Effects of Metacontingencies on Cooperative Behavior: A Systematic Replication Using Innovative Procedures during Isolation

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Abstract

The study replicated research on metacontingencies that used a chessboard simulating a simplified chess game, in a completely online environment, with participants in their homes. Dyads of participants had to work together moving two knights in L-shape. Each trial ended when the knights met in adjacent squares. The squares where the knights should meet (aggregate product [AP]) varied in two conditions, using an ABAB design. In conditions A, knights should meet anywhere on the chessboard, and there was no consequence. In conditions B, the matrix of reinforceable squares was gradually reduced in four phases and knights' encounters were followed by different messages when correct or incorrect (cultural consequences). In group 1, five dyads were allowed to communicate. In group 2, dyads had no access to video call. Results of group 1 corroborate the findings of the original studies that showed a decrease in APs variability from conditions A to B, when communication was allowed. Group 2 showed similar results, therefore extending to the setting that not allowed communication. The online platform XadrezWeb, developed for this study, was an important tool to program the interlocked behavior contingencies and collect data during social isolation.

Keywords Metacontingency · selection by consequences · shaping, social behavior · online game · humans

The research field of cultural practices in behavior analysis has developed the term “metacontingency.” Metacontingency refers to interlocked behavior contingencies that result in aggregate products, which are selected by

cultural consequences (CC; Glenn, 1986; Glenn et al., 2016; Todorov, 2012; Todorov & Moreira, 2004). Interlocked behavioral contingencies (IBCs) are social contingencies concerning the behavior of two or more people, where the behavior of one person is a discriminative stimulus (S^D) for the emission of an operant response by the other person (Carvalho & Sandaker, 2016; Glenn, 1991). The product of the IBCs is known as the aggregate product (AP). In many of these conditions, individuals engage in cooperative behaviors, which occur when “people get together to accomplish some specifiable task” (Marwell & Schmitt, 1975, p. 1).

Recent research on metacontingencies used a chessboard simulating a simplified version of a chess game (Azevedo & Todorov, 2016; Carvalho et al., 2017; Vasconcelos & Todorov, 2015; for a review, see Todorov et al., 2020). These experiments explored the concepts of variability, shaping, and stimulus discrimination at a cultural level, when two persons interact in a simplified playing setting.

Vasconcelos and Todorov (2015) and Carvalho et al. (2017) investigated interlocked behavior contingencies in a metacontingency using a program called “2 cavalos” (2 knights). Participants worked in pairs, moving the

João Claudio Todorov is deceased. This paper is dedicated to his/her memory.

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knights in an L-shape on an 8 x 8 chessboard. Data collection occurred in a laboratory room with participants working on computers placed on opposite sides of a table and they could talk to each other during these sessions. The knights had to meet in adjacent squares. In experiment 2 of Vasconcelos and Todorov, and experiment 1 of Carvalho et al., the squares where the knights should meet (AP) varied in two experimental conditions: baseline (extinction) and shaping in an ABAB design. In baseline conditions (A), trials ended when the knights met anywhere on the chessboard, and there was no consequence. In shaping (B), when knights met, the message “Congratulations, you won!” appeared on the screen, and the matrix of reinforceable squares was gradually reduced throughout four phases. In Vasconcelos and Todorov's study, the area decreased towards the center of the chessboard; in Carvalho et al.'s study, the area decreased towards one of the corners of the chessboard. The goal was to analyze the shaping procedure and its process in an experimental analog of metacontingency. Vasconcelos and Todorov conducted another experiment (experiment 1) in which the second Baseline was a signaled extinction, with a feedback message "End of trial, try again" following all knights' encounters. Carvalho et al. also reported a second experiment (experiment 2) to evaluate the effect of longer exposure to the Shaping condition. Variability indexes of APs were smaller in shaping conditions than in baselines for both studies (experiments 1 and 2).

More than manipulating independent variables, a distinctive feature of science is prediction followed by observation and confirmation. Also, replicating an experiment in other laboratories (and different contexts) improves confidence in the continuity of studies on the topic (Sidman, 1960). Thus, this research aimed to verify whether the results found by Vasconcelos and Todorov (2015; experiment 2) and Carvalho et al. (2017; experiment 1) would be replicated in a different setting: the online environment during social isolation caused by the pandemic of COVID-19.

In the present study, two experimental groups were exposed to the same experimental conditions and varying the access to verbal interactions. Studies regarding communication in metacontingencies suggest that it may facilitate the establishment and maintenance of peer cooperation and, in consequence, promote a significant increase in performance efficiency (e.g., Ardila-Sánchez et al., 2020; Costa et al., 2012; Sampaio, 2020). In group 1, dyads were allowed to communicate (as in the original study), and in group 2 they were not allowed. The different settings that allowed or did not allow communication aimed to verify whether the original studies could be replicated regardless of availability of communication by video call.

Method

Participants

Ten pairs of human adults, nine women and 11 men, aged between 18 and 45 years, were recruited through virtual invitation, using the snowball method (messages distributed voluntarily and exponentially by users of social networks). Participants accepting the invitation received a link to access the form on Google Forms that included the informed consent form, which had to be accepted after reading. Another four pairs did not complete the experiment within the maximum established time and were excluded from data analysis. This research was approved by the CEP/CHS Ethics Committee.

Materials and Instruments

Based on the software used by Vasconcelos and Todorov (2015), we developed and used the online data collection platform XadrezWeb (www.xadrezweb.psc.br). This software uses a chessboard and two to four chess knights. It records for each trial of the experiment: number of moves, correct responses, latency (ms), trial duration (ms), and location of the meeting.

To start a session, the experimenter sent the login information to the participants in an email or WhatsApp message about 10 min before the appointed time. Participants and the experimenter accessed the XadrezWeb platform using their personal computers in their homes. All sessions were monitored by an experimenter who kept their camera and microphone turned off. Dyads that had permission to communicate also received the link to start a Google Meet call. Video calls could be initiated in the participant's computer or cell phone. The audio and video of the calls were not recorded.

Procedure

Ten dyads were formed by convenience, using their information about the time and dates for the experiment. Dyads were randomly and equally distributed into groups with (group 1) and without (group 2) video call available.

The experiment used a virtual chessboard 8 x 8 with two pieces, the knights, which moved in L-shape when the participants clicked on any correct square. Every trial started with knights placed in opposite corners (A1 and H8) and ended when knights met in adjacent squares (AP).

For both groups, consequences for producing the AP varied between conditions, using a reversal design ABAB:

A—Baseline The pair could meet anywhere on the chessboard and there were no consequences. After the knights meeting (AP), a new trial started with no messages. This condition lasted 10 trials.

B—Shaping Shaping was divided into four phases. In phase 1, the message “You won” (CC) appeared on the screen when the knight pair met on any of the 64 squares of the 8 x 8 board (AP). In phase 2, the CC was presented when the two knights met on the 36 central squares (6 x 6) of the board. In phase 3, the message “You won” was shown on the screen when the knights met at the 4 x 4 central area of the board, that is, the 16 central squares. In phase 4, CC was presented only when the pieces met on the four central squares (2 x 2).

For phases 2–4, when the AP was formed with one or two knights outside the defined area, the consequence was the message “End of round. Better luck next time.” The change criterion for all phases in shaping condition was AP formation (knights meeting in predefined areas) in seven consecutive trials.

At the beginning of the experiment, subjects read the following instructions (translated from Portuguese):

Hello! From now on, you will do an activity together. Each player will have one piece, the chess knight, and you must move it on the chessboard. To move it, just click on the square where you wish to place your piece. The knight moves in *L-shape*, that is, two squares to one side and one square to the other side, in any direction. This is the only movement it can do. Each round starts with the knights placed in opposite corners of the board. The player with the highlighted square will start that round. Players must take turns moving their knight and cannot skip their turn. *The round ends when both knights meet on the board.* Pieces can meet in three different ways: side by side, facing each other, or diagonally. First rounds are for reconnaissance. After this stage, at the end of each trial, you will get a game message, which may be: “*YOU WON.*” or “*END OF ROUND. BETTER LUCK NEXT TIME.*” The goal of the game is to win most rounds. You *will not be able* to access the instructions during the experiment, so make sure you have understood them. Shall we start?

After clicking “ok” on the instruction window, the chessboard appeared on the screen with participant 1’s knight at the top left square and participant 2’s at the bottom left square of the chessboard. Each trial started with a highlighted square indicating which player should make the first move and ended when both knights met on adjacent squares (i.e., when participants formed the AP). Along the experiment, participants’ turns were alternate.

When the dyad ended phase 4 of the second shaping condition or 2 hr of the session had elapsed, the message “End of experiment! Thank you for participating” appeared on the screen and the experiment ended. Dyads that could not conclude the four conditions in 2 hr were dismissed from the experiment.

Results

There was no mention by participants about instability of the internet connection during the experiment. All participants in group 1 (video call available) effectively used the audio of the call to communicate, although verbal interactions and their duration were not recorded.

The variability index of APs was calculated as the number of occupied squares when the APs were formed throughout the trials, divided by the number of squares where the APs could have occurred (e.g., index 1.0 for the last seven trials indicated that throughout those trials 14 different squares had been occupied; on the other hand, the smallest value for this measure within seven trials would be $2/14 = 0.1429$, meaning the AP always occurred on the same two cells).

Figure 1 shows the variability index, calculated for the last seven trials in the last phase of each experimental condition. Variability of the occupied squares when knights met was high for baselines 1 and 2 (closer to 1.0 than 0.142) and low in shaping 1 and 2 (closer to 0.142 than 1.0). The exceptions are dyads 5 (group 1) and 10 (group 2), which did not recover baseline 2 variability index to level of baseline 1, and maintained similar levels as shown in shaping 1.

Discussion

Results of the present study showed the effects of the extinction and shaping contingency on variability of the APs produced by cooperation behavior between dyads, with high values in the baseline conditions and low values in the shaping conditions. These results replicate previous studies (Vasconcelos & Todorov, 2015—experiment 2; Carvalho et al., 2017—experiment 1) and extend to a different setting: a completely online environment during social isolation due to the pandemic, with participants in their homes.

The results found in baseline and shaping conditions corroborate the findings of the original studies (Carvalho et al., 2017; Vasconcelos & Todorov, 2015), which showed a decrease in APs variability with programmed CC. Further, these results demonstrate the usefulness of the shaping procedure used in operant research and applied to complex interlocked behavioral contingencies (e.g., Azevedo & Todorov, 2016; Pavanelli et al., 2014). Interlocked behaviors of dyads were successively approximated to smaller areas of

the chessboard when CCs were introduced to the IBCs and produced stereotyped IBs.

Both experimental groups, with and without video call available, replicate the differences in APs variability between baseline and shaping conditions (see Fig. 1). However, verbal interactions with secondary adjustment functions (Kantor, 1977), such as persuasion or the use of humor to evoke cooperation (Ardila-Sánchez et al., 2020) may affect other interlocked behavior measures, like trial durations and/or the number of moves per trial to produce the APs. This effect, if it happened, was not systematic in the present study, because differences between groups were not significant for both measures of baseline (t -test, $p = 0.09$ for trial duration; $p = 0.48$ for moves) and shaping conditions (t -test, $p = 0.48$ for trial duration; $p = 0.14$ for moves). Therefore, results of groups 1 and 2 showed a clear replication and extension of

Vasconcelos and Todorov (2015) and Carvalho et al. (2017) regardless of communication.

Online programs, such as XadrezWeb, may ease and increase the precision of experimental replication. They provide behavioral research with alternative ways to collect data during social isolation and participants with restricted access to laboratory facilities. These research tools may also allow researchers to reach a larger and broader sample, which enables and encourages cross-cultural studies needed in behavior science.

Author's contribution All authors contributed to the study conception and design. Platform XadrezWeb was developed by João Vianney B. C. Severo. Data collection were performed by João Guilherme S. Casalecchi, Marina S. Mendes and Sofia V. Nishiyama. Data were analyzed by all authors. All authors contributed to the first version of the

Fig. 1 Variability index of PAs in the last seven trials of baseline and Phase 4 of the shaping conditions for the dyads with and without video call available

manuscript. Only João Claudio Todorov have not read and contributed to the revised version of the manuscript due to his death in July 7, 2021.

Data Availability All data and materials as well as the software application or custom code support journal published claims and comply with field standards. Data deposition is in Research Gate of the last author's account at https://www.researchgate.net/publication/344966513_Experiment_EAB_group#fullTextFileContent. Software XadrezWeb may be shared with other researchers by request to authors.

Declarations

This research involved human participants and, therefore, was submitted and approved by Research Ethics Committee of Brazil (<https://plataformabrasil.saude.gov.br/login.jsf?jsessionid=C04DA6BED78CCD2068E0305124FE1393.serverplataformabrasil-srvjpdf130>). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Informed Consent Informed consent was present to each participant before experimental session started. Digital agreement in the form was required to start the experiment.

Conflict of Interest No potential conflict of interest was reported by the authors.

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