SELECTING VARIABILITY IN INTERLOCKING BEHAVIORAL CONTINGENCIES

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The current study explored how the variability or lack thereof in interlocking behavioral contingencies (IBC) may be brought under contextual control. Four undergraduates (two dyads) students participated in the current study. Dyads were instructed to play a game on a computer screen with the goal to earn as many “Congratulations” as possible. An ABABAB reversal design was used. A Lag 1 schedule of cultural consequence delivery for IBC topography was set in the variability (VAR) condition. During the repeated (REP) condition only one IBC topography was reinforced. For one of the two dyads, the variability of IBC topography was brought under contextual control. It is important to explore the behavioral processes at the cultural level to understand prediction and control of cultural phenomena.

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Introduction

Glenn (1986, 1988, 2004) introduced the metacontingency as a concept that might provide the basis for exploring basic processes related to the selection of cultural phenomena. The metacontingency has two terms and is defined as the contingent relation between the 1) recurrence of interlocking behavioral contingencies (IBC) and aggregate products (AP) and the 2) selecting environment (Glenn et al., 2016). IBCs are comprised of the operant contingencies of at least two or more individuals in which each individual's behavior functions as the antecedents or consequences for the other individual's behavior. IBCs produce an effect on the environment or the AP; the AP may have a selective function on the IBCs. Additionally, a cultural consequence (CC), which is part of the selecting environment, may have a selective function when it follows (i.e., is contingent on) the combination of the IBCs and the AP. The combination of the IBC and the AP is the culturant (Glenn et al.). The culturant is the unit of analysis in cultural analysis (Baia & Sampaio, 2019). The culturant can be defined descriptively or functionally. Functional culturants are a class of IBCs modifiable by selecting environmental events (Hunter, 2012). Descriptive culturants are defined by environmental effects of IBCs, in which case the AP produced by the IBCs defines a class of IBCs (Baia & Sampaio).

An example that ties these terms together might be found in a jazz quartet (Figure 5). The IBCs consist of the operant contingencies of each musician, their behavior functions as the antecedent or consequence for the other musicians' behaviors. A trumpeter for example could be playing their trumpet that serves as a

consequence for what the saxophonist is playing, and this back and forth could continue throughout the piece. In other words, the players continuously provide antecedents and consequences for one another's behavior while playing. The bass guitarist and backup trumpeter could also be engaging in similar patterns of behavior to the other two players with respect to one another. Each musician's behavior of playing serve as the antecedents or consequences for the other musicians in the group, these are the IBCs. The IBCs are the coordinated playing of all four musicians playing with respect to one another. The AP is the song produced because of their coordinated playing. It is necessary that all four musicians are playing with respect with one another to produce the sound. The culturant is the combination of the coordinated playing of the musicians (IBC) and the song that they produced as a group (AP). It is necessary that there is coordinated playing that results in a song for it to be considered a culturant. The CC would be the audience cheering for the sounds being produced by the coordinated playing of the group. The audience could request that song again, the venue could request their attendance at future concerts. It more likely that this culturant happens again.

In the jazz quartet example, a descriptive culturant would be defining the coordinated playing of the musicians by the song they produced. A functional culturant would be the changes in the coordinated playing of the musicians and the song they produced because of the audience and concert venue. The metacontingency is the recurrence of the musicians coordinated playing that produces the sound (culturant) which is selected by the audience cheering (CC).

The first experimental demonstration of the metacontingency was conducted by

Vichi et al. (2009). The experimenters utilized an 8x8 matrix with different colored columns. Half of the cells contained a + sign and half a - sign. Vichi et al. used this preparation to explore the selective effects of CCs on IBCs leading to equal or unequal distribution of tokens the group had earned (IBC+AP or the culturant) in the previous cycle. The IBCs did not have a specified topography but were composed of verbal antecedents, behaviors and consequences that resulted in one of the two APs: equal or unequal distribution of tokens among the participants. The experimenters used an ABAB design in which conditions alternated between one in which the metacontingency was placed on equal distribution of the tokens and one in which the metacontingency was placed on unequal distribution of the tokens. When the CC was contingent upon IBCs related to equitable token distribution (patterns of recurring interactions among participants that resulted in equal distribution), equitable token distribution increased; when the CC was contingent upon unequal token distribution (patterns of recurring interactions among participants that resulted in unequal distribution), unequal distribution of tokens increased. Put another way, the participants talked with one another (IBCs) that resulted in equal or unequal distributions of tokens (AP) depending on the CC. The results suggested that a programmed metacontingency did serve a selective function for the target IBCs (i.e., a CC can be arranged to favor certain types of interactions among individuals). This finding was important because the contingencies were arranged to test if the interactions among individuals could be selected as a unit.*

*Azrin and Lindsley (1956) explored how to develop, maintain, and eliminate cooperation among children using operant techniques. The experimenters found that when reinforcement was contingent on the combination of the individuals' behaviors, their rate of cooperative responses increased. This work was

Research was underway on the metacontingency when the five-term metacontingency was first proposed (Houmanfar et al., 2010). This new idea expanded the conceptualization of the three-term metacontingency (Glenn & Malott, 2004). The five-term metacontingency includes the 1) cultural-organizational milieu as a cultural analogue to antecedents that precedes 2) socio-IBs, which are those interlocking behaviors that produce an AP, that is selected by 4) consumer practices, that ultimately created a 5) group-rule that can alter the milieu. The five-term model contained a cultural analogue to antecedents (cultural-organizational milieu). Houmanfar et al. argued that the cultural-organizational milieu encompassed all antecedent factors, or a context, in which culturants are emitted. An advantage to exploring the context that culturants are emitted in is that experimenters can explore the conditions under which culturants are emitted and understand cultural processes that may function similarly to stimulus control. The terms used up to this point have undergone changes over the years (Glenn et al., 2016; Baia & Sampaio, 2019). Throughout this paper, the terms will be used in a way that is consistent with the discussion and the example presented thus far. For the purposes of this discussion, there will be an emphasis placed on the three-term metacontingency. Discussions regarding the cultural milieu have remained largely conceptual (Sanchez et al., 2019), however, the cultural milieu provides a way to discuss the conditions under which culturants occur.

Since Vichi et al. (2009) there have been several experiments using a wide variety of experimental strategies and tactics to better understand the processes that control the selection of cultural phenomena (Cihon et al., in press). Previous research

later reinterpreted from the perspective of the metacontingency arrangement (Glenn et al., 2016; Hunter, 2012).

has shown that CCs can come to control the emission of IBCs that produce a target AP (Marques & Tourinho, 2015; Ortu et al., 2012; Soares et al., 2019). However, much of this research has emphasized the production of target culturants or target APs, not how IBC topographies developed or how the APs are produced. IBCs likely have several topographies that can produce the AP, some more efficient than others. Changes in the AP are typically the focus of a metacontingency experiment rather than the variation in IBCs.

For example, Guimarães et al. (2019) explored the effects of punishment on target culturants by using a matrix preparation like Vichi et al. The target culturant was the three group members choosing rows of three different colors, and the color chosen by the left participant (who began the trial) differed from the previous participant. For example, the participants could choose different colored rows that produced the same AP. The CC was contingent on the culturant, not the IBCs or how the AP was produced. The target culturant was three different colors, it was not important how the participants chose those colors. For example, the participants could choose red, blue, and green and would be considered the same target culturant as blue, green and red. How the AP was produced, or the topography of IBCs was irrelevant to the experiment.

The pattern of arranging contingencies for target culturants or the AP is seen in other studies as well. Vasconcelos and Todorov (2015), for example, explored how a CC affects AP variability. The experimental strategy included an 8x8 chessboard with two knights on opposite corners of the board that the players could move in the shape of an L, the same as a knight in a chess game. The players' movements were the IBCs that resulted in the AP of meeting in any adjacent cells (side to side, on top of each

other, or diagonally) on the board. Both the IBC and AP could vary in several ways. For example, the IBCs could consist of different number of movements or routes taken by each participant and the APs could be in different locations. Experimenters were interested in AP variability rather than IBC variability. The AP could be anywhere on the board and was produced by the moves made from each participant. The CC was a message that said either “Congratulations!” or “End of Trial. Try Again.” and was contingent on meeting at certain points on the board. The CC was delivered contingent on meeting in a specific area of the board (AP), not how the AP was produced. The task in both experiments was to earn as many “Congratulations!” as possible. The researchers used an ABC design. In Condition A, there were no programmed CCs for the AP; Condition B was a shaping condition in which experimenters shaped where on the board the participants met (AP); in Condition C, the participants received the message “End of Trial. Try Again” any time they met at any point on the board (i.e., extinction). During Condition C, the experimenters withheld the CC for 20 trials, and then returned to the contingencies in place for Condition B. The AP was variable (i.e., the participants met in multiple areas on the board) during Condition A as compared to Condition B. The patterns of the APs produced in Condition C were similar to those produced in Condition A. During Condition B, the AP was stereotypic as compared to Condition A, meaning that the participants met in the target area of the board more often. The variability of IBCs were not measured and exclude how the same meetings on the board could be produced in a multitude of ways. There might have been variability in the IBCs but was not indicated in a measurement of the APs.

Using the same experimental preparation, Carvalho et al. (2017) extended

Vasconcelos and Todorov (2015). In Experiment 1, Carvalho et al. explored the variability index of meeting location (AP) and the frequency of moves (IBCs) as a function of the CC using an ABAB design. The variability index of APs was calculated by dividing the total cells the pieces occupied when meeting across the last five trials by the total number of cells that could potentially be occupied during the same five same trials. The variability index for IBCs was the standard deviation of the number of movements per trial, across the last five meetings. The CC was contingent on meeting in a specific area of the board (AP), not how AP was produced. In Condition A there was no CC programmed for any meeting on the board; however, in Condition B the CC was contingent on a meeting (AP) that occurred in a target area of the board. The experimenters resized the number of cells where the AP would be acceptable which restricted the target AP to an area of the board. An ANOVA repeated measures test was used to assess the effects of the CC on the variability index of the AP and IBCs with a p-value of 0.05. The results of an ANOVA showed statistically significant effects for the AP in Condition B as compared to Condition A. There were no statistically significant effects for the IBCs (the frequency of moves) in Condition B as compared to Condition A. These results replicated the findings of Vasconcelos and Todorov demonstrating the selective effect of the CC on the topography of the AP. Specifically, the provision of the CC contingent on AP location on the board reduced the variability of the APs.

In Experiment 2, Carvalho et al. (2017) measured the same variables and conditions as the first experiment using an ABAB design, variability in IBCs and APs. The researchers increased the size of the board from 8x8 to 11x11. Changing the size

of the board allowed the experimenters to observe the effects of the CC on the AP across more trials. Previously, the message was delivered on the AP within an area of the board that diminished in size after 3 phases with a stability criterion of 5 consecutive correct trials. In Experiment 2, the meeting locations were always in the upper right-hand corner of the board with 25 cells (5x5) with a stability criterion of 15 correct trials. A larger board and a higher stability criterion allowed for more variability in IBCs because there were more ways to respond over an extended period of time. The results showed that the AP was less variable during Condition B as compared to Condition A and that this reduction in variability was a result of the programmed contingencies. An ANOVA repeated measures test was used to assess the effects of the CC on the variability index of the AP and IBCs with a p-value of 0.05. The results of an ANOVA showed statistically significant effects for the AP and IBCs in Condition B as compared to Condition A. The findings from both studies demonstrated that CCs contingent on APs affect variability of IBCs and APs. Meeting locations varied and the number movements taken from both participants to get to those locations varied. This was significant because it demonstrated that the withdrawal of a CC had an effect on IBC and AP variability similarly to what is observed in topography and outcome, respectively when individual consequences are withdrawn for an individual response. Additionally, variability of IBCs was indicated by the number of moves not the topography or how the AP was produced.

In both Vasconcelos and Todorov, (2015) and Carvalho et al. (2017) the CC was contingent on the production of the AP, not the IBCs. Vasconcelos and Todorov measured AP variability as a function of the CC and IBCs were measured by the

number of movements taken by each participant as an index of IBC variability. Carvalho et al. measured the effects that contingent CCs on APs had on the IBC variability index of the number of movements. A limitation with this measure of IBCs is that it excluded the multiple ways that an AP could be produced (i.e., the topographies of the IBCs). For example, each participant might take four movements each to produce the AP, but those movements can change even though the number of movements does not. The number of movements does not capture how IBCs can still vary in producing the AP in a similar number of movements. Moreover, variability can be further explored in IBCs by considering what has been done at the operant level.

Discussions of variability have been largely restricted to operant behavior (Neuringer, 2002; Susa & Schlinger, 2012). Neuringer (2002) discussed two common ways variability is indicated which was, 1) satisfy a lag schedule, or 2) show changes in the U value. The U-value is defined as the relative distribution of frequencies among a set of responses (Page & Neuringer, 1985; Neuringer, 2002). Using the U-value for IBCs poses a challenge because of the number of possibilities is too high for any U-value to be significant, a point that will be revisited in the discussion. Alternatively, lag schedule manipulations offer a way to explore variability in culturants because cultural consequences can be manipulated in the same way individual consequences are manipulated. Lag schedules are typically contingent on a response that differs from a specific number of previous responses emitted, how many of those previous responses depended on the value of the lag schedule.

Page and Neuringer (1985), for example, used lag schedules to explore how variability may be a function of the consequences. Experiment 1 utilized a Lag 1 and a

Lag 5 schedule of reinforcement that was contingent on a sequence of 8 responses of pecking a left and right key. The pigeons pecking produced the reinforcer on 90% of their trials in which a lag schedule was in effect. The results suggested that lag schedules can be used to produce variable responding. In both Carvalho et al. (2017) and Vasconcelos and Todorov (2015) the CC was contingent on the AP, not the IBCs. There were no consequences programmed for variability in IBCs or how the AP was produced. There was an emphasis on the meeting location, although it may be valuable to understand how those meeting locations were produced. Whether or not the IBCs were variable or repetitive was unclear. It is likely that outside of an experimental setting, it may prove useful to consider how an AP is produced, or variability in the IBCs that produce the same AP. Discussions of variability have implications for culturo-behavior science, as has been alluded to in some metacontingency research (e.g., Carvalho et al., 2017; Houmanfar, 2009; Vasconcelos & Todorov, 2015).

Consider, for example, a technology-based company like Microsoft or Apple. Technology companies might have a long history of success producing a high-quality product, like a laptop. The employees discuss and work together (IBC) to reliably produce the laptop (AP), in a way that satisfies the consumer demand. The employees are working together in a way that consistently produces the laptop with the same style keyboard and screen to bezel ratio, etc. i.e. repetitive culturants. It is possible that the consumer demand can change which could set the occasion for new practices to be emitted by the company. For example, both IBCs and APs vary to meet the consumer demand. The employees could discuss new ways to put together the laptop, the keyboard, screen, and trackpad design could be altered, which results in a new product.

However, there are instances in which the APs need to stay the same, but the IBCs need to differ. For example, the product may not be produced in a timely manner, or the quantity of the product being produced is not meeting the consumer demand, or there is a feature of the product that can be improved. In this case, the AP does not change but it is necessary that the IBCs continue to vary in a way that produces the AP more efficiently. There are situations in which repetitive IBCs and variable IBCs are beneficial.

For the technology company, it was important that the IBCs adjusted to changes in the environment to effectively produce the AP. There were different contextual variables under which variable or repetitive IBCs were beneficial. One way to understand the conditions that have been alluded to in these examples is a consideration of the five-term metacontingency and the cultural-organizational milieu (Houmanfar et al.,2010). Although there do seem to be examples where variable IBCs and APs occur, the conditions under which variable IBCs and APs occur have not been explored in an experimental setting.

In both Vasconcelos and Todorov, (2015) and Carvalho et al. (2017) the experimenters explored variability of APs and IBCs. The CC was contingent on the production of the AP, not the IBC. There were multiple ways to produce a target AP; this imposed natural variation that occurred within the IBCs that was selected similarly to response variation on the individual level. If the selection processes are applied to the combination of IBC and AP, the variation of IBCs can be brought under CC control in the presence of contextual variables. The current study explored stereotypy or variation of IBCs under particular schedules of CC delivery. In addition to this focus, experimenters manipulated stimuli that preceded the culturants or contextual stimuli and

analyzed the effects on the culturants.

The purpose of the current study was to explore ways to control the range of variability in IBCs and to assess the role of possible analogues to stimulus control in differently evoking stereotyped or variable IBCs at the cultural level. The specific experimental questions addressed will be: 1) What are the effects of a Lag 1 schedule of CC delivery on the form of interlocking behavioral contingencies (IBC) within a culturant 2) How might variability or stereotypy of IBCs be reliably brought under contextual control through manipulations of stimuli that precede the emission of culturants.

Method

Participants

Four undergraduate students from a state university in the southwest region of the United States participated. Students were recruited from undergraduate Behavior Analysis courses using recruitment flyers, in-person class wide announcements, and through a cloud-based participant recruitment software (Sona). Interested students signed up by entering their class information and contact email on the Sona system. Next, the experimenter set up a meeting with each participant to go over the consent forms (see Appendix A). Participants were compensated with either $5 or one Sona credit for every 30 minutes of participation. Compensation occurred after the experiment was completed. Sona credits were converted to extra credit for the courses in which they were enrolled based on the course instructor's discretion.

Setting

Experimental sessions took place in a small room (2m x 3m) that contained a

table, two chairs, and one laptop (Lenovo, 8GB, i5 processor) that was controlled by a mouse. Participants were seated next to each other in front of the computer screen and an experimenter was also in the room to deliver the instructions and to observe their behavior. The software “Xadrez” (Todorov & Vianney, 2014) was installed on the laptop.

Description of the Experimental Task

After consent was obtained from two participants, the experimenter started a laptop that contained the Xadrez program while the participants sat next to each other in front of a small table. The experimenter opened Xadrez and double clicked “Create New Experiment”. After the program was open, the experimenter read the instructions to the participants (see below) and answered any questions the participants had. All questions were answered by restating the most relevant part of the instructions to avoid giving too much information After the instructions were read and any questions were answered, the experimenter double clicked “Execute” on the program. Once the program started, the experimenter placed the laptop and one mouse in front of the participants and asked them to begin.

Xadrez displayed an 8x8 chessboard that included two playing pieces (one for each participant), positioned diagonally on opposite corners of the board (see Figure 1). The two participants took turns moving their pieces as the program prevented simultaneous movements. Participants could move their pieces in the same patterns that the knight moves in a traditional chess game, either one square horizontally and two vertically or two squares horizontally and one vertically. These were the only patterns the participants could move their piece and players could move only their own piece. Participants took turns moving their pieces for the remainder of the experiment.

The board was also presented on either an orange or a green background depending on the experimental condition. Participants moved with respect to one another (e.g., one turn was after both participants moved, one after the other until one of the two messages were produced). When the participants' pieces met in two adjacent cells (side to side, on top of each other, diagonally) as a result of the series of movements, this defined a meeting. The combination of the movements and the meeting location resulted in one of two messages: “Congratulations” or “End of Trial” These messages were delivered for different combinations of movements and different meeting locations in each experimental condition (see below). Additionally, the “End of Trial” message was delivered if the participants timed out of the condition, which occurred if participants did not meet in adjacent cells after 14 turns or after 10-min, whichever occurred first.

Experimenters defined a cycle as the opportunity for the participants to produce either message. A cycle started when the first participant moved their piece and ended when the sequence of the players’ moves produced one of the two messages. After participants received one of the two messages, the board would reset, with both pieces returning to opposite corners of the board, and a new cycle would begin. Each “Congratulations” or “End of Trial” message the participants produced earned 1 point in the corresponding box located to the top right of the chessboard titled “Hits” or “Errors”, respectively. The number of Hits and Errors accumulated during each condition and remained visible to the participants for the duration of the condition. The message delivery was contingent upon the movements of both players that satisfied the contingency and meeting in a specific quadrant of the board.

The quadrant location on the board was randomized in each condition. Across all experimental conditions Xadrez assigned one of three random quadrants at the beginning of each presentation of the condition, restricting where on the board meetings would earn a CC. Each quadrant consisted of a 4x4 block of cells on the board (16 cells total) such that the CC for that condition was delivered contingent on meetings that occurred in only one of three quadrants. Quadrant 1 was the top right corner of the board, Quadrant 2 was the middle of the board, and Quadrant 3 was the bottom left of the board (see Figure 1). The quadrant was assigned at the onset of each condition and participants were not told which quadrant it was; however, the quadrant did not change within an experimental condition. As previously mentioned, the quadrant signified the area on the board in which a “Congratulations” would be produced if participants coordinated their movements such that they met in that quadrant (i.e., a culturant was reinforced in a condition only if the meeting was produced within the quadrant).

Players were allowed to talk throughout the experiment. Between each experimental condition the experimenter also asked the participants what they thought they were doing to earn “Hits” in each condition. The computer recorded the verbal interactions between the participants both during experimental conditions as well as between experimental conditions. The participants would discuss what they thought they were doing to earn “Hits” for approximately 1-min before the experimenter began another round of reversals.

Experimental Variables Defined

The IBCs were defined as the movements the participants engaged in with respect to one another (e.g., Player 1’s total moves followed by Player 2’s moves that

resulted in one of the two messages was counted as one IBC). The AP was defined as participants meeting in any adjacent cells next to one another (side to side, on top of each other, diagonally) as a result of the IBCs. The combination of both the IBC and AP was considered the culturant. The contextual stimuli were the colors presented in the background. The CCs were the messages that were contingent on different combinations of IBC topography and AP production in each condition (end of trial or congratulations).

Independent Variable

The independent variables included a CC schedule manipulation and manipulation of contextual stimuli that preceded the emission of a culturant. During the VAR condition a green background (contextual variable) was presented and the CC was delivered contingent on a Lag 1 contingency for IBC topography (routes taken by both participants). During the REP condition an orange background (contextual variable) was presented and the CC was delivered contingent on IBC topography being the same as the previous cycle.

Dependent Variable

Experimenters measured the cumulative number of IBCs that differed from the previous cycle. The routes taken required both participants to be moving with respect to one another and these movements could either be different or the same as the previous cycle.

Patterns of IBCs were defined as variable or repetitive. A variable pattern of IBCs was emitted when it met the contingency during the VAR condition under a Lag 1 schedule. In addition to variable IBCs in the VAR condition, the participants were also

required to produce APs in the correct quadrant to produce the condition change before the session timed out. A repetitive pattern of IBCs is said to have been emitted when it met the contingency during the REP condition. In addition to repetitive IBCs in the REP condition, participants were also required to produce the APs in the correct quadrant. CC delivery for both patterns of IBCs was dependent both on the IBCs of the previous cycle and producing the APs in the correct quadrant.

Procedure

Both dyads were exposed to two conditions, variability (VAR) and repetitive (REP), following a brief instructional period.

For Dyad 1 a change in condition occurred after 10 non-consecutive “Hits” within a condition or timed out of the condition at 10-min. The dyad moved on to the next condition after achieving 10 “Hits”, regardless of errors, or if they failed to achieve 10 “Hits”, they timed out of the condition.

For Dyad 2 a change in condition occurred after 10 consecutive “Hits” within a condition or timed out of the condition at 10-min. The dyad moved on to the next condition after achieving 10 consecutive “Hits”, regardless of errors. If the participants failed to achieve 10 consecutive “Hits”, they timed out of a condition at the end of 10-min.

For both dyads, each cycle resulted in an error (restarting at their respective spaces on the board) if they failed to meet the contingency or if they engaged in 14 total movements (7 movements from each player) without meeting at any point on the board.

The experimenter read the following instructions prior to the start of the experiment:

> Hello! You are going to play a game together. Each player will have just one piece throughout the game. Before you start, choose yours. Keep that same piece for the remainder of the game. These pieces move in the shape of an “L” on the board, like the knight in a chess game. The piece moves two cells forward and one cell to the side in either direction. This is the only way to move the piece. You must move the pieces around the chessboard using the mouse. To move the piece, it is necessary to click above the cell where you wish to place your piece. A trial starts with each piece located at opposite corners of the chessboard. The player who owns the piece at the top of the board always begins the trial. You will move your pieces one after the other and you are not allowed to skip your turn. Your goal is to get as many “Congratulations” as possible. The game ends when the message “END” appears. I will come and make adjustments before you begin again. When you see an “End of Trial” message, just click anywhere in that box to remove the message, the same with the “Congratulations” message. You all are allowed to talk as much as you want for the duration of the experiment. You will first be introduced to a brief phase to familiarize yourself with the game and learn how to move the pieces. Do you have any questions? Choose who will be each piece in the chessboard. Ready?

Instructional Phase

The experiment began with a 2-min instructional phase. The purpose of this phase was for the members of each dyad to familiarize themselves with the game and how to move the pieces. Participants played Xadrez in the absence of all programmed contextual stimuli and consequences for the duration of this condition.

Variability

In the VAR condition, the chessboard was presented on a green background and the CC “Congratulations” was contingent upon the production of an AP in the correct quadrant according to a Lag 1 schedule of reinforcement on IBC topography. This meant that to produce the CC, participants were required to engage in IBCs that varied from the IBCs emitted in the previous cycle and produce the target AP in the correct quadrant. If participants failed to meet the contingency arranged by the Lag 1 schedule after 14 total movements, then the message “End of Trial” appeared on the screen and

both participants' playing pieces were reset to the starting position and a new cycle began.

Repetitive

In the REP condition, the chessboard was presented on a red background. The CC "Congratulations" was contingent on an IBC topography that produced an AP in the correct quadrant that was the same as the previous cycle. If one player's move deviated from the target IBC, the CC "End of Trial" message appeared, and a new cycle began. Termination criteria for the REP condition was the same as the VAR condition.

Experimental Design

Both dyads went through two conditions with replications of each experimental condition consistent with an ABABAB reversal design. Dyads were exposed to two conditions that alternated based on termination criteria (defined above). The purpose of this arrangement is to demonstrate a functional relationship or lack thereof between our manipulations and the changes in culturants. If IBCs are consistently variable during the VAR condition and repetitive during the REP condition, then it would likely be a result of the manipulations. Replications of the functional relationship between the independent variable and the dependent variable can be observed across conditions. Any changes observed in the culturant will be the result of the presentation and removal of the independent variable. (Cooper et al., 2007; Sidman, 1960).

Data Analysis

The data were collected on the movements of each participant automatically with the Xadrez program across both conditions. Participants' movements and where they

met on the board, were recorded during each condition. The experimenter graphed the movement data in Excel. The movement data were also manually inputted into another program in the online integrated development environment service JSFiddle* program to create visual representations of each participant's individual movements.

Results

Figure 2 shows the cumulative number of IBCs that differed from previous cycles for Dyad 1. For Dyad 1, conditions were changed even if 10 CCs were not produced consecutively (or after 10 min whichever occurred first). In general, IBCs were variable across both experimental conditions. During the first exposure to the VAR condition, the players' behaviors interlocked (IBCs) and met in the target quadrant (AP), therefore producing the CC on 10 of 13 opportunities. During the first exposure to the REP condition, the IBCs were variable; the CC was produced twice in 13 opportunities. In the first reversal back to the VAR condition, the IBCs followed the same pattern as the first VAR condition. In the first return to the REP condition, participants engaged in 18 cycles, again producing the CC on two of these opportunities. During the third exposure to the VAR condition, the participants' pieces met in the target quadrant and produced the CC once in 19 opportunities. In the third exposure of the REP condition, there was an increase in variable IBCs and toward the end of the condition there was a pattern of repetitive IBCs, producing the CC on 10 of 16 opportunities. In the last VAR condition, the IBCs followed the same pattern as in the first and second VAR conditions. In the last REP condition, IBCs were variable and produced the CC 10 times within the condition.

Figure 3 shows the cumulative number of IBCs that differed from previous cycles

* https://jsfiddle.net/

for Dyad 2. In Dyad 2, conditions were changed after 10 consecutive CCs (or after 10 min whichever occurred first). During the first exposure to the VAR condition, the players' behaviors interlocked, and their pieces met in the target quadrant, producing the CC on 10 out of 20 opportunities. During the first exposure to the REP condition, the IBCs were variable, and the participants' pieces met in the target quadrant, producing the CC once out of 22 opportunities. During the second exposure to both the VAR and REP conditions, there were few IBCs that met in the target quadrant and participants produced the CC on three of 22 cycles and one of 26 cycles, respectively. During the third exposure of the VAR condition, IBCs were variable; however, the IBCs resulted in APs outside of the target quadrant. As a result, the CC was produced once, and the session timed out. In the third exposure to the REP condition, IBCs were repetitive, and APs occurred in the target quadrant on 10 of 11 cycles. During the fourth exposure to both the VAR and REP conditions, their IBCs met the programmed contingencies in the target quadrants and produced the CC on 10 of 12 cycles and 10 of 11 cycles, respectively. The participants replicated this pattern across the last three reversals between VAR and REP conditions.

Figure 4 shows the cumulative rounds for each participant in Dyad 2. The frequency of each movement is depicted by the thickness of the line, with less frequent movements appearing as thinner lines and vice versa. During the first two exposures to each condition, both participants' movements were variable. During the third exposure to the VAR condition, both participants' movements remained variable. During the third exposure to the REP condition, both participants' movements were repetitive. During the fourth exposure to the VAR condition, participants switched between two routes.

During the REP condition, both participants repeated the same routes throughout the condition. Participants replicated these patterns across the next three reversals between VAR and REP conditions.

Discussion

Prior to commenting on the results more generally, it is important to note that the data collected do not provide sufficient replications across dyads. Data collection was interrupted due to the onset of Covid-19. Combined with the change in procedure from Dyad 1 to Dyad 2, these variables prevent strong conclusions from being drawn. The implications of these two variables present the following limitations in the interpretation of the results pertaining to both internal and external validity. First, it is difficult to argue that the findings were a result of the current manipulations and not extraneous variables. Second, the procedures were not directly replicated across dyads, which restricts the external validity of the findings. Due to these two variables, the experimenters are unable to make any strong claims of a functional relation between the independent and dependent variable. Further, the experimenters are unable to generalize the findings to other dyads or groups. To improve the internal and external validity of the current findings it is necessary that the current preparation with Dyad 2 be replicated with more dyads. Additional data will be collected pending approval of an IRB modification request to conduct sessions virtually.

General Findings

The current study was a preliminary attempt to bring variability in IBC topographies under contextual control using a Lag 1 schedule of CC delivery. In Dyad 1, the color and the CC that the color was correlated with did not come to control IBC

topography (Figure 2). The cumulative number of IBCs that differed from the previous cycle were high in the VAR condition; however, these IBCs resulted in an AP outside of the target quadrant. In the REP condition, the cumulative number of IBCs that differed from the previous cycle was also high. However, in Dyad 2, IBC topographies did come under the control of the color corresponding to the CC (Figure 3). The cumulative number of IBCs that differed from the previous cycle was higher in the VAR condition as compared to the REP condition. Data from Dyad 1 suggest that participants were not given enough opportunities within each condition to contact the CC. This prompted the investigators to adjust the condition change criterion. In Dyad 2, there were more opportunities to produce the CC without changing the condition because the criterion for the condition change was consecutive.

For Dyad 2, when the background was green, the cumulative number of IBCs that differed from the previous trial occurred more often. There are a few possible interpretations of these findings.

One likely interpretation is that there was extinction induced variability as a function of the randomized quadrants. The CC was delivered contingent on how the participants met in an area of the board. The colors in the background indicated the IBC topography that was necessary to produce the AP. Contingencies were not explicitly arranged for the participants to meet in a certain area of the board. In other words, the participants were unaware that where they met on the board was important. The randomized quadrants prevented contact with the contingency because it was not established as correlated with the CC. When the IBCs and AP produced the CC the background color was the only stimulus that was visible to the participants, not the

quadrants. The quadrants induced extinction at the beginning of each condition until the AP was produced in the target quadrant. The routes taken and meeting locations by both participants was not resulting in the CC. The lack of CC delivery resulted in more variability in the IBCs and APs. Carvalho et al. (2017) also observed variability in the IBCs and APs when they withdrew the congratulations message. However, Carvalho et al. measured the variability of IBCs was indicated by a variability index on the number of moves and in the current investigation variability in the IBCs was measured by satisfying a Lag 1 schedule. Additionally, the contingency was placed on IBC topography not the AP to explore how variability in IBCs might come under control of the CC.

Another interpretation is that the participants switched between a few responses to satisfy the contingency (Page & Neuringer, 1985, 2012; Silbaugh et al., 2017; Susa & Schlinger, 2012). The visual representations of cumulative individual movements (Figure 4) show that individual movements switched between a few routes that satisfied the Lag 1 schedule. The Lag 1 schedule necessitated that the routes in one cycle differ from the previous cycle, which allowed participants to switch between a few routes that produced the CC. This finding was consistent with Page and Neuringer (1985) in which the experimenters observed switching between a few responses with a low lag value.

These results could also be interpreted as the colors exerting contextual control over the emission of variable and repetitive IBCs within culturants. The colors consistently correlated with a CC that was contingent on a combination of IBCs and APs. The colors were considered part of the cultural-organizational milieu because they were part of the context that the culturants were emitted in. The colors made it more

likely that variable or repetitive IBCs were emitted because of their correlation with the “Congratulations” message.

The remaining future directions and limitations will be discussed in the context of Dyad 2’s performance. The rationale for this was that the data from Dyad 1 suggested that participants were not given enough opportunities within each condition to contact the CC. Participants were able to change the condition without repeated exposures to the CC. For example, the participants could change the condition regardless of the “Errors” in between their “Hits”. The CC was produced infrequently and did not allow for the CC to select the IBCs. This prompted the investigators to adjust the condition change criterion. In Dyad 2, there were more opportunities to produce the CC without changing the condition because the criterion for the condition change was consecutive. This allowed for a reliable correlation between the participants movements and the CC to be observed because it was necessary that it was consecutive. The procedures used for Dyad 2 were the most representative of what would be used to complete the investigation.

Limitations and Future Directions

The randomization of quadrants presents a confound in interpreting the results. The contingencies were arranged so that a green background always correlated with the CC for variable IBCs and an orange background always correlated with the CC for repetitive IBCs. However, it was possible that when IBCs varied in the presence of green it would not be met with the CC. The reason was that it occurred outside of the target quadrant. These randomized quadrants determined what area of the board an AP needed to be produced to achieve the CC. The participants were unaware of the

changes that occurred. One explanation for the variability observed in IBCs across both conditions throughout the experiment was the ambiguity in the contingencies that these quadrants may have created. As previously mentioned, the quadrants likely induced extinction at the onset of each condition. The participants started each condition under extinction until they met in the target quadrant. Extinction has been known to induce variability, and in the VAR condition where variable IBCs were required it may be misleading to suggest that the variable IBCs were a function of the lag schedule. The same confound presented itself in the REP condition. The participants were likely to vary their IBCs at the start of the condition rather than repeating their IBCs.

Satisfying a Lag 1 schedule was used as an indicator of variability in IBCs. The visual representations of cumulative individual movements (Figure 4) suggest that IBC topography switched between a few combinations of routes that satisfied the Lag 1 schedule. In the current investigation the participants were only required to engage in two different IBC topographies. If the current IBC was different from the previous one, the lag schedule was satisfied. This was a limitation because the IBCs satisfied the lag schedule; however, there were only a few IBC topographies that were required. This finding was consistent with operant variability research that suggests subjects will switch between a few responses when lower lag values are in effect (Page & Neuringer, 1985, 2012; Silbaugh et al., 2017; Susa & Schlinger, 2012). Future research can explore higher lag values effect on IBCs to address switching. In Experiment 3, Page and Neuringer gradually increased the criterion for reinforcement to up to 50 sequences (Lag 50 schedule). The results of Experiment 3 showed that pigeons generated variable sequences with increasing lag values. This manipulation could address the switching

observed toward the end of the experiment and promote more variable IBC topographies throughout. Additionally, IBCs that satisfy a higher lag value may be more meaningful in that they have multiple ways to produce the AP. It may be beneficial for IBCs to vary in a multitude of ways to produce the AP in an environment that changes rapidly and requires variability in IBCs.

Another indicator of variability includes the U-value. The U-value is defined as the relative distribution of frequencies among a set of responses (Page & Neuringer, 1985; Neuringer, 2002). The experimenters excluded this measure for the current study because of the nature of the preparation used to study IBCs. Unlike a pigeon pecking two keys in a sequence of 4, with 16 possible outcomes, the number of possible outcomes for IBC movement combinations was too high for a U-value to show meaningful sensitivity to socially valid levels of variation. As a result, any U-value would be insignificant regardless of how much the IBCs varied. Part of the U-value calculation includes the number of possible outcomes and in the current preparation there were thousands of possible outcomes.

Manipulating an experimental preparation can affect the type of observation made by the experimenter (Sidman 1960). Carvalho et al. (2017) increased the board size to promote variability in IBCs. Future research could explore alternative preparations that restrict the number of IBC topographies which would allow for a U-value measurement. A limitation of this is that experimenters would be restricting variability and potentially excluding other ways IBCs can possibly vary. Even if responses are limited to several possibilities, it may be more meaningful to see changes in a U-value with a smaller number of IBC topographies rather than a higher number of

IBC topographies. Including both the U-value and a lag schedule could provide more indicators of IBC variability than are present in the current investigation. Neuringer (2012) noted that there is no single measure of variability. Satisfying the lag schedule alone meets the requirements for the consequence delivery and can provide evidence of successful conditioning, while changes in the U-value can be used to assess absolute changes in variability.

The background colors at the start of each condition might be conceptualized as a part of the cultural-organizational milieu, or the context that the culturants were emitted in (Houmanfar et al., 2010). These colors consistently correlated with the CC; however, the randomized quadrants made contact with the contingency inconsistent. The IBCs could have varied or repeated in a way that produced the CC, however because it occurred outside of the target quadrant it did not produce the CC. Behavior analysis has emphasized prediction and control over behavioral phenomenon, often achieved through the manipulation of antecedent and consequent variables. It is important that the variables manipulated need to be controlled for in a way that allows the experimenters to argue a functional relation between the independent variables and the dependent variables.

Future studies could explore how to establish control over the IBCs in a changing cultural-organizational milieu. Recall that the cultural-organizational milieu is a term that describes the context that culturants are emitted in. For example, researchers could implement the Lag 1 schedule of CC delivery first for IBCs without the randomized quadrants. This would increase the likelihood that when the participants IBCs varied or repeated it would consistently produce the CC. After a pattern of variable or repetitive

responding, the randomization of quadrants would be introduced. This allowed researchers to observe how variable or repetitive IBCs. Further, it would also provide more convincing evidence that the variation observed was a function of the schedule manipulation and not extinction induced by the quadrants.

The current study included one property of the cultural-organizational milieu, which was color. Future studies could explore different properties of the cultural-organizational milieu or include multiple contextual variables within a metacontingency arrangement. The cultural milieu has been restricted to theoretical interpretations of past events. For example, Ardila Sanchez et al. (2019) analyzed cultural milieu factors by establishing what researchers described as community boundaries classified as psychological, geographical, and ecological. These boundaries helped the researchers analyze the cultural milieu factors that surrounded metacontingencies in Puerto Rico in response to Hurricane Maria. The IBCs and APs within metacontingencies changed over time in response to a changing cultural milieu. This analysis demonstrated how the cultural milieu can help behavior analysts understand how culturants within metacontingencies outside of an experimental environment developed. The colors in the current preparation were the conditions under which variable or stereotypic IBCs were emitted. Understanding the conditions under which culturants occur can be helpful in developing metacontingencies for social change. For example, Ardila et al. discussed the cultural milieu of a past event that involved multiple aspects of the environment that the metacontingencies were occurring in. In the current experiment, multiple aspects of the environment included the colors and the quadrants. Although not as extensive as those environment aspects found in Ardilla et al., it included more than one part of the

context that culturants are emitted in. The addition of multiple stimuli (colors, quadrants, rules, points, etc.) can help researchers understand how multiple aspects of an environment can come to control the recurrence of culturants. This positions behavior analysts to explore how the cultural milieu and cultural-organizational milieu play a role in metacontingencies outside of an experimental setting. Basic research exploring the cultural-organizational milieu and cultural milieu might provide a bridge into translational research.

The experimenter audio recorded the participants verbal behavior; however, they were not formally analyzed. Vichi et al. (2009) found that certain types of verbal interactions can be selected via a CC manipulation. Anecdotally, the current study provided indicators into how rules may have developed and changed over time as a product of the current manipulations. However, additional research exploring verbal behavior and communication between participants is needed. Glenn (1989) and Skinner (1953) described cultural phenomena as including communication and social contingencies. However, research that includes verbal behavior within networks contingencies is rarely explored. Smith et al. (2011) discussed plans to analyze the role of verbal behavior in producing the AP and outcomes in the context of crews of naval officers in command of Naval warships.

More recently, Ardila Sanchez et al. (2020) examined the effects verbal behavior had on IBC efficiency. Participants had a higher percentage of target products when they could communicate compared to when they were not allowed to communicate. These results suggest that verbal behavior improved the efficiency of target IBCs. Anecdotally, in the current study the participants formed rules after being exposed to

each condition. For example, the participants discussed what they needed to do prior to each condition starting. When their rule did not correspond to the contingencies, they would adjust and come up with a new rule at the start of their next exposure to the condition. The five-term metacontingency (Houmanfar et al., 2010) can help to conceptualize how this might look with the current investigation. Figure 6 depicts a five-term metacontingency for the current investigation. The 1) background colors would set the occasion for the 2) movements taken between each participant that 3) produced the meeting location, that is 4) changed by the message delivery, then the 5) group discussed what needs to be done. The group-rule formed becomes part of the cultural-organizational milieu. Given that any culture involves multiple individuals communicating with one another it would benefit our analysis to understand how this communication affects IBCs, APs, and culturants within the culture. The five-term metacontingency may offer a way to conceptualize.

Additionally, future research can create a more analogous experimental preparation by including multiple individuals. In the jazz quartet example discussed, there was a dynamic environment that included multiple people behaving with respect to one another, people were a part of the audience cheering, people were part of the venue that discussed the bands return, and people discussed tour dates. The current experimental preparation included two people; however, it is clear that metacontingencies outside of a lab include multiple individuals. There are several parameters that Xadrez included that can be manipulated. One option includes increasing the number of participants up to 4. Outside of an experimental setting, metacontingencies include multiple individuals which could affect how culturants

develop and maintain over time. Variability of APs and IBCs has only been explored in metacontingency arrangements with two individuals (Carvalho et al., 2017; Vasconcelos & Todorov, 2015). Future studies could explore how contingencies programmed for variable IBCs may affect verbal behavior with multiple individuals. Communication with more individuals in a metacontingency arrangement allows for a closer understanding of how communication between multiple individuals may be shaped and maintained over time as a result of the contingencies. It is likely that there are multiple individuals communicating in a culturant outside of an experimental setting rather than just two.

Contributions

Findings from the current study contributed to a growing literature base that utilized metacontingency arrangements to understand cultural phenomena. Additionally, the current study provided a way to explore variability in IBCs within a metacontingency beyond what has been previously observed (Carvalho et al., 2017; Vasconcelos & Todorov, 2015). The current study suggests that IBC variability may be affected by CCs similarly to how operant variability is affected by consequences. The inclusion of the cultural-organizational milieu with the changing quadrants and background color was an attempt to create an analogue to some of the dynamics in cultural phenomena that might be seen outside of an experimental setting. However, the ambiguity in the contingencies restricted current interpretations. Establishing the lag schedule prior to introducing the randomized quadrants helps to avoid extinction induced variability at the onset of the experiment. Future directions include replicating the current findings with more dyads to strengthen the external validity of the current findings. These findings will inform ongoing research that may include: 1) Introduce the lag schedule manipulation

prior to the changing quadrants to establish the history of lag schedules 2) exploring how verbal behavior may develop and change over time as a product of contingencies on variability of IBCs or APs, 3) gradually increasing the lag value to promote higher levels of variability or a lag schedule combined with changes in a U-value, 4) manipulating properties of the cultural-organizational milieu to understand how culturants may come under strict contextual control and create experimental environments more analogous to what is observed outside of an experimental setting, and 5) how to explore variability in IBCs of groups outside of an experimental setting, and understand why some groups solve problems and adapt to changes in the environment more efficiently than others.

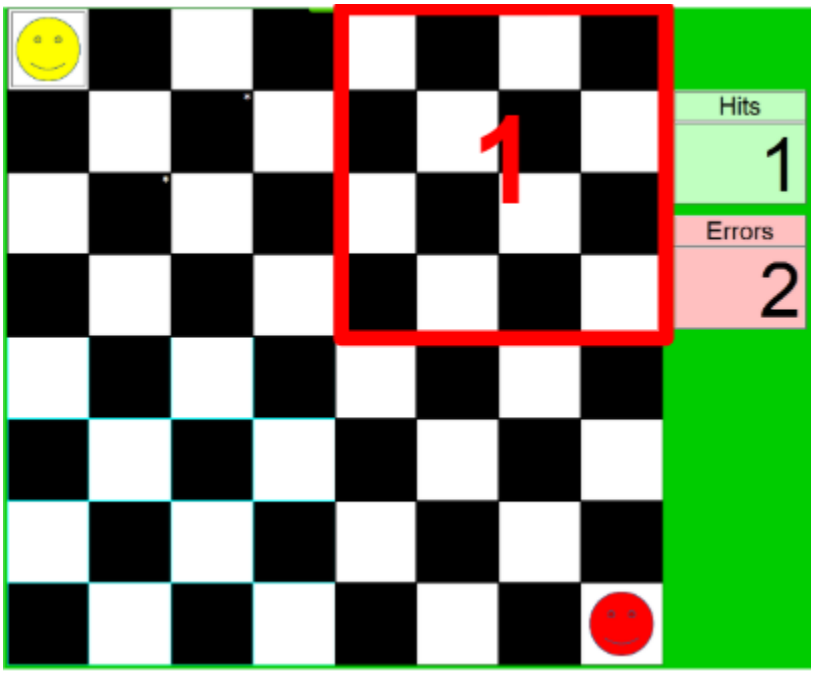

Figure 1. Xadrez presented an 8x8 board with modifiable elements that included two playing pieces, a box for hits and errors, and a colored background. Each player started on opposite corners with their pieces. Hits and errors are tracked on the right side of the screen. Each quadrant was a 4x4 area and the red square in the top right represents Quadrant 1. The middle 4x4 area of cells was Quadrant 2, and the bottom left 4x4 area of cells was Quadrant 3.

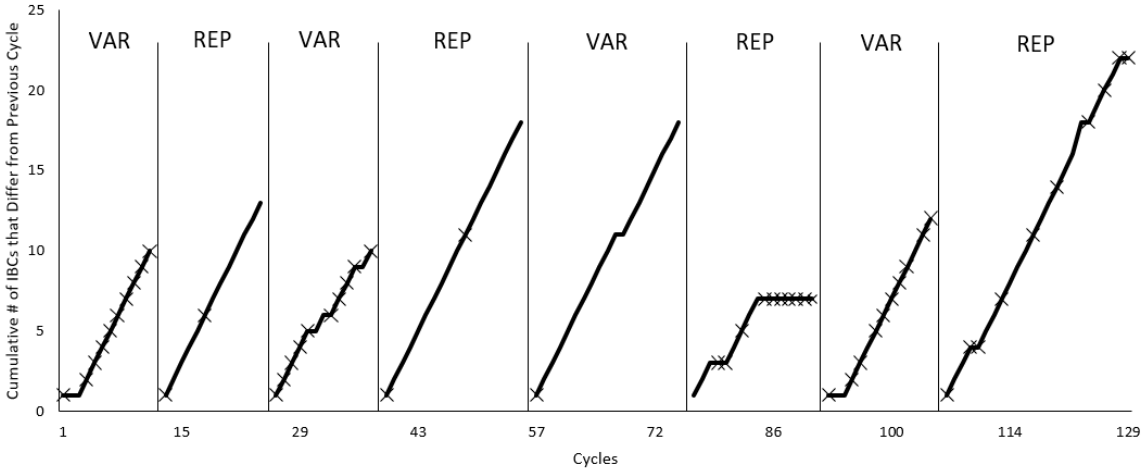

Figure 2. Cumulative number of IBCs that differ from the previous cycle for Dyad 1. The tick marks represent when a cultural consequence was delivered.

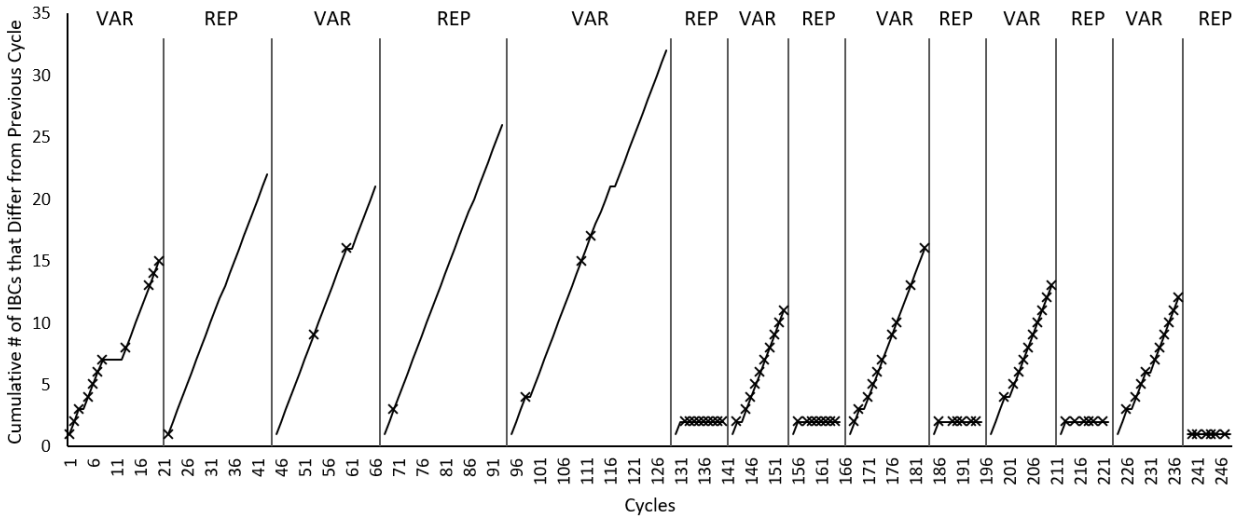

Figure 3. Cumulative number of IBCs that differ from the previous cycle for Dyad 2.

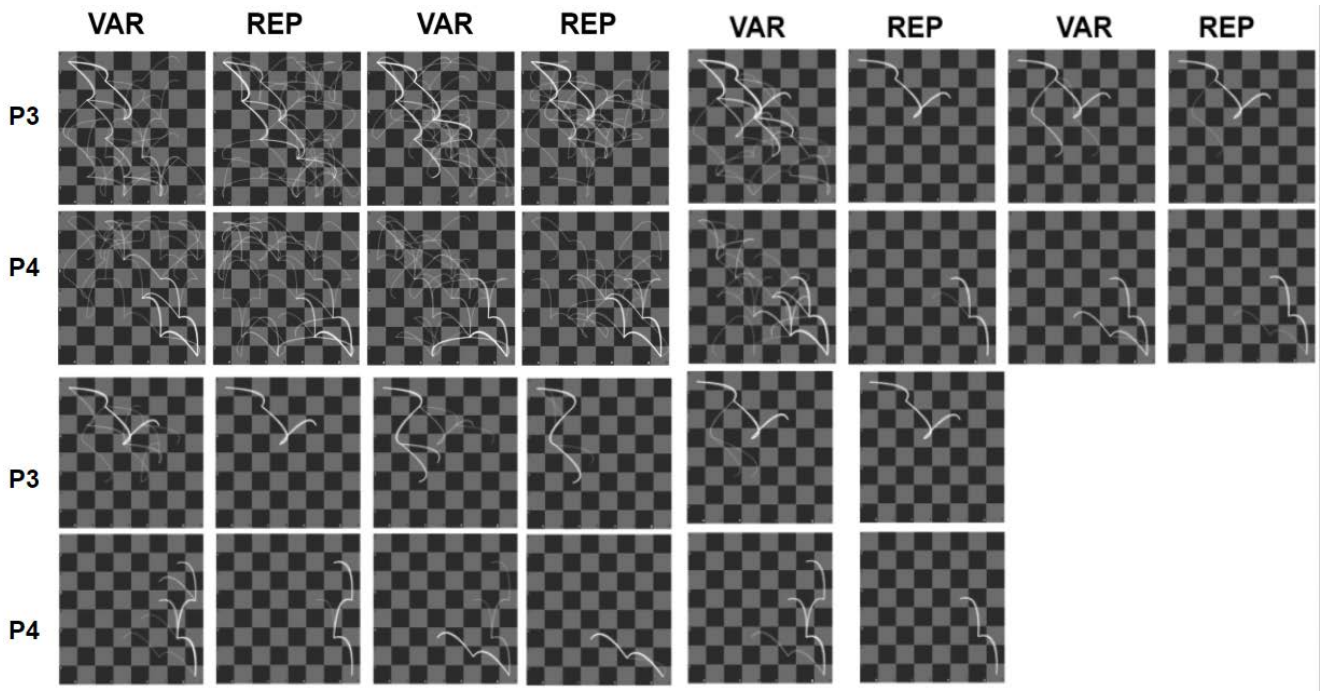

Figure 4. A visual representation of the cumulative movements made by each individual participant over time in each condition. This visual is read left to right, top to bottom. The top left single panel and the panel below it shows the first exposure to the VAR condition for both P3 and P4. From left to right shows the exposure to each condition throughout the experiment for both participants. Lines vary in thickness, with thicker lines indicating higher frequency of that path being taken and vice versa.

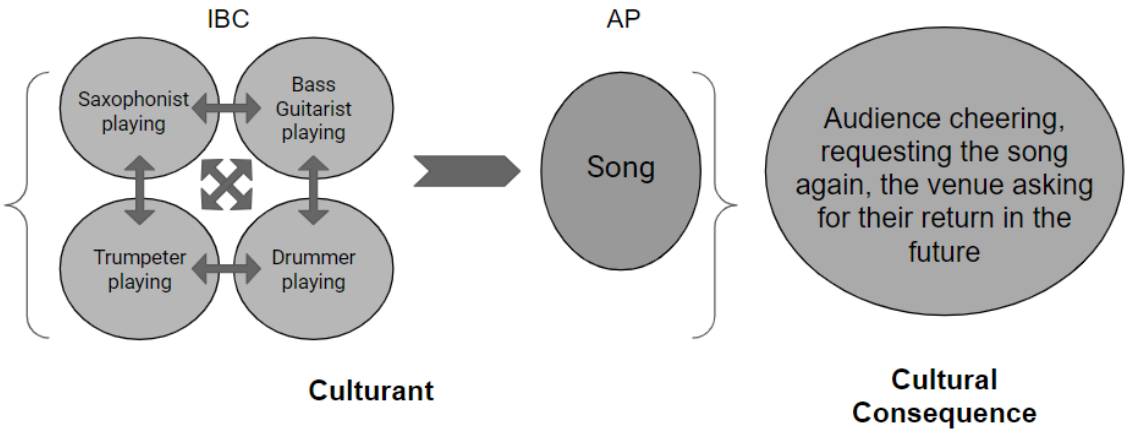

Figure 5. The interlocking behavioral contingencies, aggregate product, culturant and cultural consequence involved in a jazz quartet.

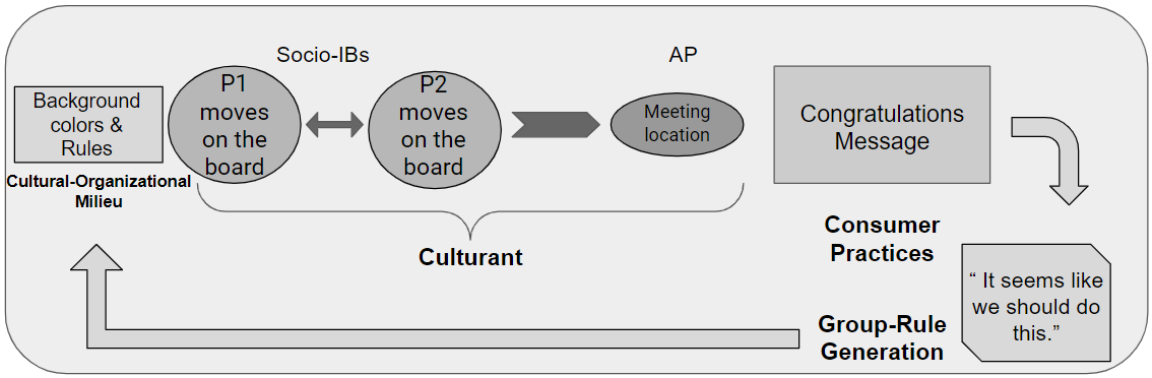

Figure 6. Conceptualized five-term metacontingency with the current experimental preparation. 1) Cultural-organizational milieu, the background colors and the rules formed , 2) socio-IBs, the movements between each player, 3) aggregate product, the meeting location, 4) consumer practices, the congratulations message, and 5) group-rule generation, the rule formed.

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APPENDIX

SUPPLEMENTAL MATERIALS

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 different opportunity to earn extra credit in the class if you cannot or do not wish to participate in the current investigation. 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

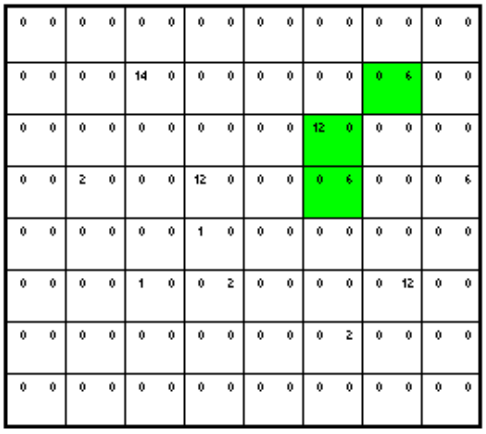
For the Investigator or Designee:

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

Condition B			Condition C		
15	10	10	15	10	10
Yes			Yes		
4		Q1	4		Q1
Corners			Corners		
10			10		
4			0		
0:02:44			0:01:33		
Move	Time	Event	Move	Time	Event
2;3	0:00:07	Player 1		0:00:00	Begin
7;6	0:00:09	Player 2	2;3	0:00:02	Player 1
4;2	0:00:11	Player 1	6;7	0:00:05	Player 2
6;4	0:00:12	Player 2	4;4	0:00:07	Player 1
6;3	0:00:13	Player 1	4;6	0:00:12	Player 2
0	0:00:13	Error	3;6	0:00:13	Player 1
	0:00:15	Begin	0	0:00:13	Hit
2;3	0:00:17	Player 1		0:00:14	Begin
7;6	0:00:19	Player 2	2;3	0:00:16	Player 1
4;2	0:00:21	Player 1	6;7	0:00:17	Player 2
6;4	0:00:22	Player 2	4;4	0:00:21	Player 1
5;4	0:00:23	Player 1	4;6	0:00:22	Player 2
0	0:00:23	Error	3;6	0:00:23	Player 1
	0:00:25	Begin	0	0:00:23	Hit
2;3	0:00:27	Player 1		0:00:24	Begin
6;7	0:00:29	Player 2	2;3	0:00:25	Player 1
4;4	0:00:30	Player 1	6;7	0:00:27	Player 2
4;8	0:00:31	Player 2	4;4	0:00:28	Player 1
3;6	0:00:33	Player 1	4;6	0:00:30	Player 2
2;7	0:00:34	Player 2	3;6	0:00:31	Player 1
0	0:00:34	Hit	0	0:00:31	Hit
	0:00:37	Begin		0:00:33	Begin
2;3	0:00:39	Player 1	2;3	0:00:35	Player 1
6;7	0:00:41	Player 2	6;7	0:00:36	Player 2
4;4	0:00:43	Player 1	4;4	0:00:38	Player 1
4;8	0:00:45	Player 2	4;6	0:00:39	Player 2
3;6	0:00:46	Player 1	3;6	0:00:40	Player 1
2;7	0:00:47	Player 2	0	0:00:40	Hit
0	0:00:47	Error		0:00:42	Begin
	0:00:49	Begin	2;3	0:00:44	Player 1
2;3	0:00:50	Player 1	6;7	0:00:46	Player 2
6;7	0:00:51	Player 2	4;4	0:00:48	Player 1
4;4	0:00:53	Player 1	4;6	0:00:49	Player 2
4;6	0:00:56	Player 2	3;6	0:00:50	Player 1
3;6	0:00:57	Player 1	0	0:00:50	Hit

Synthesis - Condition B



Synthesis - Condition C

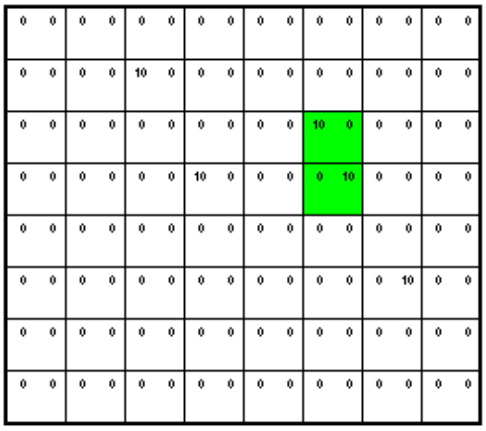


Figure A1. Sample of output data via Xadrez.

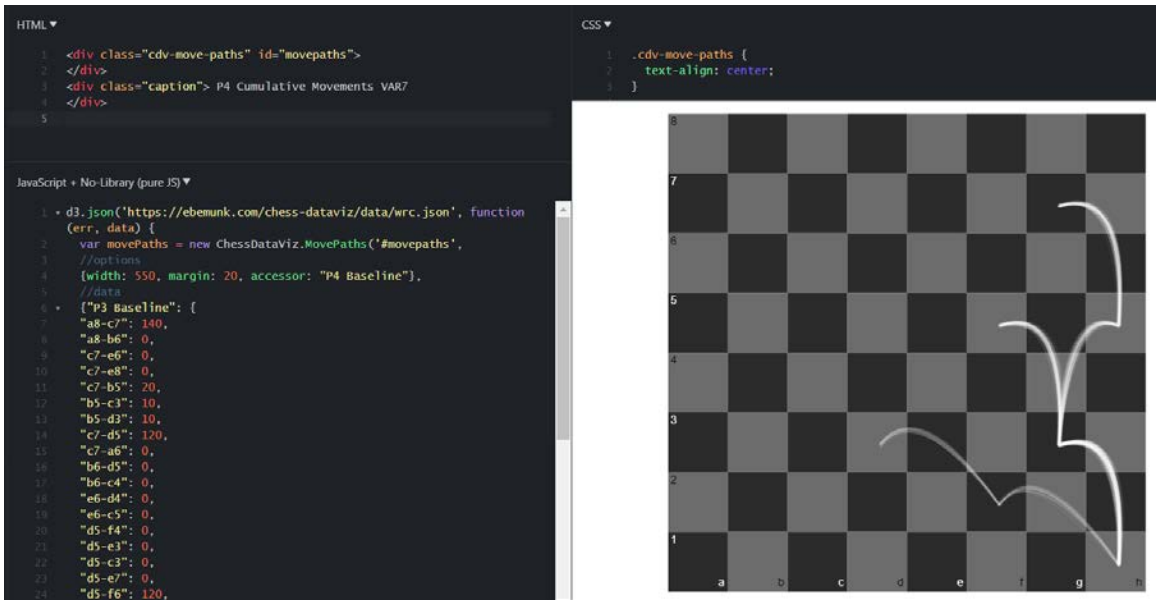


Figure A2. Sample of JSFiddle Interface with raw data.