half of the condition and did not oscillate thereafter with the exception of two oscillations between YG and YY at the end of the condition. During Condition D, the distribution of APs was as follows: GG was produced two times, GY was produced on two occasions, YG was produced on 10 times, and YY was produced on eight occasions. The players oscillated consistently between YG and YY only toward the end of the condition.

In Condition C’, GG was produced seven times, GY was produced on three occasions, YG was produced 27 times, and YY was produced on 11 occasions. The players oscillated between YG and YY intermittently throughout the condition. In Condition D’, the AP distribution was as follows: GG was never produced, GY was produced once, YG was produced on seven occasions, and YY was produced seven times. The oscillation between YG and YY occurred consistently throughout the condition.

Figure 10 depicts the cumulative points earned by each player in Dyad 2 across conditions. In conditions favoring Player 1, four patterns were shown: 1) a point disparity was shown in conditions without a CC (Condition A: Player 1 = 492 points and Player 2 = 336 points), 2) a point disparity persisted throughout a condition with a CC (Condition B: Player 1 =

507 points and Player 2 = 303 points), 3) a point disparity between the players was shown until the middle of the condition but was eliminated by the end of the condition (Condition A': Player 1 = 426 points and Player 2 = 426 points), and 4) a point disparity was nearly non-existent throughout a condition with a CC (Condition B': Player 1 = 180 and Player 2 = 186).

The results for conditions in which Player 2 was favored show the greatest point disparity in Condition C. A near non-existent point disparity is shown toward the middle of the condition; however, the point disparity increases throughout the rest of the condition (Condition C: Player 1 = 216 points and Player 2 = 654 points). In Condition C', the players did not produce a point disparity (Condition C': Player 1 = 399 points and Player 2 = 399 points), mainlining equal points between the players throughout the condition. A small point disparity persisted between the players in both Condition D and Condition D' (Condition D: Player 1 = 156 points and Player 2 = 192 points; Condition D': Player 1 = 105 points and Player 2 = 123 points, respectively).

The results for Dyad 3 are depicted in Figures 11 and 12. During Condition A, the distribution of APs was as follows: GG was produced 10 times, GY was produced on 29 occasions, YG was produced seven times, and YY was produced on four occasions. The data show only three oscillations between GY and YY during the condition. During Condition B, GG was produced seven times, GY was produced on 18 occasions, YG was produced twice, and YY was produced on five occasions. One oscillation between GG and GY occurred at the beginning of the condition. The players consistently oscillated between GG and GY in the middle of the condition before shifting to a consistent oscillation between GY and YY for the remainder of the condition.

In Condition A', GG was produced six times, GY was produced on 31 occasions, YG was produced five times, and YY was produced on nine occasions. The players intermittently oscillated between GY and YY throughout the condition. In Condition B’, GG was produced two times, GY was produced on nine occasions, YG was produced twice, and YY was produced on nine occasions. The consistent oscillation between GY and YY was shown throughout the condition.

During Condition C, the distribution of APs was as follows: GG was produced eight times, GY was produced on 18 occasions, YG was produced 16 times, and YY was produced on nine occasions. The players oscillated between GG and YG as well as YG and YY intermittently throughout the condition. During Condition D, GG was never produced, GY was produced on two occasions, YG was produced 13 times, and YY was produced on nine occasions. The players oscillated between YG and YY intermittently in the first half of the condition then oscillated between YG and YY consistently for the second half of the condition.

In Condition C’, the distribution of APs was as follows: GG was produced seven times, GY was produced on five occasions, YG was produced 30 times, and YY was produced on eight occasions. The intermittent oscillation between YG and YY was shown in the beginning and the end of the condition while an intermittent oscillation between GY and YG was shown in the middle of the condition. In Condition D’, GG was never produced, GY was produced on three occasions, YG was produced six times, and YY was produced on 10 occasions. The players oscillated between YG and YY twice in the first half of the condition and then oscillated between YG and YY consistently during the second half of the condition.

Figure 12 depicts the cumulative points earned by each player in Dyad 3 across all conditions. The results for conditions favoring Player 1 show that a point disparity was present during Condition A but was nearly non-existent during Condition A’ (Player 1 = 450 points and

Player 2 = 408 points and Player 1 = 429 points and Player 2 = 435 points, respectively). There was no point disparity produced during Condition B while a small point disparity persisted between the players in Condition B’ (Player 1 = 273 points and Player 2 = 273 points and Player 1 = 195 points and Player 2 = 147 points, respectively).

The results for conditions in which Player 2 was favored show the greatest point disparity in Condition C. A small point disparity persisted in the beginning of the condition and then increased for the remainder of the condition (Player 1 = 261 points and Player 2 = 549 points). Points between the players remained nearly equal throughout Condition C’ (Player 1 = 429 points and Player 2 = 435 points). The point disparity was nearly nonexistent throughout Condition D (Player 1 = 183 points and Player 2 = 195 points) and equal throughout Condition D’ (Player 1 = 126 points and Player 2 = 126 points).

# DISCUSSION

The objective of this study was to investigate the effects of a CC on cooperative responses between players during an asymmetric IPDG (under unequal conditions). The current study used an asymmetric IPDG to create an analogue of the unequal conditions present in our everyday environments. Both players experienced the unequal conditions throughout the experiment. A metacontingency was arranged in a way that gave the players an opportunity to make earnings equal after two consecutive cycles. The results indicated six major findings.

The first major finding showed that the CC maintained certain target oscillations (culturants) across all dyads. This finding supports results shown in studies in which researchers placed a CC contingent on target culturants, but players were not subject to unequal conditions (Morford & Cihon, 2013; Ortu et al., 2012; de Toledo et al., 2015). This finding also suggests the dyads' IBCs and APs produced across two consecutive cycles served as the functional unit that was selected by the CC. This finding is also similar to the results of Vichi et al. (2009) that showed the selection of culturants that occurred during the cycle previous to the one in which the CC was delivered. Similarly, the CC in the current study selected target culturants that consisted of IBCs and APs that were produced across two consecutive cycles, the cycle in which the CC was delivered along with the previous cycle. These results suggest that a CC can select target culturants that consist of multiple IBCs and APs. This study may contribute to further investigations of the selective effects of a CC on a variety of culturants. The finding also shows that cooperation, as defined by the oscillations between two target APs, was established and maintained regardless of the unequal conditions established by the asymmetric IPDG.

The second major finding is that the CC maintained both possible target oscillations during conditions favoring Player 1 in Dyads 1 and 3. The two target oscillations that would produce a CC in conditions favoring Player 1 were GG-GY (producing 18 individual points for both players) and GY-YY (producing 15 individual points for both players). The results for Dyad 1 and Dyad 3 showed that the players consistently engaged in both target oscillation while Player 1 was favored. In one case (Dyad 3), the players consistently oscillated between GG-GY before oscillating consistently between GY-YY during the same condition.

There are two possible explanations for the second major finding. First, it is possible that after ending Condition A with a point disparity, Player 1 selected G, allowing Player 2 the opportunity to select Y, which resulted in Player 2 receiving a higher payoff (Dyad 1). Given this, along with receiving a CC for engaging in a target oscillation, the oscillation of GG-GY was selected and continued throughout the condition. However, during condition A', a CC was not available. After Player 2 had engaged in the selection of Y for several cycles in Condition B, it is likely that Player 2 continued to select Y as it had previously resulted in a higher payoff than what Player 1 received. Therefore, it was unlikely that the players would again sample the GG-GY oscillation as Player 2 never selected G.

Second, it is possible that during Condition B, the players produced APs that resulted in Condition A ending with both players earning close to equal points (Dyad 3). With the initial production of GG, the members of Dyad 3 observed that Player 1 received the most individual points. After frequent production of GG and Player 1 earning the most cumulative points, GY was produced. Once GY was produced, the members of Dyad observed that Player 2 received the most individual points. Given GY and YY were produced most frequently throughout Condition A, the players ended the condition with near equal points. In Condition B, GY was produced most frequently before the CC was delivered. When the oscillation between GG and GY occurred, Dyad 3 received the group points, allowing for the selection of the oscillation between GG and GY during the first half of the condition. Additionally, Player 1 selected Y during this condition, a response that had previously resulted in earning more individual points than Player 2. However, when Player 1 selected Y, this formed the AP of YY, following the production of GY, which likely led to the selection of the GY-YY oscillation within the same condition. In Condition A' the players maintained equal points throughout the conditions via the intermittent oscillation between GY and YY in the absence of a CC. Once the dyad oscillated between GY and YY in Condition B', the CC selected the consistent oscillations between GY and YY for the remainder of the condition.

In summary, for Dyad 1, the oscillation that was most beneficial (GG-GY) was likely selected due to Player 1's selection of G which allowed Player 2 to receive the highest individual points after Player 2 selected Y. The oscillation that was less beneficial (GG-YY) was likely selected after the oscillation of GG-GY due to Player 1 selecting Y which resulted in the most individual points for Player 1. And, in Dyad 3, the oscillation that was most beneficial was likely selected due to the AP production that lead to near equal points at the end of Condition A. The oscillation that was less beneficial was likely selected due to Player 1's selection of Y which resulted in the highest individual points.

The third major finding was that the oscillations between target APs were produced in conditions even before the CC was introduced (Dyads 1 and 2). This could be attributed to an embedded metacontingency that was not designed or tracked by the experimenters. The result of equal or near equal individual points at the end of certain experimental conditions might have had selective effects on the target oscillations. In all conditions, players were able to see their own cumulative points as well as the cumulative points earned by the opposing player. If the players engaged in certain oscillations, they could see if the cumulative points for each player remained the same for both players or that the point disparity between the players decreased. This suggests that the lack of a point disparity between players that resulted from certain oscillations even in conditions without a programmed CC could have functioned as an embedded metacontingency, selecting the target oscillations. However, even if the oscillations occurred before the introduction of the CC, the oscillations occurred only intermittently throughout the conditions without a CC. In conditions with a CC, the oscillations were more consistent, suggesting that the CC did in fact have a selective function beyond that of the potentially embedded metacontingency.

The interpretation of the data showing target oscillations prior to the onset of conditions in which the CC might be contacted highlight the importance of how social reinforcement outside the laboratory might affect patterns of cooperation within the experiment. In an attempt to investigate this, future researchers might arrange a scenario that manipulates the visibility of the player's cumulative points. Specifically, the experiment might be arranged such that some dyads are able to view the cumulative points while other dyads are not. Alternatively, the experimenters might manipulate the visibility of cumulative points for each dyad across conditions. The visibility of points can be arranged such that conditions are reversed between the player's having a cumulative point box on their screen and not having a cumulative point box on their screen. This arrangement can be conducted in a reversal design that does not include conditions with another experimenter arranged CC (Conditions A and Condition C). This may allow researchers the opportunity to observe any oscillations that occurred during conditions with only the hypothesized embedded CC, and not the CC contingent upon the oscillations as manipulated in the current study. Additionally, experimenters might investigate how the history of reinforcement may affect cooperation in the laboratory such as Cohen (1962), arranging participants in a way that dyads consist of friends, family members, and strangers. Participants may also be replaced with other members of other dyads within a session. This arrangement will allow researchers to observe the frequency of cooperation as defined by the oscillation between target APs between different types of player relationships.

The fourth major finding is that GG was not produced as frequently as other APs in conditions without a CC. The infrequent production of GG might have occurred because the individual contingencies were arranged such that each player would receive a greater number of individual points if they selected Y, the defection response in an asymmetric IPDG. The infrequent production of GG is consistent with the results found in other studies that employed an asymmetric IPDG and resulted in infrequent cooperation responses (Croson, 1999; Sheposh & Gallo, 1973) as GG is the AP that is defined as the cooperative response in a regular or asymmetric IPDG and also as defined in this study. Therefore, based on previous research that shows a decline in cooperative responses in asymmetric IPDGs over time (Ahn, 2007; Croson, 1999; Sheposh & Gallo), we would expect a similar decline in the current study. The low frequency of the occurrence of GG in conditions without a CC strengthens the support for the selective properties of the CC on target oscillations during conditions with a CC. In some instances, the CC did select for cooperation, as defined by the regular and asymmetric IPDG literature during one cycle (GG), and cooperation, as defined by the authors of this study, across two cycles. This finding suggests that future research further investigate cooperation by comparing the frequency of GG production in asymmetric conditions to those produced in any other condition that researchers might introduce. This will allow researchers to consistently observe the frequency of cooperation as defined by asymmetric IPDGs and as defined by the researchers conducting the future studies. Studies such as these would aid in developing an understanding of how cooperation might occur during one cycle and across two or more consecutive cycles.

A fifth major finding was that the greatest point disparity across all three dyads was seen in Condition C. Condition C was the first condition in which Player 2 was favored. The size of the disparity in this condition shows that Player 2 might have been engaging in counter control (Sidman, 1989) – or making selections that lead to greater individual points due to their history of having experienced the unequal conditions when Player 1 was favored. Condition C occurred after Player 2 had undergone four conditions that favored Player 1, which likely created an aversive condition for Player 2. During these conditions, Player 1 would receive more points than Player 2 in three out of the four possible APs. The production of GY was the only AP that produced fewer points for Player 1 than for Player 2. However, if Player 1 consistently selected Y, they could avoid the possibility of the production of GY during any one cycle. In cycles in which Player 1 selected Y, Player 2 was left in a situation for which either available selection would still produce fewer points than those available to Player 1. Essentially, Player 1 held a position of ‘power’ over Player 2 due to the consequences arranged to favor Player 1 and because Player 1 had to be the player to switch to the cooperative response (i.e., G) in order for Player 2 to receive more points. In a sense, Player 1 controlled Player 2’s outcomes. Player 2 had no available response options that would guarantee them more points than Player 1 during conditions that favored Player 1. However, the contingencies that allowed Player 1 to be in ‘power’ reversed once the payoff matrix was arranged to favor Player 2 in Condition C. Once Player 2 had the opportunity to make selections that assured them more points than those that would be awarded to Player 1, Player 2 engaged in such responding. Sidman (1989) described how people will find a way to defect punishment or threats of punishment when they are unable to escape or avoid such situations. Given that Player 2 had no way to predict if the conditions would shift back to favoring Player 1, their selections of Y might have been a form of counter control against Player 1.

This finding suggests that the researchers established aversive contingencies that may be similar to those seen in organizations and systems outside the laboratory setting leading to coercion and counter control. If researchers are able to further understand the conditions under which counter control occurs, such as those seen in Condition C, they might also gain a better understanding of how to arrange conditions that will prevent coercion in settings outside the laboratory. Future studies to this effect might focus on arranging the asymmetric conditions in a way that favor Player 2 sooner within the session. A potential sequence of conditions might be arranged as follows: ABCDABCD. This allows researchers the opportunity to observe any potential counter coercion responses after only two conditions where Player 1 is favored. A line of research focusing on this finding might give researchers an understanding of how unequal conditions can create coercive contingencies that lead to counter control. It might also give researchers a better understanding of the contingencies that are required to avoid coercive establishments. These studies might assist researchers in arranging contingencies that can prevent coercive systems from being established and maintained.

A sixth major finding was that the oscillations between target APs that would maximize the payoff for the dyad was rarely seen. The oscillations between the target APs that produced the highest points for the dyad are as follows: Favoring Player 1 conditions: GG - GY, Favoring Player 2 conditions: GG - YG. These oscillations would produce 18 individual points and 12 group points across two consecutive cycles; however, the most common oscillation the players produced was GY-YY in conditions favoring Player 1 and YG-YY in conditions favoring player

2. These oscillations would produce 15 individual points and 12 group points across two consecutive cycles, 3 individual points less than the more favorable oscillation. It is possible that the dyads did not oscillate between the APs producing the more favorable outcomes for the group because the production of GG was less probable given the asymmetric IPDG (Ahn, 2007; Croson, 1999; Sheposh & Gallo,) or that the production of GG resulted in the favored player receiving fewer points than had they selected Y. During any cycle, the favored player received 12 individual points while the non-favored player received six individual points. If the favored player selected Y and the non-favored player selected G, the favored player received 18 individual points and the non-favored player received zero individual points. With this contingency in place, the favored player benefited most if they selected Y. Although the non-favored player benefited most from selecting G.

The only situation in which the non-favored player received more individual points than the favored player was if the favored player selected G and the non-favored player selected Y. These selections resulted in six individual points for the favoring favored player and 12 individual points for the non-favored player. With this contingency in place, the non-favored player benefited most by selecting Y. With just these two contingencies in place, the players were more likely to produce YY. YY was part of an oscillation that produced fewer individual points for each player across two consecutive cycles (Conditions favoring Player: GY-YY; Conditions favoring Player 2: YG-YY). Given that YY was produced more frequently than GG, the only way a CC could be produced was to engage in the oscillations that contained YY as part of the target APs. This reduced the probability of players producing GG which was one of the target APs for the oscillation that resulted in the greatest individual points.

This finding suggests that although there were two target oscillations that could produce a CC during CC conditions, the individual consequences created a higher probability for players to oscillate between the target APs that produced fewer individual points for the players. Future research might explore what would happen if the CC were contingent on only the oscillation that produces the most points for both players as well as the group, GG-GY. Conditions might include those that were used in the current study with the exception that the CC would be provided on only one target oscillation (the oscillation that produces the highest individual points for the players). This extension might prove insightful in identifying contingencies that promote cooperation when the favored player must be the one to choose a response that results in fewer individual points but offsets the unequal conditions experienced by the non-favoring player. The extension might also help produce conditions where the wealthier individual must sacrifice the accumulation of wealth in order to assist the less wealthy. A line of research addressing this finding might allow researchers the understanding of what contingencies are required in the environment outside the laboratory to promote conditions in which the wealthy assist the less wealthy. Having such contingencies in place throughout society can aid in addressing social issues that contain disparities between individuals or between groups of individuals.

## Limitations

There are also at least two limitations that are of note. One limitation may be the difference in definitions of cooperation used in this study as compared to those used in previous studies conducted with the IPDG and asymmetric IPDG. The IPDG was originally designed to study cooperation as the selection of the same stimulus by both players, in this case, GG. The selection of GG during one cycle would be considered cooperation in a regular IPDG. This definition of cooperation is used to investigate cooperative responses between individuals within one cycle, delivering feedback through the use of individual points at the end of each cycle. As the cycles progress and specific selections recur, the delivery of points can be said to reinforce the specific selections during each cycle. Specific responses can be easily selected given that each player needs to engage in only one response per cycle in order to receive reinforcement. In the current experiment, cooperation was defined as the oscillation between target APs across two consecutive cycles. The players needed to engage in two target behaviors across two consecutive cycles in order to receive a CC. Essentially, although the CC was produced by IBCs and APs across two consecutive cycles, the CC was delivered during the cycle in which the IBCs and APs occurred that completed the target oscillation. However, given the CC did show selective effects, it is unlikely that the differing definition of cooperation alters the findings shown in the results.

A second limitation of this study is the discrete format of the players' responses. Each player engaged in a response only after the researcher instructed them to do so, which was then followed by the researcher delivering points to each player before beginning a new cycle. This restricted each player to engage on only one response each during each cycle. The players were unable to engage freely in multiple selections such as participants can in a free operant paradigm (Ferster, 1953). Without the ability to engage in the response without the restriction of the researcher's initiation, moment-to-moment changes in the behavior of the individuals cannot be analyzed. One way to address such a limitation is through the utilization of a free-culturant paradigm such as the one described in de Toledo et al. (2015). The free-culturant paradigm has the ability to program for operant and cultural contingencies that conflict with one another and allows for, "the analysis of moment-to-moment interactions between behavioral and cultural-level selection processes" (p. 369). If cooperation is studied within a free culturant paradigm, the frequency of cooperative responses can be investigated without any restrictions from the researchers. Also, the free culturant paradigm might allow for the study of leadership roles such as those observed in Cohen (1962) and how they might be affected with the addition of the metacontingency arrangement. Lastly, the paradigm is conducive to the control of the time between responses such as the manipulations seen in (Azrin & Lindsley, 1956; Cohen, 1962; Schmitt & Marwell, 1968; Skinner, 1962).

## Future Research

Several possibilities for future research have already been discussed; however, additional research might explore arranging the contingency between the AP and the CC on only one oscillation: the oscillation between the target APs that would maximize the payoff for the dyad. The results from this study show that although the oscillation that maximized the payoff for a dyad occurred, the oscillation was only observed once in Dyad 1 and Dyad 3. Furthermore, only oscillations between target APs that produced fewer individual points for the players were shown in conditions favoring Player 2. These results were shown across all three dyads. If additional research was conducted to explore the selective effects of a CC on the oscillation that maximized the payoff for the dyad then researchers could use metacontingency arrangements to select for such oscillations in groups and organizations.

## Strengths and Contributions

There are number of strengths the current study offers that contribute to the culturo-behavior science literature. First, researchers utilized a different experimental strategy that arranged conditions that serve as an analogue of disparities seen in everyday situations where cooperation can be observed. As such, the current investigation brings the laboratory research on the metacontingency closer to translational research (see also Cihon et al., in press for a discussion on this topic). Mace and Critchfield (2010) emphasized that translational research aids basic behavioral research by considering the generality and relevance of behavioral principles in everyday environments. The current study aids the experimental investigation of cooperation as seen in the laboratory settings by allowing for a different modality of cooperation that had not been previously studied. The use of a CC that was contingent upon APs produced across two consecutive cycles allowed for the selection of multiple IBCs and APs as a functional unit. With more of an understanding of how cooperation can be established and maintained under unequal conditions, scientists can begin expanding research to the applied setting through the use of a metacontingency arrangement. By establishing cooperation that is maintained regardless of unequal conditions, individuals and groups of people can reach a mutual goal or find a solution to a common social issue. Society is currently facing systems that have created and continue creating oppressive contingencies for many individuals throughout society. There has been attempts to disrupt oppressive systems through different means such as protests, boycotts, and demonstrations. Although these efforts have been prevalent, oppressive systems have intensified their effects on society causing racial divide, economic disparities, and health disparities. The current research may assist researchers in developing contingency arrangements that aid individuals undergoing disparities. Although the current study may not lead to ways that will disrupt oppressive systems, it may lead to the development of environmental arrangements that result in less disparities than those caused by oppressive systems.

Second, the experimental strategy, the preparation, and the results of this study speaks to the overall criticism of the metacontingency research recently discussed by Zilio (2019). Zilio noted that one general criticism of the metacontingency is its limited necessity and usefulness. This study shows that a metacontingency arrangement can be used to select target culturants that consist of various IBCs and APs. The operant framework can be used to identify and explain the behaviors that occur during social interactions. However, the metacontingency arrangement allows for the identification and systematic changes of various behaviors that make up social interactions and phenomenon such as cooperation. The metacontingency allows researchers to identify functional units (culturants) that consist of various individuals and behaviors. Just as the operant as a unit of analysis aids behavior analysts in producing effective change in individuals, the culturant as a unit of analysis can allow culturo-behavior scientists in producing an effective and meaningful change for large number of individuals. The metacontingency can be an aid in arranging the contingencies that promote cooperation throughout society.

The current study offered contributions to the following three lines of research: 1) early behavioral analytic experimental studies, 2) experimental work conducted outside of behavior analysis by psychologists and economists, and 3) recent experimental work in behavior analysis that brings the two approaches together alongside principles of culturo-behavior science (see Cihon & Mattaini, 2019).

First, the study contributed to the early behavioral analytic experimental studies by showing how the introduction of a stimulus such as a CC can produce an increasing effect on a target culturant similar to the reinforcing effect a stimulus has on a target behavior. This allows researchers the ability to expand the study of cooperation without the need to restrict a study to a purely operant analysis. Although operant behaviors still occur during cooperation, the analysis of CCs and their selective effects on culturants might aid behavior analysts in developing pragmatic arrangements that promote cooperation in the natural environment.

Second, the study contributed to the experimental work conducted outside of behavior analysis by psychologists and economists. The current study showed that cooperation, although operationally defined differently than that of typical IPDG and asymmetric IPDGs, could be investigated through the use of an IPDG paradigm. Cooperation consisting of IBCs and APs across two consecutive cycles was able to be observed at the same time as cooperation defined by both players selecting G during one trial. This study allows psychologists and economists to investigate cooperation in a way that is not restricted to responses that occur in one trial. Also, the metacontingency arrangement used in the current study allows for the investigation of the effects of a CC on either definition of cooperation. This study's arrangement can establish an analysis of cooperation that uses a behavior analytic framework along with the framework of game theory.

Lastly, the current study contributed to the recent experimental work in behavior analysis that brings the two approaches together alongside principles of culturo-behavior science. The current study supports the claim that the culturant serves as a functional unit of analysis. Results showed that the CC selected target culturants consisting of the oscillation between target APs across two consecutive cycles. This study also contributed to this line of research by exploring the effects of a metacontingency arrangement on cooperation under unequal conditions that serve as an analogue to disparities seen in the setting outside the laboratory. The current research conducted allows for various investigations of cooperation that may or may not occur under unequal conditions.

Overall, the current study has provided a new way of investigating cooperation under conditions that serve as an analogue to disparities observed in everyday life. Several findings were highlighted throughout this study. These findings support results from previous literature while also contributing novel findings to the study of cooperation. This study provides opportunities for a number of future studies on cooperation. Researchers are encouraged to conduct extensions of this study in hopes of identifying the contingencies that promote cooperation and result in an equitable society.

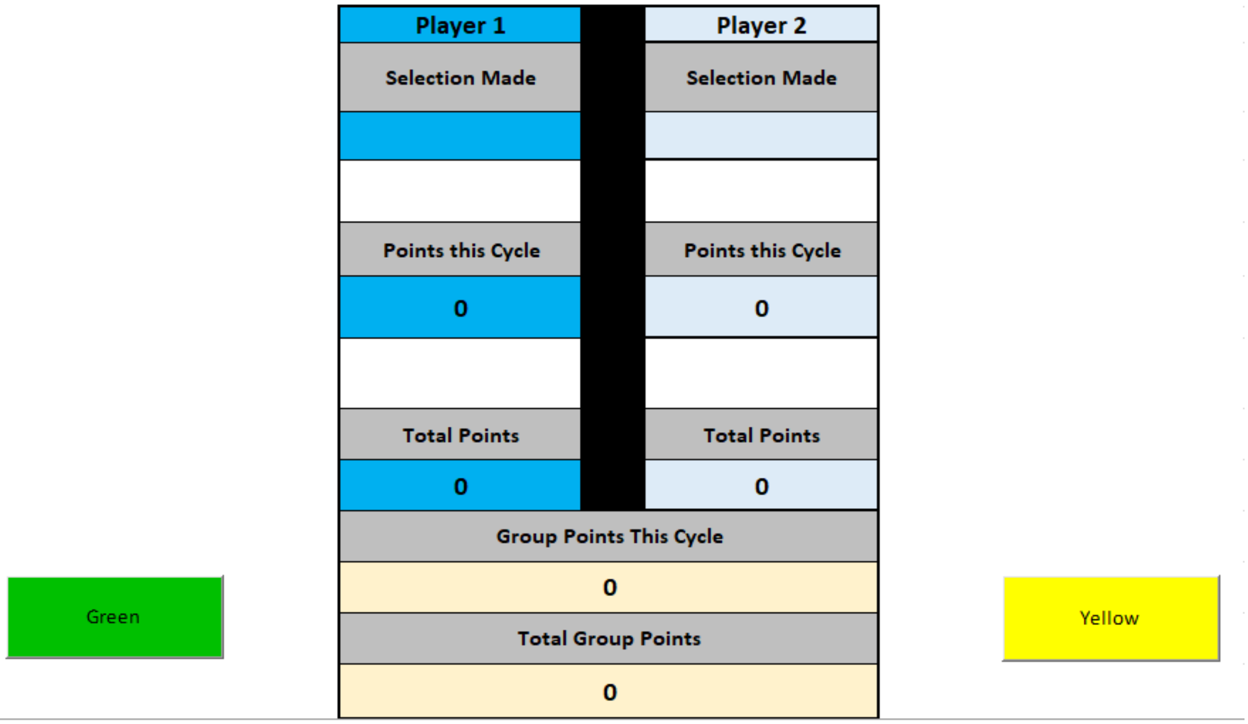


*Figure 1.* Table depicts selections made by each player, the amount of points made during each cycle, the cumulative (total) points for each player, and the group points earned during each cycle along with the cumulative (total) group points. The green button on the left side of the table and the yellow button on the right side of the table are the only two selections that could be made by both players.

| P1 \ P2 | Green | | Yellow | |
|---|---|---|---|---|
| Green | 6 | 6 | 0 | 12 |
| Yellow | 12 | 0 | 3 | 3 |

*Figure 2.* Payoff matrix for an iterated prisoner's dilemma game (symmetric payoffs). Points delivered to Player 1 are depicted by the left values and the points delivered to Player 2 are depicted by the right values.

| P1 | P2: Green | | P2: Yellow | |
| --- | --- | --- | --- | --- |
| Green | 12 | 6 | 6 | 12 |
| Yellow | 18 | 0 | 9 | 3 |

*Figure 3*. Payoff matrix for both players in the asymmetric iterated prisoner's dilemma game condition favoring Player 1. Points delivered to Player 1 are depicted by the left values and the points delivered to Player 2 are depicted by the right values.

| P1 | P2: Green | | P2: Yellow | |
| --- | --- | --- | --- | --- |
| Green | 6 | 12 | 0 | 18 |
| Yellow | 12 | 6 | 3 | 9 |

*Figure 4*. Payoff matrix for both players in the asymmetric iterated prisoner's dilemma game condition favoring Player 2. Points delivered to Player 1 are depicted by the left values and the points delivered to Player 2 are depicted by the right values.

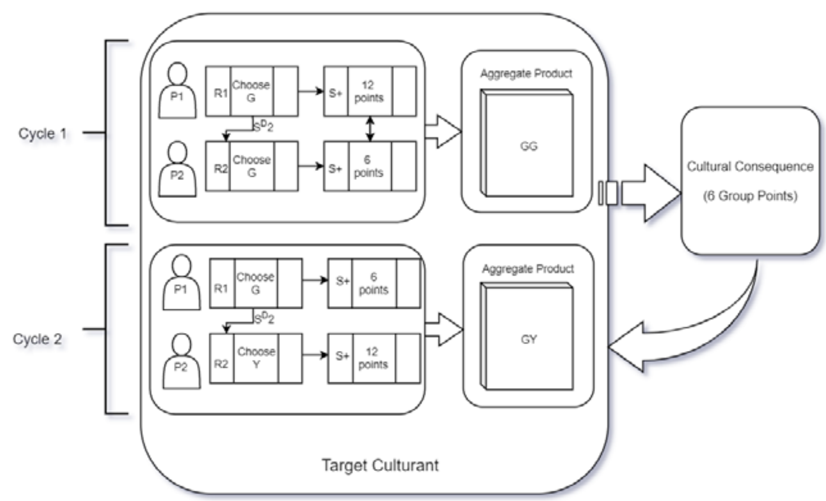


Figure 5. The figure depicts an example of one of the target oscillations across two consecutive cycles (Target Culturant) that will produce the CC during Condition B where Player 1 is favored.

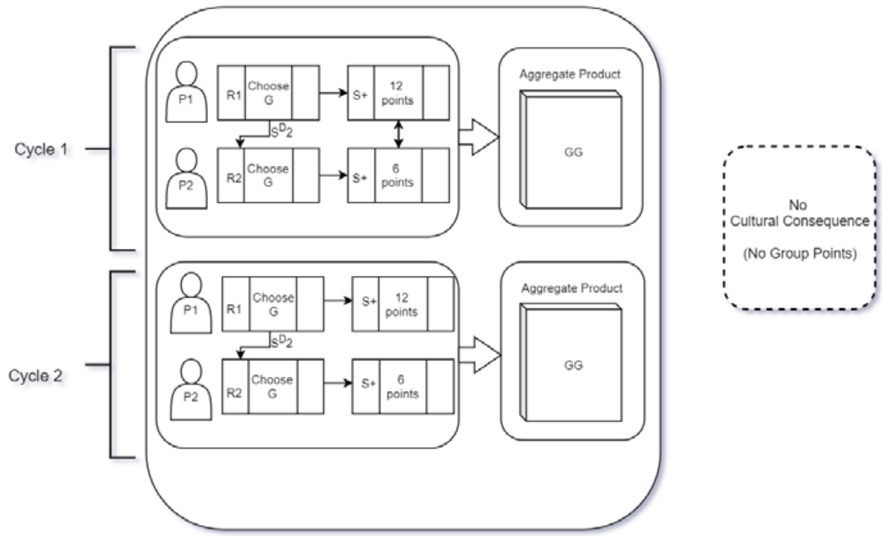


*Figure 6.* The figure depicts an oscillation across two consecutive cycles that will not produce a CC during Condition B where Player 1 is favored.

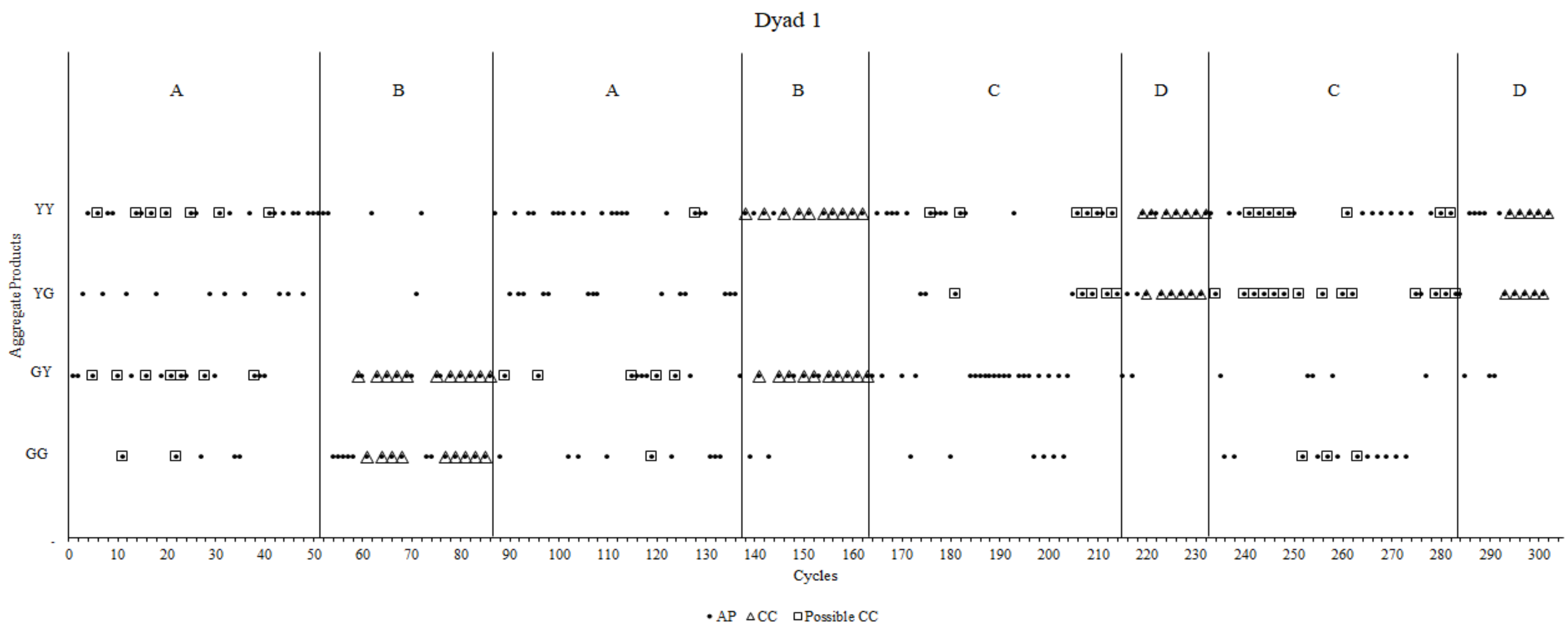


*Figure 7*. The graph displays the aggregate products produced by Dyad 1 during each condition. The open squares depict the target oscillations that would have produced a CC if it was made contingent on such oscillations during those conditions. Open squares are shown during conditions that did not have a CC delivery. The open triangles depict the target oscillations where the CC was delivered.

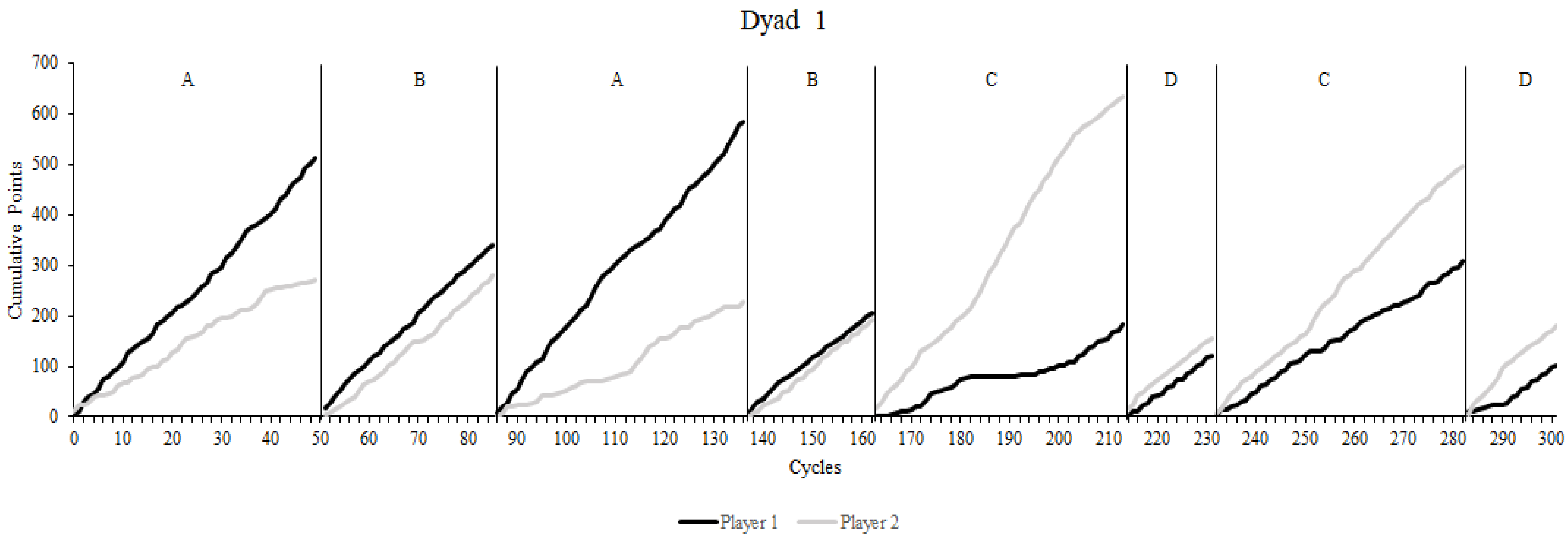


*Figure 8*. The graph displays the cumulative points earned by each player within each condition for Dyad 1. Cumulative points for Player 1 are depicted by the black data path. Cumulative points for Player 2 are depicted by the gray data path. A separation in the data paths suggests a point disparity between the players.

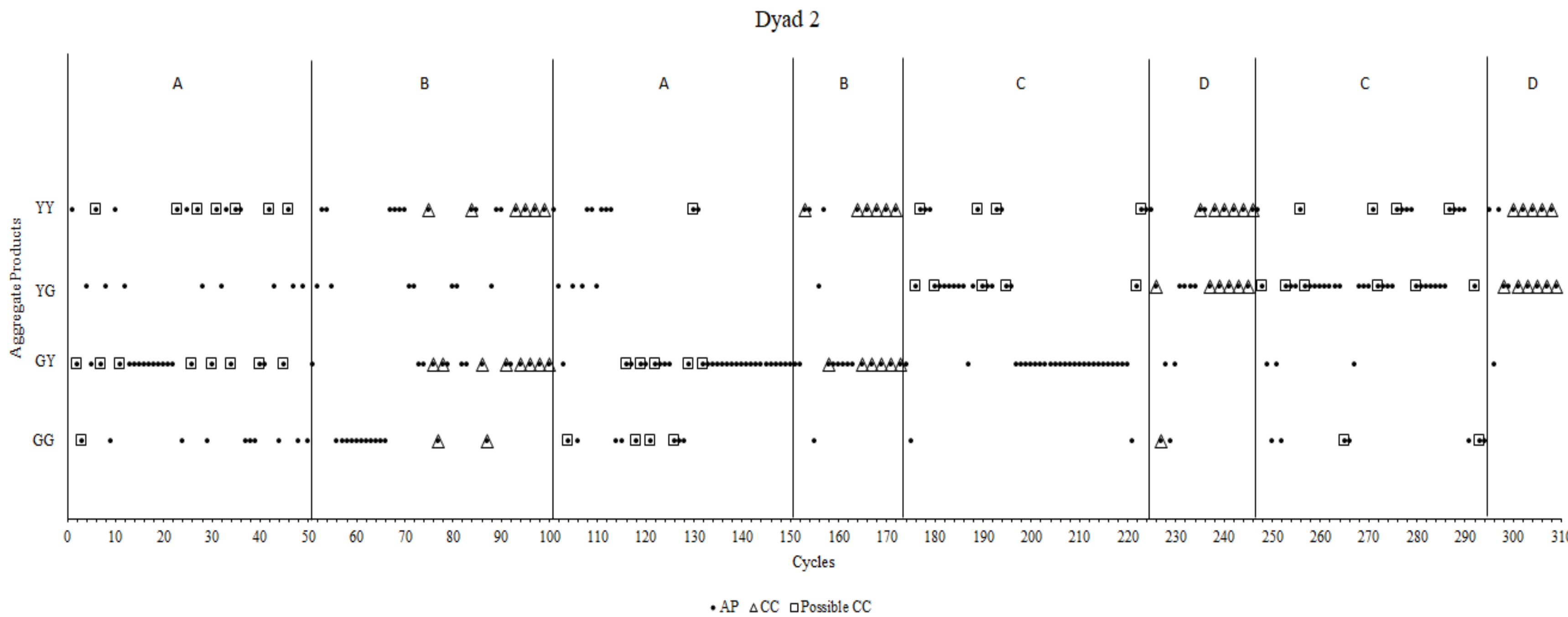


*Figure 9.* The graph displays the aggregate products produced by Dyad 2 during each condition. The open squares depict the target oscillations that would have produced a CC if it was made contingent on such oscillations during those conditions. Open squares are shown during conditions that did not have a CC delivery. The open triangles depict the target oscillations where the CC was delivered.

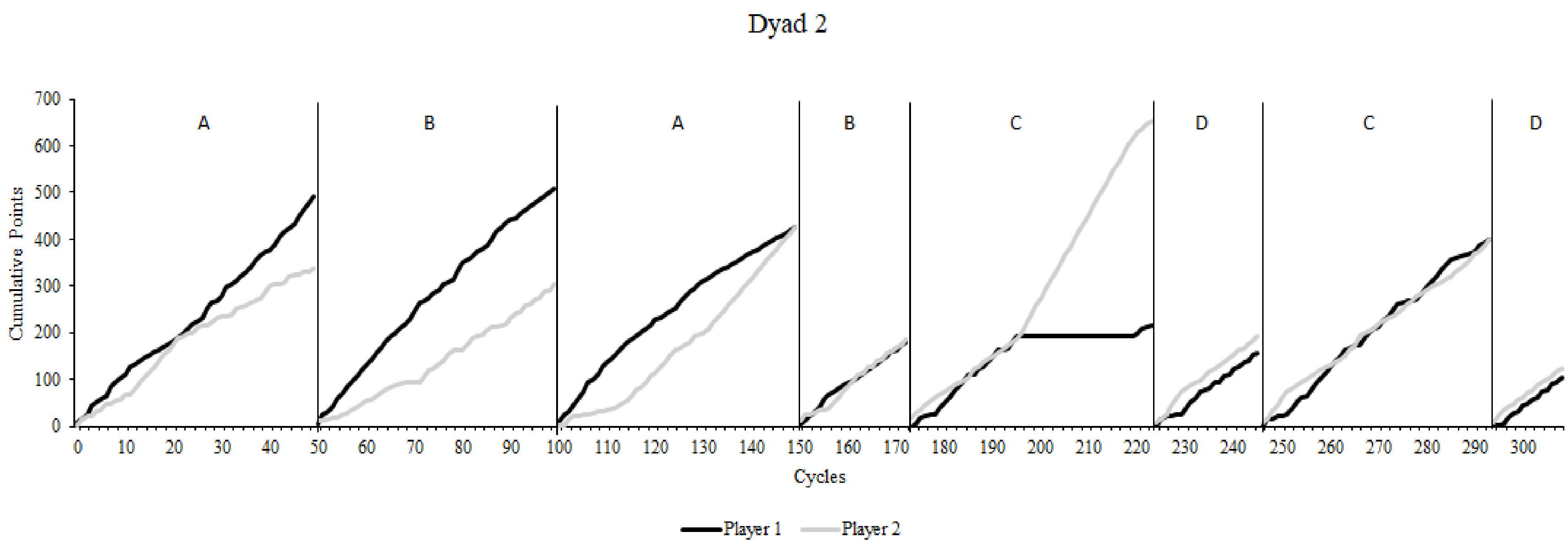


*Figure 10*. The graph displays the cumulative points earned by each player within each condition for Dyad 2. Cumulative points for Player 1 are depicted by the black data path. Cumulative points for Player 2 are depicted by the gray data path. A separation in the data paths suggests a point disparity between the players.

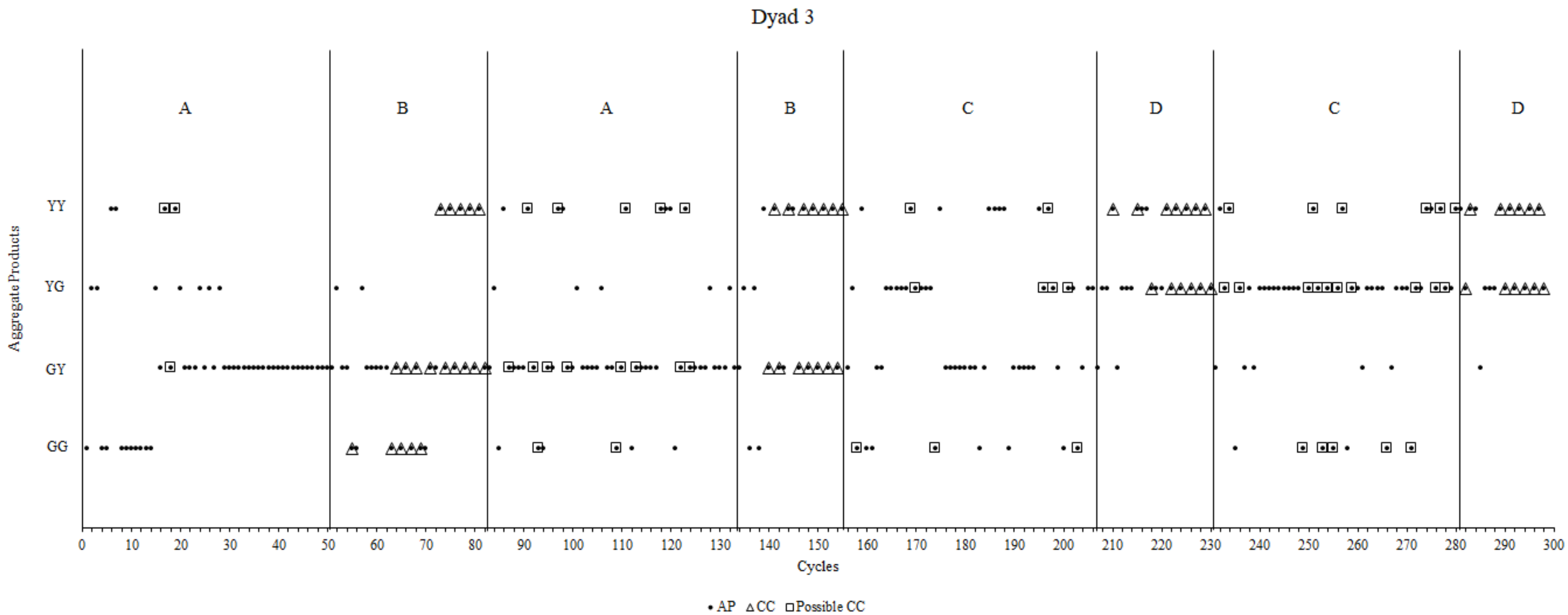


*Figure 11*. The graph displays the aggregate products produced by Dyad 3 during each condition. The open squares depict the target oscillations that would have produced a CC if it was made contingent on such oscillations during those conditions. Open squares are shown during conditions that did not have a CC delivery. The open triangles depict the target oscillations where the CC was delivered.

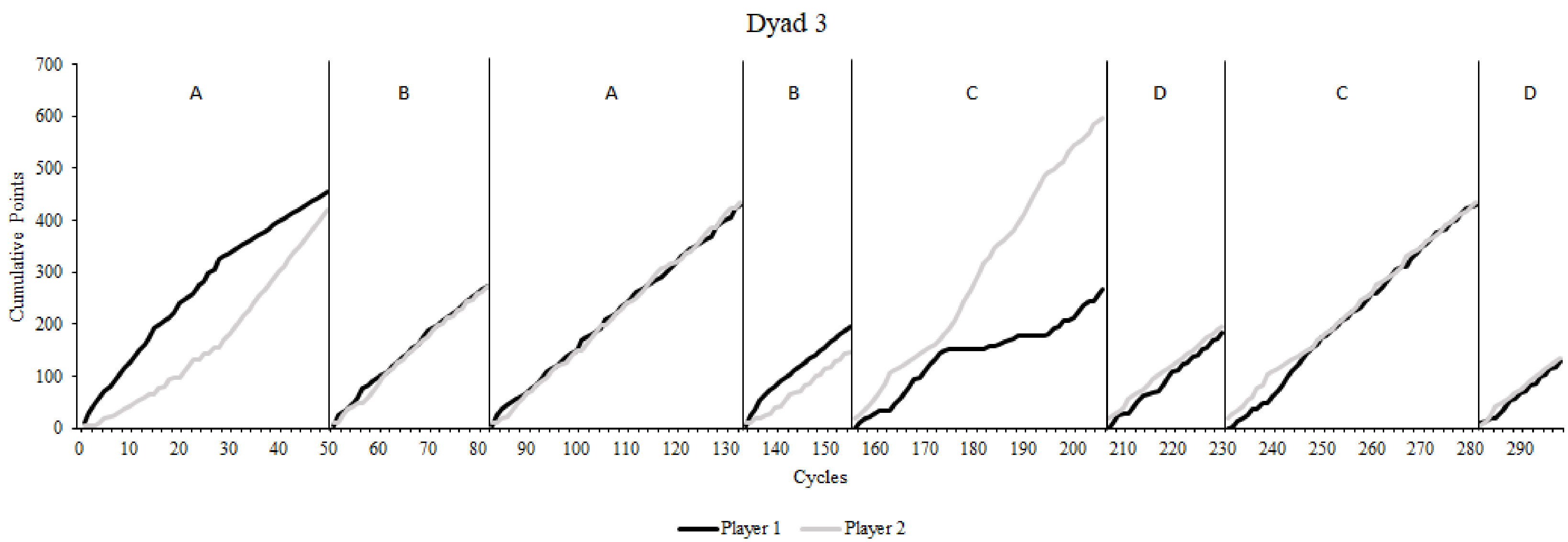


*Figure 12*. The graph displays the cumulative points earned by each player within each condition for Dyad 3. Cumulative points for Player 1 are depicted by the black data path. Cumulative points for Player 2 are depicted by the gray data path. A separation in the data paths suggests a point disparity between the players.

# APPENDIX A

# RECRUITMENT FLYER

**An Exploration of Variables to the Selection of Cultural Practices in Experimental Microcultures**

**Seeking UNT students to participate in a variety of experimental games exploring cultural practices and group behavior for a study conducted by the Cultural Design & Systems Lab, Department of Behavior Analysis, of the University of North Texas.**

UNT
EST. 1890
DEPARTMENT OF BEHAVIOR ANALYSIS
College of Health & Public Service

For more information please contact:

- Dr. Traci Cihon
- Traci.cihon@unt.edu

IRB SBS # (IRB-18-167)

***Principal Investigator*: *Dr. Traci Cihon, PhD. BCBA-D***

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APPENDIX B

INFORMED CONSENT FORM

University of North Texas Institutional Review Board

Informed Consent Form

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

**Title of Study:** An Exploration of Variables Relevant to the Selection of Cultures

**Investigator:** Dr. Traci Cihon, University of North Texas (UNT) Department of Behavior Analysis.

**Purpose of the Study:** The purpose of our research is to examine different variables that affect how individuals in a group behave as well as how groups maintain their cultural practices. Our overarching goal is to understand the processes involved in cultural practices that promote or interfere social progress in society.

**Study Procedures:** You will be introduced to a program where you will learn how to play a game with a partner(s) (a dyad or trio). The program will give you instructions and it is up to you and a partner(s) how you decide to play the game. The goal of each trial is for you and your partner(s) to earn as many points as possible. There may be minor stressors related to working together with others or technical difficulties during the experiment.

**Foreseeable Risks:** This study entails minimal risks. You may experience minor stress related to possible technical difficulties with computer software. Experimenters will minimize these stressors by having extra computers available and reassuring you that you will be compensated for your time while technical issues are getting resolved. You may also experience minor stress related to working with others. You will also be individually compensated for your time regardless of your responses or your partner(s) responses during the experiment. You can withdraw from the experiment at any time without penalty or loss of compensation for the time spent in the experiment.

**Benefits to the Subjects or Others:** You may learn different ways to cooperate in a group or other problem-solving strategies that may arise when faced with a problem. There is also a possibility that you enjoy the playing the games in general have will have fun doing so. During your time in the experiment it is possible that you may learn new strategies for cooperating with other individuals to achieve a goal. The results of the current investigation address a number of questions being asked by the discipline more broadly such as: how can cooperation within a group be generated despite conditions that may not support cooperation? These findings may also further support some previous research that initially explored by replicating some of the parameters used. These findings also have implications for society that include many people behaving but not necessarily working together in an optimal way, and the current investigation attempts to isolate some of those variables. These findings may also allow researchers to conceptualize what cultural level interventions may look like when attempting to address social issues.

**Compensation for Participants:** You will be compensated either monetarily ($5 for every 30 minutes) or with extra credit points for courses that award extra credit through the SONA system (the number of points will be given by the course instructor offering extra credit opportunities for participation in research). Various conditions during some experimental sessions will give participants the opportunity to acquire points that can be exchanged for monetary compensation or donation to a charity of the participant's choosing at the end of the session in addition to the extra credit received through the SONA system. The total amount of compensation will vary depending on the number of points that are earned by the participants during the experimental sessions. The course instructor will provide a non-research alternative to earn extra credit for those that do not wish to participate in the study that is equal to the time and effort of the study. You will be compensated after each session either financially or through the SONA system.

**Procedures for Maintaining Confidentiality of Research Records:** Student investigators will transcribe any audio recordings and participants will be referred to by a pseudonyms or number. Videos will be used only by experimenters for data collection purposes. Neither audio nor video recordings will be used in any dissemination efforts (e.g., manuscripts prepared for submission or presentations) resulting from this research. Moreover, all recordings will be downloaded to a password encrypted external hard drive and kept in a locked filing cabinet in the principle investigator's locked office for 3 years, at which point, all records will be shredded, destroyed, etc.

**Questions about the Study:** If you have any questions about the study, you may contact Dr. Traci Cihon at Traci.cihon@unt.edu or 940.565.3318.

**Review for the Protection of Participants:** This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (940) 565-4643 with any questions regarding the rights of research subjects.

**Research Participants' Rights:**

Your signature below indicates that you have read or have had read to you all of the above and that you confirm all of the following:

- Dr. Traci Cihon has explained the study to you and answered all of your questions. You have been told the possible benefits and the potential risks and/or discomforts of the study.
- You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits. The study personnel may choose to stop your participation at any time.
- Your decision whether to participate or to withdraw from the study will have no effect on your grade or standing in this course.
- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant and you voluntarily consent to participate in this study.

- You have been told you will receive a copy of this form.

______________________________
Printed Name of Participant

______________________________ ____________
Signature of Participant Date

**For the Investigator or Designee:**

I certify that I have reviewed the contents of this form with the subject signing above. I have explained the possible benefits and the potential risks and/or discomforts of the study. It is my opinion that the participant understood the explanation.

___________________________________ ____________
Signature of Investigator or Designee Date

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