

# Effect of Resource Scarcity on Dyadic Fitness in a Simulation of Two-Hunter Nomocloners

## Efectos de la escasez de recursos sobre la adaptabilidad diádica en una simulación de nomoclonos de dos cazadores

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### Resumen

Se condujeron dos experimentos en una Universidad en la cual diadas de estudiantes participaron en una simulación de cazadores que debían compartir su presa para mantener la adaptabilidad diádica (grupal). El compartir era una contingencia conductual entrelazada que contribuía a la supervivencia de la diada, conceptualizada como un nomoclón de cacería (Harris, 1964). La simulación incluyó seis temporadas de caza consecutivas en las cuales la variable antecedente de la escasez de presas fue manipulada como variable independiente. Los resultados del primer experimento no mostraron diferencias en la adaptabilidad diádica como función de la escasez de presas. En el segundo experimento, la diferencia entre condiciones de pobreza y riqueza se aumentó. En las condiciones de riqueza, todas las diadas se desempeñaron de forma similar a las del primer experimento. Sin embargo, en las condiciones de sucesiva pobreza, las diadas comenzaron menos adaptadas pero aumentaron su adaptabilidad progresivamente. De este modo, compartir contingencias entrelazadas fue más

### Abstract

Two experiments were conducted in a college where students in dyads participated in a simulation of hunters who were required to share prey in order to maintain dyadic (group) fitness. The sharing was an interlocking behavioral contingency contributing to survival of the dyad, conceptualized as a hunting nomocloner (Harris, 1964). The simulation comprised 6 consecutive hunting seasons in which the antecedent variable of prey scarcity was manipulated as the independent variable. Results of the first experiment did not show a difference in dyadic fitness as a function of prey scarcity. In the second experiment the difference between poor and rich conditions was increased. In rich conditions, all the dyads performed similarly to those in the first experiment. However, in successive poor conditions, dyads started out less fit and became increasingly fit. Thus, sharing IBCs were more difficult to form under significant scarcity, but they became more frequent over time. The experiment is discussed in the context of Skinner's view (1981)

difícil en condiciones menos significativas de escasez, pero las mismas se hicieron más frecuentes con el tiempo. El experimento se discute a la luz de la visión de Skinner (1981) sobre la evolución cultural, la taxonomía de cosas culturales de Harris (1964) y la formulación de metacontingencias de Glenn (1988, 2004).

*Palabras clave: análisis cultural, contingencias conductuales entrelazadas, metacontingencias.*

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In *Selection by Consequences*, B. F. Skinner (1981) accounted for human behavior in terms of three kinds of selection. He compared operant conditioning, as a second kind of selection, to natural selection and suggested that a third kind of selection was involved in the evolution of cultures. "A culture evolves when [its] practices... contribute to the success of the group in solving its problems. The effect on the group, and not the reinforcing consequences for individual members, is responsible for the evolution of cultures" (Skinner, 1981, p. 502).

Skinner's 1981 article was reprinted in 1984 as the subject of commentaries by scholars in numerous disciplines. Among the commentators it was the cultural anthropologist Marvin Harris, who began by acknowledging his "fundamental agreement with Skinner's positivism and materialism and [his] own intellectual grounding in reinforcement principles as taught by William Schoenfeld and Fred Keller..." (Harris, 1984, p. 490). Harris then called the "group" in Skinner's statement quoted at the end of the last paragraph "an epistemological lapse (unoperationalized entity)". In his taxonomy of "cultural things", Harris distinguished among different types of phenomena commonly called "groups" and explained that these various kinds of groups play different roles in the analysis of cultures. Of current interest are those "groups" that Harris (1964) designated as *nomoclonas*.

Nomoclonas, like all "cultural things", begin with individual human behavior; but they do not end there. Identifying a nomoclone entails identifying specific actors performing at a particular place, who repeatedly behave with respect to one another's behavior and behavioral products in particular ways. An example of a nomoclone given by Harris is the crew of a fishing boat who repeatedly "meet only for performances of a series of idioscenes

about cultures evolution, Harris's (1964) taxonomy of cultural things, and Glenn's (1988, 2004) formulation of metacontingencies.

*Keywords: Cultural analysis, experimental analysis, interlocking behavioral contingencies, metacontingencies*

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of the 'same' scene", i.e., fishing episodes (Harris, 1964, p.115). Harris clarifies that the nomoclone is identified both by its particular individual participants and by the repetition of their interrelated performances. We view these repetitions as constituting the interlocking behavioral contingencies (IBCs) that Glenn (1988, 2003, 2004) suggested as the cultural level units undergoing selection by "metacontingencies". Sometimes, Glenn (e.g., 1988; 2003) viewed the product of the IBCs as the selecting agent; at other times, the product was itself part of the unit undergoing selection (e.g. Glenn, 2004; Glenn & Malott, 2004). The fact that metacontingencies can work in either way is suggested.

Vichi, Andery and Glenn (2009) reported an experiment in which metacontingencies worked in the latter way. In their experiment, specific IBCs were required to achieve a group monetary consequence that was contingent on the product of IBCs. In this metacontingency arrangement, the contingency between IBC products and the group consequence was manipulated. Depending on condition, the group consequence was contingent on either equal or unequal distribution of proceeds in the previous round. The distributions (products of the group IBCs) conformed to the requirements of the metacontingency. No participant reported verbalizing the relation between previous distribution of proceeds and subsequent group earnings.

In the present experiments, products of the interlocking behavioral contingencies are viewed as consequences of the IBCs and the metacontingency is held constant while antecedent environments are manipulated as the independent variable. The experiments draw on the method of Ward, Eastman and Ninness (2009), who developed an experimental analog of 2-person nomoclonas. They

viewed Harris as suggesting “a negative correlation between production efficiency and resource sharing” (Ward et al, p. 60) and they sought to model that relation by manipulating production efficiency in a simulation of hunter/gatherer dyads in which resource sharing was the dependent variable. Participants obtained “resources” on each trial and were required to expend a resource to continue playing. If a player did not have resources to continue playing, that player “went out” and lost all resources previously obtained. This also made it more likely that the other player would go out. There were six experimental conditions beginning with a condition that provided a steady supply of resources to both members of the dyad. Intense scarcity of resources characterized the second condition, and increasingly less scarcity (greater production efficiency) characterized each successive condition. Opposite to the predicted negative correlation between sharing and production efficiency, sharing occurred a total of only four times for all four dyads combined across all six conditions. Those rare occurrences of sharing were in conditions of less scarcity (greater production efficiency).

The researchers reasoned that allowing participants who “went out” to keep resources earned in conditions where they hadn’t gone out did not model hunter-gatherer conditions very well. In a second experiment, three more dyads were exposed to the same conditions with one change in procedure: Restarting after going out resulted in loss of all tokens in a player’s possession, including those acquired in past and current conditions. One dyad showed a general trend toward increased sharing across Conditions 3-6, thus a clear *positive* correlation between resource sharing and production efficiency. One dyad had no sharing/group saves, and one dyad had one sharing/group save in the last condition.

In these experiments, the selection of a hunting nomocloner in which a specific IBC is required to produce dyadic fitness (ability to hunt) was modeled. This reflects the earlier metacontingency formulation in which the product of the IBCs selects its properties and thus differs from Vichi et al. (2009), who modeled the later formulation of metacontingency. These experiments differ also in that the antecedent environment while the relation between IBCs and product is held constant was manipulated. Vichi et al. manipulated the cultural consequence.

The experiments herein are based on the method used in Ward et al. (2009). Their procedures to study the effect of prey scarcity on dyadic fitness when sharing requirements for survival were the same under all conditions and it was adapted during procedures. Besides, the procedures of the Ward et al (2009) study and automated them for computer delivery were simplified.

## General Method

### Overview

Two experiments were conducted in which subjects participated in dyads functioning as nomocloners. The members of each nomocloner “hunted” independently, each returning with a quantity of rabbits on each trial. Each participant was required to “eat” a rabbit to continue to the next trial. Remaining rabbits could be “stored” for one trial, “traded” for money, or “shared” (given to the other participant). Dyads hunted for six “seasons”. Each season was identified as offering either a “rich” environment or a “poor” environment, determined by the average number of rabbits the experimenters allowed the two hunters. Thus, environmental scarcity was manipulated as the independent variable.

The dependent variable was dyadic fitness, compared in Rich and Poor conditions. Dyadic fitness was defined as both participants being able to hunt and it was measured by the proportion of trials in a season that both participants hunted. The program was designed so that maintaining dyadic fitness through each season required both participants to give at least three rabbits to the other participant during the course of the season. That is, interlocking behavioral contingencies were necessary for survival of the nomocloner.

### Experiment 1 Method

#### Participants and Setting

Five females and one male, ages between 18 and 26, participated in three dyads. Three participants were undergraduate students, taking an introductory course in behavior principles, and three were behavior analysis graduate students. One dyad included two female undergraduates,



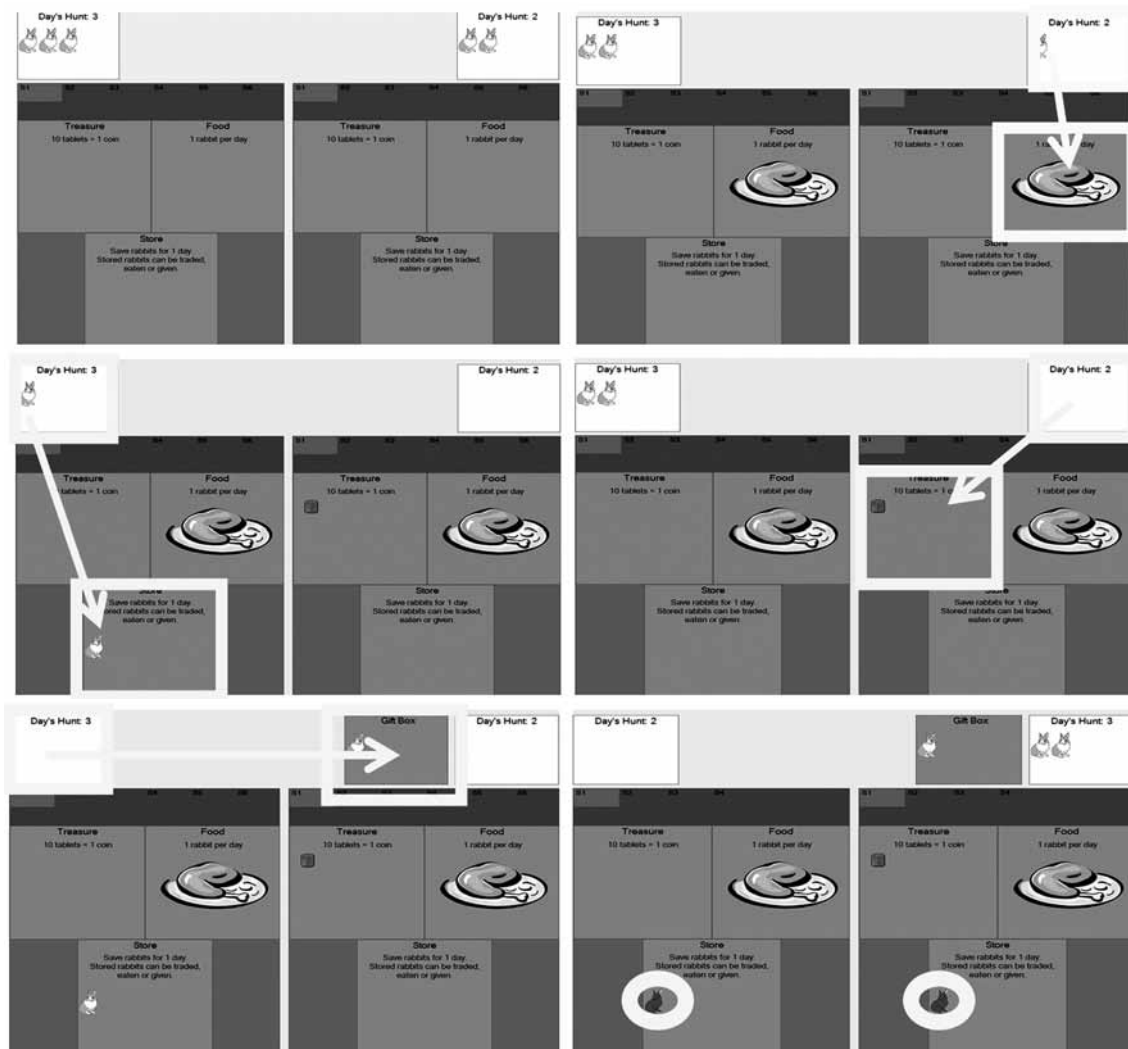


Figure 2. Schematics depicting elements of the experiment for two participants on shared computer monitor. The top left figure shows the beginning of the trial, when either participant pressed the key labeled “Hunt”. The top right figure depicts the screen when participants pressed the key labeled “Eat It”; the middle left figure depicts when participants pressed “Store”; the middle right figure depicts when participants pressed “Trade”; the bottom left figure depicts when participants pressed “Give” and the bottom right figure shows a rabbit in the store one trial after it was hunted (this rabbit is about to become inedible, so it changed colors from colorful to grey).

In each season, there were 10 trials in which each participant received only 1 rabbit. During seasons of “Poor” conditions there were 22 trials in which one or the other participant received 0 rabbits at different times, 14 trials in which one received 2 rabbits and 14 in which one received 3 rabbits. In “Rich” conditions participants received 0 rabbits in 14 trials, 2 rabbits in 18 trials, and 3 in the remaining 18 trials.

An Excel program was constructed to program the sequence of rabbits obtained in the experimental conditions. The sequence was designed to insure that in all conditions,

each participant was required to give a rabbit to the other at least 3 times in order for both to continue hunting throughout the entire 60-trial season. A situation where one participant had to give a rabbit in order for the other to continue hunting an “opportunity to save” was labeled.

### Data Collection

The program was designed to collect data on several variables so that it could be used by several experimenters. The variable of interest in the current experiment was how many cycles in a season both participants were fit to hunt



on the next trial. For dyad 3, the “needless giving” and “giving back” responses also became variables of interest, due to particularities of that dyad’s interlocked behavioral contingencies. All data were collected using the Visual Basic. NET and graphed using Microsoft Office Excel.

### Results

Figure 3 compares dyadic fitness in Rich and Poor conditions for Dyads 1, 2 and 3 when all Rich conditions for each dyad are combined and compared to Poor conditions for that dyad. There is no difference in overall fitness as a function of environmental scarcity, with the possible exception of Dyad 2. Dyad 1 was fit 204 of the 240 days (85%) in four poor seasons and 109 of the 120 (90.8%) hunting days in two rich seasons. Dyads 2 and 3 hunted 180 days when environmental resources were scarce (poor) and 180 days when environmental resources were more abundant (rich.); Dyad 2 was fit for 153 of 180 days (85%) in poor seasons and 180 of 180 days (100%) in rich seasons; Dyad 3 was fit for 168 of 180 days (93.3%) days in both poor and rich seasons.

Figure 4 displays the fitness data for the three dyads across alternating Rich and Poor seasons showing trends over time in fitness relative to environmental scarcity. Dyad 1 was fit for 46 of the 60 days of Season I (Poor), 49/60 days of Season II (Poor), 58/60 days of Season III (Rich), 51/60 days of Season IV (Rich). In the last two Poor conditions, Dyad 1 was fit 54 and 55 days respectively. Dyad 2 was fit for 33 days of Season I (Poor) and all 60 days in all subsequent seasons. Dyad 3 was fit for 54 days of Season I (Poor), 60 days in Season II (Rich), 54 days in Season III (Poor), 60 days in Season IV (Rich), 60 days in Season V (Poor), and 48 days in Season VI (Rich).

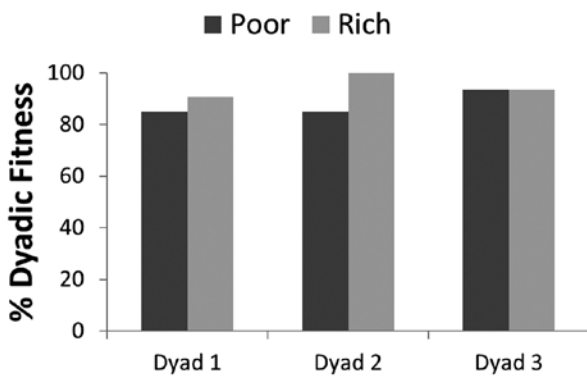


Figure 3. Overall dyadic fitness in Rich vs. Poor environments for three dyads.

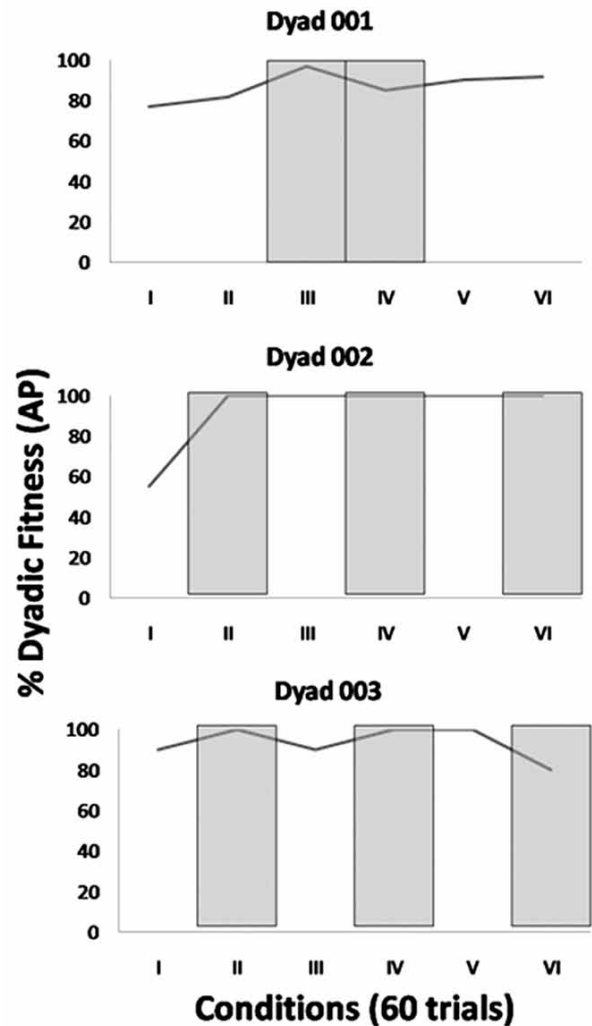


Figure 4. Dyadic fitness across alternating Poor and Rich environments for three dyads.

In Dyad 3, one participant or another sometimes gave a rabbit to the other when the recipient did not need one, and sometimes the recipient of this needless giving immediately returned the unneeded rabbit. In Figure 5, the cumulative record displays “needless giving” in Dyad 3 and the hash marks on the record represent the “giving back” in Dyad 3. The participants needlessly gave four rabbits in Season I (Poor) and no rabbits were returned. In Season II (Rich), participants needlessly gave 12 rabbits and seven of them were returned. In Season III (Poor), participants gave five rabbits and returned three. In Season IV (Rich), a participant gave one rabbit and it was returned. Three rabbits were given in Season V (Poor) and one was returned. One rabbit was given, and returned, in Season VI (Rich).



Figure 5. Dyad 3's needless giving (cumulative) and giving back (hash marks) across alternating Poor and Rich environments.

## Discussion

Figure 3 shows that overall dyadic fitness was not very different in Rich and Poor conditions. But when data are displayed over time it is possible to see that, in general, dyadic fitness was high in all Rich conditions, suggesting that sharing was easily achieved. The lower dyadic fitness for all three dyads in the first Poor condition cannot be unequivocally attributed to scarcity because Poor conditions were always experienced first. So the lower dyadic fitness in the first condition for all dyads probably represents the development of the IBC as the individuals in the dyad learned to behave with respect to relevant stimulus conditions. However, the changes in dyadic fitness over time for Dyad 1, and perhaps Dyad 3, suggest that the IBCs representing dyadic performance emerged and strengthened across all Poor conditions.

In the first experiment, the probability of getting 0 rabbits in the Poor conditions was 0.36 and the probability of getting 0 in the Rich conditions was 0.23. Therefore, there was not much difference in scarcity in the Rich and Poor conditions. In the second experiment the difference in the values of Rich and Poor conditions was increased, so that the probability of getting 0 in the Poor conditions was 0.46 and the probability of getting a 0 in the Rich condition was 0.16. In order to allow for that discrepancy, it was necessary to extend the seasons to 100 trials.

## Experiment 2

### Method

### Participants and Setting

Three females and one male, ages between 18 and 45, participated in two dyads. All were undergraduate students,

taking an introductory course in Behavior Principles. All were naïve with respect to concept of metacontingencies. One dyad included two female students, ages 20 and 23; and the other dyad included one 22-year-old female student and one 45-year-old male student. The experiment took place in a research room equipped with a table, three chairs and a computer. Stimuli, responses and delivery system were the same as for Experiment 1.

## Experimental Design

The level of environmental scarcity was the antecedent condition manipulated. Poor and Rich conditions were quantified as proportion of hunts that each player obtained 0 rabbits ( $p = .46$  in rich conditions and  $p = .16$  in poor conditions). Each dyad worked under two different conditions of environmental scarcity, shown in Table 1. A reversal A-B-A-B-A-B design was used, beginning with a poor condition. Dyadic fitness, measured as in Experiment 1, was compared in Rich and Poor conditions.

## Procedure

A sequence of 100 pairs of numbers (rabbits obtained from the 100 hunts) was programmed in Python for Experiment 2. In each season, there were 14 trials in which each participant received only one rabbit. The number of rabbits received on the remaining 86 trials differed for seasons in the "Poor" and "Rich" conditions. During "Poor" seasons there were 36 trials in which participants received 0 rabbits, 25 trials in which they received 2 rabbits and 25 in which they received 3 rabbits. While in "Rich" seasons participants received 0 rabbits in 16 trials, 2 rabbits in 35 trials, and 3 in the remaining 35 trials.

The dyads took part in one session comprising six "hunting seasons" of 100 trials each. Other elements of the procedure were the same as in Experiment 1.

## Results

Figure 6 shows overall dyadic fitness for Dyads 4 and 5, comparing performance for all Rich conditions to performance for all Poor conditions. Dyads 4 and 5 hunted 300 days, when the environment was characterized by scarcity (Poor), and 300 days when the environment was characterized by more abundance (Rich). Dyad 4 was fit for 199 of 300 (66.3%) days in Poor seasons and 262 of

the 180 (87.33%) hunting days in Rich seasons. Dyad 5 was fit for 146 of 300 (48.7%) days in Poor seasons and 252 of 300 (84%) of Rich seasons.

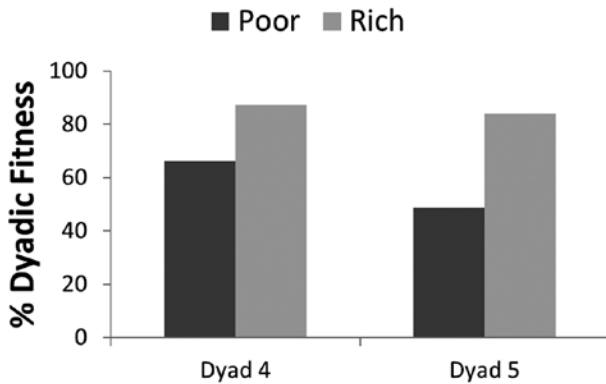


Figure 6. Overall dyadic fitness in Rich vs. Poor environments for two dyads

Figure 7 shows season by season dyadic fitness as the independent variable was manipulated across the six seasons. Dyad 4 was fit for 40 days in Season I (Poor), 100 days in Season II (Rich), 65 days in Season III (Poor), 71 days in Season IV (Rich), 94 days in Season V (Poor) and 91 days in Season VI (Rich). Dyad 5 was fit for 20 days in Season I (Poor), 89 days in Season II (Rich), 49 days in Season III (Poor), 100 days in Season IV (Rich), 89 days in Season V (Poor), and 77 days in Season VI (Rich).

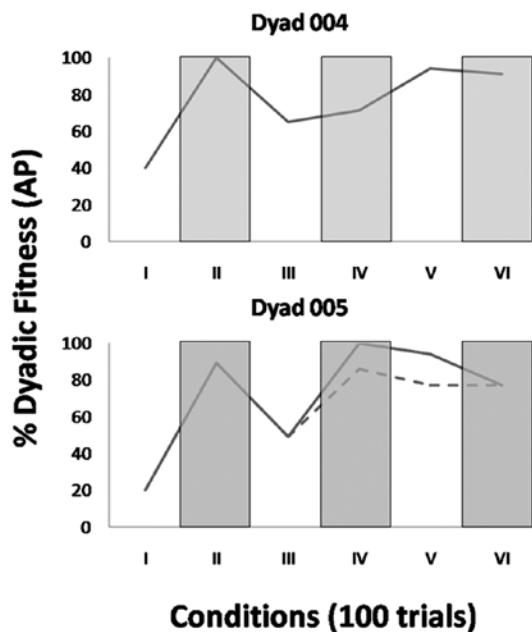


Figure 7. Dyadic fitness across alternating Poor and Rich environments for two dyads.

In Poor conditions, dyadic fitness was low in the first season and increased in each of the succeeding Poor seasons (III and V) for Dyads 4 and 5. Dyadic fitness was fairly consistent across Rich conditions. It dropped slightly in the fourth season for Dyad 4, increased again in the next Rich season (VI). For Dyad 5, dyadic fitness increased slightly from the first to the second Rich season (II and IV) and dropped slightly in the last Rich season (VI). In seasons IV and V, rapidly performing participants sometimes pressed the *Done* key “erroneously” (i.e., when they had rabbits to eat.) The data points connected by the dashed data path in Figure 7 depict results corrected for that error which was likely an artifact of the preparation.

## Discussion

The two dyads in the second experiment show an overall difference in dyadic fitness as a function of scarcity in the environment. A comparison of Figures 3 and 6 reveals that an overall quantitative difference in dyadic fitness as a function of scarcity, which was not clear in Experiment 1, is evident in Experiment 2. Further, it can be seen in Figure 7 that, given repeated opportunities for the dyads to function as a unit, IBCs consistent with requirements of the environment gradually form as Poor seasons are experienced. By the end of the experiment, dyadic fitness is as high in Poor as in Rich conditions for both dyads.

The experiments reported here as well as those reported by Ward et al. (2009) did not support the hypothesis that rich environments (or production efficiencies) are less likely to produce IBCs of sharing resources than are poor environments (inefficiencies). All the nomoclones in all the experiments showed as much or more sharing in richer environments. However, in Ward et al. environments became steadily richer over time, so the appearance of sharing at the end of their experiments may have resulted from continuing experience. In the current experiments, discrepancies between sharing in rich and poor conditions could not be attributed to continuing experience.

## General Discussion

The experiments reported here derived from the authors’ interest in similarities (and differences) in the formulations of Harris, Skinner, and Glenn with respect to cultural analysis.



All three of those authors posit reinforcement contingencies as the phenomena from which cultural processes emerge. However, the concept of *metacontingency* adds a dimension that neither Harris nor Skinner addressed, which is a cultural level unit (i.e., IBCs) that can undergo selection. It is thought Harris gave us a clue in saying “The cumulative shaping of individual behavior is precisely what cultural evolution is all about. Of course, these *behaviors are interrelated* and, in conjunction with various environmental and social feedback processes, *possess systemic* properties that are the logico-empirical basis for the concepts of society, culture, and sociocultural systems” (Harris, 1984, p. 491, emphases added).

In adopting the concept of nomoclon, groups as recurring interlocking behavioral contingencies in which two people produced outcomes (dyadic fitness) that contributed to the origin and maintenance of the IBCs were operationalized. The object of interest in the experiment was on the interlocking behavioral contingencies, not the organisms. This is similar to the focus in operant experiments on behavior rather than on the organism itself. In addition, the focus is on the relation of the IBCs to their antecedent and consequent environments rather than on the topography or controlling variables accounting for individual behavior of participants.

Perhaps it is important to highlight that performance of individual participants at some length and was unable to detect orderly changes in the operant contingencies for individual participants were examined. The research failure to detect regularities may have been due to the complexity of the experimental arrangement. The several ways in which a subject could respond on any given trial and the constantly varying stimulus conditions for each subject across trials may have presented a computational challenge we were not equipped to meet. It is also possible that operant contingencies embedded in IBCs can be highly variable and still meet the requirements of metacontingencies.

Finally, it is remarkable that close examination of Harris’s taxonomy of cultural things will yield further

opportunities for the extension of a behavior analytic world view to the evolution of cultures. And the study hopes the present experiments offer a preparation that can be used to investigate both antecedents and consequences in metacontingency arrangements. They represent one effort to construct an apparatus that allows measurement and experimental analysis of cultural level units.

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