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INTERINDIVIDUAL PERFORMANCE IN METACONTINGENCIES*

DESEMPEÑO INTERINDIVIDUAL EN METACONTINGENCIAS

José G. Ardila-Sánchez[1], Ramona A. Houmanfar
and Will Fleming
Department of Psychology, University
of Nevada-Reno, Reno, NV, USA

Abstract

The primary unit of analysis in metacontingencies are interlocking-behavioral contingencies (IBCs) measured by their aggregate product (AP). The experimental literature has demonstrated selection APs by factors external to the group (also known as "cultural consequences"). By contrast, social interactions occurring inside of IBCs have received little examination, although they constitute a key element to understand different types of social dynamics. In this study interindividual performance and verbal interactions of individuals inside of IBCs were examined. Communication between participants in dyads was experimentally manipulated such that some dyads wore noise-cancelling headphones while working together and other group of dyads used

* All procedures performed in this study involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments. Informed consent was obtained from all individual participants included in this study. Datasets analyzed during this study are available from the corresponding author on reasonable request.

1. Correspondence concerning this study should be addressed to José G. Ardila Sánchez, Department of Psychology/296, University of Nevada, Reno, Reno, Nevada 89557. E-mail: jose.ardila@nevada.unr.edu

headsets to talk to each other during the experimental session. Verbal interactions were measured using video/audio digital recordings. Three type of rules were presented to dyads to assess their effects on dyads performance under ambiguous circumstances throughout the task. Rules varied in their degree of ambiguity in each condition: high- (A), medium- (B), and low-explicit instructions (C). The order of rule presentation was alternated between groups. Our finding demonstrated significant differences in interpersonal performance between groups (verbal dyads vs nonverbal dyads). Overall, dyads spent more time engaging in cooperative verbal interactions than in any other type of verbal interaction, and similar acquisition patterns of these interactions were observed across dyads

Keywords: interlocked behaviors; metacontingency; interlocking behavioral contingencies; communication; verbal behavior

Resumen

La unidad de análisis en el estudio de las metacontingencias son las contingencias de conductas entrelazadas (CCE), medidas como parte de su producto agregado (PA). La literatura experimental ha demostrado la selección de PA en función de factores externos al grupo (también conocidos como "consecuencias culturales"). En contraste, y a pesar de que constituyen un elemento importante para la comprensión de las distintas dinámicas sociales, ha sido escasa la investigación que se ha realizado en trono a las interacciones sociales que ocurren al interior de la CCE. En el presente estudio, se evaluó el desempeño interindividual y las interacciones verbales de los individuos al interior de la CCE. Se manipuló entre diadas de participantes la comunicación, de tal manera que algunas de estas usaran audífonos con cancelación de sonido mientras trabajaban, mientras que el otro grupo de diadas utilizaban los audífonos para comunicarse entre sí durante la sesión experimental. Se midieron las interacciones verbales por medio de las videograbaciones de las sesiones. A cada diada se le presentó tres tipos de reglas para evaluar sus efectos a lo largo de la tarea. Las reglas

variaron según su grado de ambigüedad en cada condición: alto (A), mediano (B), y bajo (C); alternando su orden de presentación entre grupos. Se identificaron diferencias significativas en la ejecución interpersonal entre grupos (diadas verbales vs. no verbales). De manera general, las diadas emplearon mayor tiempo en interacciones verbales de cooperación que cualquier otro tipo de interacción, y se observaron patrones similares de adquisición de estas interacciones entre diadas.

Palabras clave: conductas entrelazadas; metacontingencia; contingencias conductuales entrelazadas; comunicación; conducta verbal.

The metacontingency provides an experimental basis to study cultural phenomena (Baia & Sampaio 2019, Zilio 2019). The main unit of analysis in metacontingencies are interlocking-behavioral contingencies (IBCs) measured by their aggregate product (AP), also known as "culturants" (*see* Glenn et al., 2016). Said another way, a metacontingency is a conditional (temporal) relation between culturants and external consequences (Glenn et al., 2016). It is generally assumed by researchers in this area of analysis that measurement of APs is a way to account for IBCs. The 'interlocks' in IBCs are sequential responses between individuals wherein the behavior of one is under the control by stimuli produced by the behavior of the other. In this context, a culturant as a unit of analysis deemed 'social' given the presence of two or more individuals (Schmitt 1998; Skinner 1953) and its measured effect on the environment via APs (i.e., a conjoint outcome of the interaction of individuals). As discussed by Houmanfar et al. (in press), the analysis of psychological phenomenon and sources of behavioral variation in the context of culturant (i.e., IBCs together with APs) which is identified as the fundamental unit of analysis in metacontingencies, can be expanded by further exploration of the role of the social episode (see Parrott, 1983) –which is the secondary sociobehavioral unit inside of IBCs. Houmanfar et al. (2010) conceptualized the social episode occurring inside of IBCs as interlocked behaviors (IBs), characterized by the shared history of the individuals with respect to

environmental factors. Moreover, the critical role of verbal behavior in this process is captured by a number of recent experimental studies in behavior analysis (*see* Smith et al., 2011; Smith et al., 2012; Johnson et al., 2010).

Language and metacontingency studies

The study of language phenomena in metacontingencies is primarily based on Skinner's (1953) analysis of verbal behavior and Glenn's (1991) analysis of cultural practices. From these vantage points, verbal interactions are understood in terms of their consequences on the environment, such as how the speaker's behavior or verbal stimuli affect recurrence of behavior products. It is also assumed that language phenomena support cultural selection in the forms of effective modes of communication via tacts, mands, and autoclitics (Skinner 1957, 1986). Moreover, the communicative function of language helps propagate ways of living and shared modes of behaving useful for cultural survival in established civilizations. The selection of verbal activities is said to be closely associated with survival practices, including the support of a myriad of cultural practices (Glenn 1991). In sum, the verbal behavior of individuals affects modes of communication as well as transmission of practices that are useful for cultural survival. The role of language in metacontingencies, then, is closely associated with propagation of effective IBCs generating viable APs (Glenn et al., 2016).

Five metacontingency studies have examined the role of language in selection of culturants by measuring frequency, duration of classes of verbal utterances, and generation of APs by group members (Costa et al., 2012; Hosoya & Tourinho 2016; Sampaio et al., 2013; Smith et al., 2011; Soares et al., 2018). For the most part, these researchers have examined verbal behavior in metacontingencies under the assumption that its primary function is to support transmission of practices among individuals or as consequence to establish operant behavior associated with generation of accurate APs. Hosoya and Tourinho (2016) examined the punitive and reinforcing functions of verbal utterances

in selection of IBCs generating correct APs in two microcultures. Their study used an ABAC design in which type of contingency (operant versus meta) and either allowing or restricting verbal interactions among participants were manipulated. Also, these verbal interactions were limited to the first five minutes following change of generation (i.e., new participants replacing old ones). Hosoya and Tourinho's findings indicated that verbal interactions may function as consequences for selection of IBCs. It is important to note that the extent to which verbal interactions were needed in the development of IBCs was not addressed in this study (Hosoya & Tourinho 2016).

Sampaio et al. (2013) analyzed differences in selection of IBCs generating APs in triads that were allowed to communicate versus those in which communication was restricted. Results from this study showed covariation in quantity of utterances and IBCs, suggesting that the effects of consequences on IBCs are mediated by verbal utterances (Sampaio et al., 2013). It was not possible to make further conclusions about the participatory role of language in selection of IBCs due to a small sample (four dyads total, one in the communication group). Verbal interactions of triads were only reported anecdotally but no functional analysis of language was provided. However, Sampaio et al. noted that some participants developed leader roles during the task, which bespeaks of the importance of accounting for rule-following and individuals' histories of verbal relations to explain variations of IBs inside of IBCs. More recently, Soares et al. (2018) examined effects of verbal and nonverbal consequences (i.e., different messages appearing in each participant computer screen) over production of culturants (i.e., IBCs and APs). Their results suggest that verbal messages have a selective effect on production and recurrence of IBCs.

Overall, the participation of language in metacontingency has been studied by measuring quantity of speaker utterances, analyzing transmission of instructions among participants and consistent generation of APs, and examining the effects of different forms of rules on participants' performance. These measurements of language phenomena have been developed primarily from Skinner's (1957) definition of

verbal behavior, which applies to the speaker and leaves the listener as a secondary element whose participation may only be limited to mechanical action. However, Skinner also acknowledged that we need to account for the total verbal episode in order to explain the "verbal" aspect in the interaction (1957, p. 34). In short, verbal interactions may be understood as the functions of the behavior of speaker and listener and the verbal properties of the setting (e.g., instructions, symbols, schematics, etc.) in which these relations occur.

For example, communication inside organizations may occur in the form of verbal products (e.g., rules passed from managers to employees) and depends on a history of verbal relations with those products (Houmanfar et al., 2009). Individuals may act as listeners in different ways depending on how rules affect their relational responding, such that some individuals may form rules allowing their behavior to be more susceptible to changing contingencies, while others may behave under the basis of a history of socially mediated consequences (Ghezzi et al., 2020; Rafacz et al., 2019)

Communication also occurs in the form of referential interactions, wherein speaker, listener, and referents participate in the context of a cultural environment. Referential interactions refer to a person's simultaneous reactions to a listener and a referent—the thing being talked about—, under a specific setting (Kantor 1977). The listener may be another person or the speaker herself (talking to oneself). A referent may be present or absent, concrete or abstract, existent or nonexistent. Setting conditions may be social, physical, psychological, or a combination of the three. These conditions affect the stimulus functions and response functions in an interaction. An analysis of verbal interactions can assist with our analysis of response variabilities in IBCs due to individuals' similar or shared histories of reinforcement.

The secondary adjustment function of verbal behavior (Kantor 1977) which captures the shared histories of individuals, presents another important feature of the dynamic interaction of individuals inside of IBCs. To define this additional function of verbal behavior, an emphasis is given to the use of speech to achieve determined results

beyond referential adaptations (i.e., completing a task). In this context, verbal behavior is analyzed in terms of ways by which (e.g., persuasion, humor etc.) the speaker evokes some action on the part of the listener, (e.g., cooperation). In other words, the analysis of verbal interactions constitutes not only the orientation to the task, but also individuals' adjustments to other factors in the cultural environment (*see* Houmanfar et al., 2010; Houmanfar et al., in press).

Measurement of secondary verbal adjustments may allow researchers to examine the relationship between social interactions and the contextual factors (*see* discussion of cultural milieu by Houmanfar et al., 2010 & in press) under which they occur. In the context of individuals interacting inside of IBCs, the speaker may indicate current, past, or future iterations of the task (i.e., lineages) and refer to an event that has occurred or is imaginary. The majority of metacontingency research thus far may be said to be derived from a similar experimental arrangement (i.e., Wiggins 1969; *see* Zilio 2019 for a complete review of experimental metacontingency literature) in which participants interact in a programmed sequence of steps to generate conjoint or aggregate products that must meet some selection criteria. In this process, the particulars of objects, events, or persons may include: (a) elements of or composite aggregate product, (b) group members, (c) participants' roles (if any), (d) other people (external to the group), and (e) institutional (if speaker's referent is about activities related to consumer demands, instructions, or rules inherent to the task). A majority of these factors may play a role in interpersonal and interprofessional dynamics, that is, in the recurrence (or nonrecurrence) of IBs that in turn affect the recurrence of IBCs and associated APs. In short, how verbal behavior participates in metacontingencies, in terms of the communication and secondary adjustment function of verbal behavior, warrants empirical examination.

Smith et al. (2011) examined effects of different forms of rules (explicit, implicit, and no rule; *see* the taxonomy of rules developed by Peláez & Moreno 1998) presented to dyads throughout their performance during an organizational task, conceptualized as a five-term

metacontingency analog. Individuals in dyads generated APs consisting of a rectangle and a circle by choosing correct color and size for each shape. Dyads achieved correct APs by correctly choosing, in a sequential manner, first the color and size for the rectangle, and later the same dimensions for the circle. The dimensions of the shapes were specified (in different degrees of explicitness) in the rule provided at the beginning of each trial. Smith and colleagues found that interindividual performance (measured as accuracy and number of APs) is influenced by ambiguity of the rules presented to participants. Their results indicate that higher percentage of correct APs are observed when working under explicit rules and higher response variability occurs under implicit rules. The authors also reported that dyads developed patterns of verbal interactions on the basis of their shared history by the end of the experimental task, however, the types of patterns were not reported in this study.

Smith and colleagues' (2011) research indicated two important aspects regarding the development of IBs inside of IBCs: (a) verbal interactions between individuals are needed to perpetuate occurrences of IBs and variations thereof; (b) generating correct APs does not necessarily indicate selection of associated IBs (Smith et al., 2011). We extended these findings by examining ways the level of ambiguity of antecedent factors(three degrees of explicitness in rules were presented to participants throughout the experimental task), may affect recurrence of IBs in dyads. We addressed two limitations pointed out by Smith et al. (2010) about their procedure. First, the time-criterion used to change conditions was replaced by a stability criterion of APs production such that variability in pace and cycle completions per dyad were unaffected by the procedure. Second, communication among participants in dyads was experimentally controlled, which permitted between-group comparisons in terms of the effects of communicating on interindividual performance. In addition, we addressed a third limitation in Smith et al.'s study concerning the discriminative feature in their task—individuals were able to observe their partner's choice. In this experiment, the computer screens only displayed the in-

dividual's own choices (color and size), and not their partner's choice. This allowed the systematic account of presence or absence of verbal interactions in IBCs. In short, this study sought to (a) examine effects of increasingly ambiguous forms of rules presented to participants in their performance, and (b) investigate the participation of verbal behavior in acquisition and maintenance of IBs. We extended Smith et al.'s findings by examining effects of three degrees of explicitness of rules presented to participants in their performance and verbal interactions. The verbal behaviors of participants were analyzed as total interactions, wherein speaker, listener, and functions of stimulus objects or events constituted the main elements to analysis referential interactions in designed IBCs.

Method

Subjects

Fifty-four students from the University of Nevada, Reno participated in this study. Participants were all female (to account of homogeneity of sample) undergraduate students, ranging from 18 to 22 years of age. All the procedures were approved by the university's institutional review board (IRB). Students earned course credits and money based on their performance in the experimental task by participating.

Setting and apparatus

The study was conducted in a small laboratory room on the university campus in which two desks faced each other with a divider in between such that participants did not have direct visual contact with one another and could not see each other's computer screen. On each desk there were a monitor, a personal computer, a keyboard, a mouse, and noise-cancelling headphones. A research assistant monitored (hearing closely) participants from outside the room to ensure that they did not talk. A headset with microphone and a webcam (for the purpose of sinking of the participant's verbal responding and what was seen on the screen) were present in each desk for the dyads in the

experimental group in which participants were allowed to talk to one another. To allow communication over the headsets, an audio call was initiated via VSee (Version 4.9; Chen & Chuang 2008) between the computers before participants entered the experimental room. Using Open Broadcaster Software (Version 26.0.2; Bailey 2012), participants' performance and verbal interaction were recorded. At the end of the session, each participant completed a questionnaire about the task.

Independent variables

The independent variables included the following rules that were presented to the participants at the beginning of each trial: (A) high explicit–HE; (B) medium explicit–ME; (C) low explicit–LE. The rules specified how participants should respond in order to correctly complete APs on which they worked (*see* Appendix B). High explicit (HE) rules specified precisely how participants should respond in terms of size and color of forms (e.g., "Your product must be PURPLE in color and within Q size range"); medium explicit (ME) rules only specified color whereas size was vague (e.g., "Your product must be ORANGE in color and SOMEWHAT SMALL in size"); and in low explicit (LE) rules specifications of both color and size of forms were ambiguous, and fairly open to interpretation by participants (e.g., "Your product must be the color of FLAMINGOS and within LOW size range"). Following Peláez and Moreno's (1998) rule taxonomy, rules varied in degrees of explicitness such that the more implicit the more elements were implied (the discriminative stimuli, context, or consequence). The rules in all conditions described consequences in a similar way but differed with respect to the clarity of which they describe stimuli relevant to the orientation required for a particular response. HE rules contained explicit/explicit components (explicit color and size), ME rules contained explicit/implicit components (explicit color and implicit size), and LE rules comprised implicit/implicit components (implicit color and size). See Table 1 for a complete definition of each rule type.

Table 1
Operational definitions of different levels of explicitness of rules

Experimental Condition	Rule Type	Operational Definition
A	High Explicit (HE)	Rules that specify the entire contingency arrangement (color and size).
B	Medium Explicit (ME)	Rules that only specify one of the elements in the contingency arrangement (color), while the second element is not assigned a concrete identification (size).
C	Low Explicit (LE)	Rules that do not clearly specify any of the elements in the contingency arrangement. Both color and size are named in a way not identifiable by the characteristics of the task.

Dependent variables

The dependent variables included frequency of correct responses and APs across experimental conditions and time to complete three consecutive APs for the same rule. The dependent variables associated with verbal interactions included the frequency and types of secondary verbal adjustments such as persuasive statements and humor during five-minute intervals (*see* Table 2) across experimental conditions. The method to analyze verbal interactions was based on Bijou et al.'s (1988) coding system of referential interactions (*see* Smith et al., 2011; Smith et al., 2012; Johnson et al., 2010).

Referential interactions

Referential interactions consist in a speaker referring something, someone, or some place, to a listener who acts in some way to the referred circumstances.

Secondary verbal adjustments

Secondary verbal adjustments were identified when the speaker's verbal actions had an additional effect on the listener's behavior, such as to persuade or use humor to evoke listener's cooperation. Each type

of secondary verbal adjustment was defined in terms of its observed effect on the listener (*see* Table 2).

Table 2
Operational definitions of elements in referential interactions

Item	Operational Definition
Duration	The duration is total time of the interaction
Talk with Other	The speaker addresses the listener by name. Also can be coded when the speaker is soliciting a response from the listener (e.g., "hey, what do you think of this study?")
Talk Aloud	The speaker is talking and has not addressed the listener by name or is not soliciting a response from the listener (e.g., after a prolonged absence of communication between the participants one says, "this game is boring")
Past	Talk regarding a previous time frame
Present	Talk about what is occurring during the current session
Future	Talk about a future time frame
No Time Frame	No specified time frame in the verbal interaction
Amuse	The speaker amuses the listener (e.g., sarcasm, joke telling)
Teach	The speaker imparts knowledge to the listener (e.g., "we are supposed to pick the same color")
Persuade	The speaker influences the listener to act in a specific manner (e.g., "you should choose the color on the top")
Support	The speaker provides support to the listener (e.g., "don't get frustrated, I'm not getting what we are doing wrong either")
Cooperate	The speaker establishes an agreement or strategy with the listener to solve a problem or achieve a goal (e.g., "let's try this color and then that one")
Aesthetic Appeal	The speaker impresses the listener or an imaginary external agent (e.g., "we nailed it, this game is fun").

Interobserver agreement (IOA) was determined by point-by-point agreement between a principal rater and a second rater. Both raters independently analyzed data pertaining to the verbal interactions. IOA was obtained for 30% of the total number of verbal interactions per dyad with an agreement ranging between 86 and 98% for all dyads analyzed from the verbal groups.

Experimental design

A counterbalanced reversal design was employed for four groups: Nonverbal (NV): HE-LE; Nonverbal (NV): LE-HE; Verbal (V): HE-LE; and Verbal (V): LE-HE. A total of 27 dyads were randomly assigned to one of the four experimental groups[2] (*see* Table 3). The primary function of the reversal design was to compare the differential effects of the three forms of rules (HE, ME, & LE) on development of IBs and production of APs. Additionally, the counterbalanced sequences were employed to assess any potential sequence effects.

Table 3

Dyad assignment in four experimental groups

Order	V	NV
HE-LE	8	6
LE-HE	9	4

Note. HE = High explicit; ME = Medium explicit; LE = Low explicit; V = Verbal; and NV = Nonverbal.

Procedures

Once participants signed consent forms, instructions were handed to them and also read by a research assistant. The instructions advised participants that they will be working together as a team to design and generate products with two specific dimensions and that they would each earn 10 cents for every three consecutive correct product they produced (*see* Appendix A). They were told that their job was to find the best strategy to understand the rules presented throughout the study in order to generate revenue. The researcher noted that their revenue would be tracked on each of their screens and they would receive their earnings at the end of the experiment. Once the task ended, participants had to complete a questionnaire addressing questions about the task.

2. Due to the impact of the pandemic of COVID-19 on students' participation in academic research, it was not possible to continue running participants and thus the sample size is uneven across groups (see Discussion).

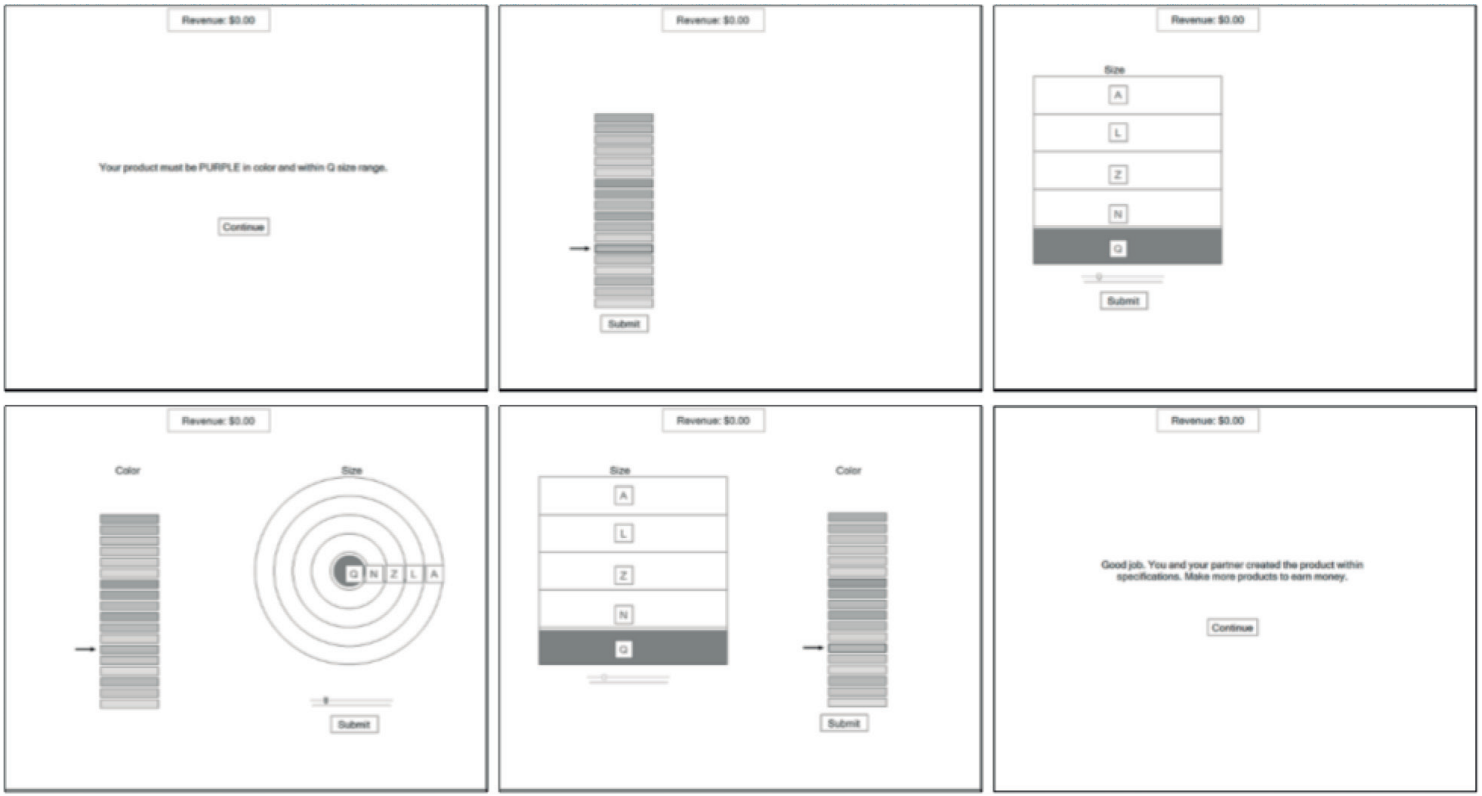
As in Smith et al. (2011), participants took turns responding in each trial to generate a product comprised of a circle and a rectangle with specific dimensions. During a given experimental trial participant one (P1) had to first choose the color of the rectangle (using a mouse click), after which participant two (P2) selected the size for the same part; it was then P1 who had to choose the size for the circle, followed by P2 choosing the color for the circle part (*see* Figure 1). The four-response sequence constituted one trial and no one of the responses could be emitted until the prior response had been completed. Upon completing a trial, participants received a message specifying whether their product was correct or not. If the product was not correct, another message was provided to each participant on their computer screens saying: "Sorry, either your product or your partner's product was not within specifications", and the trial restarted with the presentation of the same rule; if product was correct then the following mes sage would appear on their screens "Good job. You and your partner created the product within specifications. Make more products to earn money." Based on the pilot data, a criterion of three consecutive correct APs per rule or 20 trial attempts were required to move from one rule to the next within a condition. An experimental condition ended after the completion of 9 APs or 60 trial attempts. The task terminated after 2 hours or after dyads completed 18 rules (3 per condition). All dyads included in this analysis were exposed to the same number of rules (i.e., 18 rules, *see* Appendix B). Dyads that reached the 120-minute mark but did not complete all the rules were payed the amount of money earned and dismissed.

All colors and sizes of rules were presented in a randomized order phase to phase such that no one color, or size, could be part in consecutive rules. Selection of rules for each condition was the same across groups such that all dyads were exposed to the same rules in same order, according to the experimental group. Rule criteria (color and size) were the same for both participants in each phase. Participants could choose from 18 color options, three variations (hues) per color. Participants selected the color for their product by clicking over one of

the options and clicking submit. Different from selecting color, the size was selected by moving a scroll bar such that a portion (i.e., size) of the part was filled varying along a continuum. The only difference between phases were the rules presented at the beginning of each trial and a change in consumer demand (correct size and color). Phase changes were therefore signaled by the presentation of a new form of rule. After completing a questionnaire, participants were shown a screen telling them to inform the research assistant that the task had ended.

Figure 1

Sequence of events in a given trial



Nota. Sequence of events in a given trial. The four responses, two per participant, are shown in a sequential order of completion. Colors were selected from a discrete range of 18 options, while size was selected by filling an interval using scrolling option.

Results

For all 27 dyads, measures of incorrect products were tested for differences across groups (V HE-LE, V LE-HE, NV HE-LE, NV LE-HE). Incorrect products were defined as APs whose dimensions don't meet the rule criteria in terms of color and size for both shapes. A summary of incorrect products and trial duration of dyads for V and NV groups is provided in Table 4. Total incorrect products for V HE-LE group (n = 8) averaged 3.1 (SD = 2.8) wherein LE_1 condition had the highest average of 10.4 incorrect products. Trial duration for this group averaged 19.9 (SD = 18.5) and HE_1 condition had the highest average of 44.7 seconds to complete a trial. Total incorrect products for V LE-HE (n = 9) averaged 3.9 (SD = 2.8) wherein LE_1 condition had the highest average of 14.8 incorrect products. Trial duration for this group averaged 15.7 (SD = 3.6) and LE_1 condition had the highest average of 44 seconds to complete a trial. Total incorrect products for NV HE-LE group (n = 6) averaged 14.7 (SD = 5.3) wherein LE1 had the highest average of 40.8 incorrect products. Trial duration for this group averaged 17.6 (SD = 3.3) and LE_1 condition had the highest average of 40.8 seconds to complete a trial. Total incorrect products for NV LE-HE group (n = 4) averaged 30 (SD = 11.5) wherein LE_2 condition had the highest average of 45.5 incorrect products. For these two groups, the average incorrect products were higher in medium than in low explicit conditions, that is from ME_2 (M = 16.2 SD = 10) to LE_2 (M = 15.8, SD = 6.5) for dyads in NV HE-LE group, and from ME_1 (M = 35.8, SD = 7.9) to LE_1 (M = 25.8, SD = 9.5) for dyads in NV LE-HE group. Trial duration for this group averaged 26.3 (SD = 5.5) and LE_1 condition had the highest average of 34 seconds to complete a trial.

Table 4

Summary of descriptive statistics of incorrect responses and trial duration across conditions by group

		Mean (SD) Median Incorrect Products		Mean (SD) Median Trial Duration	
Order	**Condition**	**V**	**NV**	**V**	**NV**
HE-LE	HE_1	3.8 (5.2)	0.7 (0.5)	44.7 (20.6)	20 (1.1)
		2	1	38.8	20.1
	ME_1	3.5 (3.9)	14 (8.7)	29.8 (3.5)	20.7 (5.7)
		2	16.5	27.9	17.9
	LE_1	10.4 (4)	40.8 (4.6)	25.4 (5.9)	14.6 (1.9)
		10.5	40	24.2	15
	HE_2	1.8 (2.1)	0.8 (1.6)	20 (6.6)	14.6 (1.9)
		1	0	17.2	15
	ME_2	1.5 (2.3)	16.2 (10)	19.6 (4.7)	17.5 (4)
		1	18.5	20.1	16.5
	LE_2	3.9 (4.8)	15.8 (6.5)	20 (3.5)	18 (5.4)
		2	14.5	19.7	15.7
LE-HE	LE_1	14.8 (8.3)	25.8 (9.5)	44 (14)	34 (6.9)
		16	21.5	48	36.2
	ME_1	5.3 (5.4)	35.8 (7.9)	25 (4.7)	21.9 (3.9)
		2	39	23.7	20.7
	HE_1	0.7 (0.9)	1.3 (2.5)	17.2 (2.8)	14.2 (3)
		0	0	17.2	13.8
	LE_2	12.3 (8)	45.5 (5.2)	21.7 (4.7)	18.7 (3.9)
		12	45	20.4	18.9
	ME_2	2.1 (2.4)	11 (19.3)	18.6 (4)	16.3 (3.2)
		1	2	18	16.8
	HE_2	0.1 (0.3)	0.8 (1.5)	17.2 (2.8)	13.6 (0.9)
		0	0	15.3	13.9

Note. HE = High explicit; ME = Medium explicit; LE = Low explicit; V = Verbal; and NV = Nonverbal.

Shapiro-Wilk normality tests showed that data pertaining to generated APs across dyads were not normally distributed at $p < 0.05$. Accordingly, the collected data were tested using nonparametric statistics. Variability and types of verbal interactions for each group were analyzed, including measures of frequency of interactions per dyad

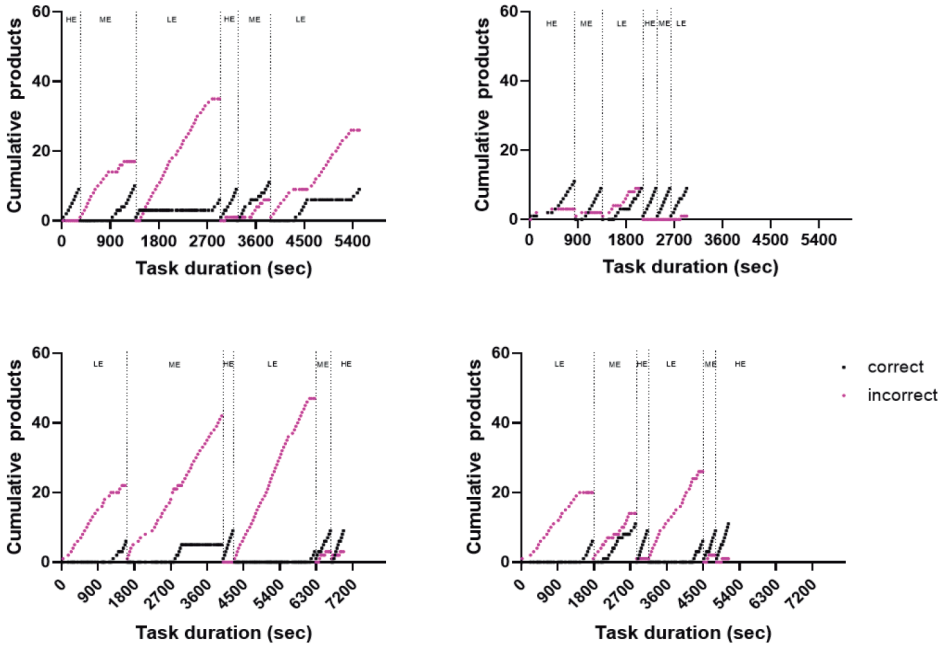
across conditions. In the following sections, the data pertaining to interindividual performance will be presented, followed by the results associated with verbal interactions for individuals in V groups.

Interindividual performance

Figure 2 shows cumulative number of correct and incorrect products for an exemplar dyad in each group. Dyads from the V HE-LE group generally contacted all rules in each condition while also generating incorrect APs, making a certain number of incorrect APs before contacting the solution to a given rule. Inversely, dyads from the NV HE-LE group generally hit the limit of incorrect APs (60 per condition, 20 per rule) without contacting all rules in first presentation of LE conditions, showing patterns of correct APs by second exposure to similar levels of ambiguity but still making high levels of incorrect products. Dyads from the NV LE-HE group generally hit the limit of incorrect products in both ME and LE conditions without producing any correct products in LE conditions. Dyads from the V LE-HE group also generated more incorrect products under LE conditions than in HE and ME; however, the number of incorrect products diminished by second exposure to LE condition.

Figure 2

Cumulative correct and incorrect products across conditions

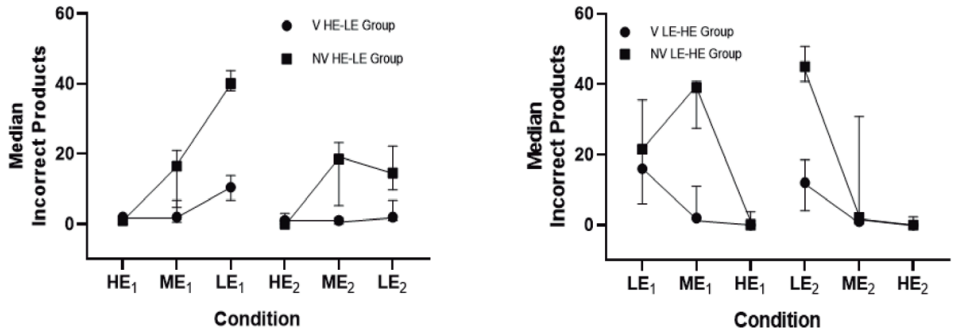


Note. Cumulative correct and incorrect products across conditions by exemplar dyads in the NV HE-LE (*top left*), V HE-LE (*top right*), V LE-HE (*bottom right*), and NV LE-HE (*bottom left*) groups.

Figure 3 demonstrates median incorrect products produced in each condition for HE-LE groups (left panel) and LE-HE groups (right panel). For HE-LE groups, Mann-Whitney *U*-tests found no significant differences in incorrect products produced in either HE condition when dyads were or were not allowed to talk $(p \geq .0596)$. In all ME and LE conditions, dyads that were allowed to talk were shown to produce significantly less incorrect products than dyads that were not $(p \leq .0393)$. For LE-HE groups, dyads that were allowed to talk were shown to produce significantly less incorrect products than dyads that were not in the first ME condition and second LE condition $(p \leq .0028)$, but no significant differences were found in any other condition $(p \geq .1399)$. See Table 5 for more information.

Figure 3

Mean incorrect products produced across conditions



Note. Mean incorrect products produced across conditions for HE-LE (*left*) and LE-HE (*right*) groups. Circles denote medians for dyads that were allowed to talk; squares denote medians for dyads that were not allowed to talk. Error bars denote interquartile range.

Table 5

Mann-Whitney U comparisons between incorrect products produced across conditions by V and NV groups

		Median Incorrect Products			
Order	**Condition**	**V**	**NV**	**W**	**p**
HE-LE	HE_1	2	1	9	.060
	ME_1	2	16	8*	.039
	LE_1	10.5	40	0***	<.001
	HE_2	1	0	17	.354
	ME_2	1	18.5	2**	.003
	LE_2	2	14.5	2.5**	.003
LE-HE	LE_1	16	21.5	8	.140
	ME_1	2	39	0**	.001
	HE_1	0	0	16.5	.961
	LE_2	12	45	0**	.003
	ME_2	1	2	15.5	.730
	HE_2	0	0	15	.769

Note. HE = High explicit; ME = Medium explicit; LE = Low explicit; V = Verbal; and NV = Nonverbal.

* denotes significance (α<.05)

** denotes significance (α<.01)

*** denotes significance (α<.001)

n = 8 (V HE-LE), 6 (NV HE-LE), 9 (V LE-HE), and 4 (NV LE-HE)

Friedman tests were performed to assesses differences in median incorrect products produced across conditions for each round (i.e., set of HE, ME, and LE conditions) for each group, as shown in Table 6. Significant differences were found in incorrect products across conditions in each round for all groups ($p < .01$) with the exception of round 2 for the V HE-LE group ($p = .12$). Post-hoc Dunn's multiple comparisons tests with Bonferroni correction found significant differences between median incorrect products produced in ME_1 and LE_1 for the V HE-LE group ($p < .05$), LE_1 and HE_1, ME_2 and HE_2, and LE_2 and HE_2 for the NV HE-LE group ($p < .05$), LE_1 and HE_1 as well as LE_2 and HE_2 for the V LE-HE group ($p < .001$), and ME_1 and HE_1 for the NV LE-HE group. No other pairwise differences were found to be significant.

Table 6

Differences in incorrect products produced across conditions in each round by group

	Round 1				Round 2			
		Z				Z		
Group	x^2	**ME-LE**	**ME-HE**	**LE-HE**	x^2	**ME-LE**	**ME-HE**	**LE-HE**
V HE-LE	9.87**	2.750*	0.250	2.500*	4.52	-	-	-
NV HE-LE	11.57***	1.876	1.443	3.320**	9.00**	0.000	2.598*	2.598*
V LE-HE	15.60****	1.768	2.121	3.889***	17.18****	2.357	1.650	4.007***
NV LE-HE	7.60**	1.061	2.652*	1.591	6.62*	1.414	0.884	2.298

Note. Chi-square values were calculated using Friedman tests. Z-values for post-hoc Dunn's multiple comparisons with Bonferroni p-value corrections were conducted for each significant Friedman test. HE = High explicit; ME = Medium explicit; LE = Low explicit; V = Verbal; and NV = Nonverbal.

* denotes significance ($\alpha<.05$)

** denotes significance ($\alpha<.01$)

*** denotes significance ($\alpha<.001$)

**** denotes significance ($\alpha<.0001$)

n = 8 (V HE-LE), 6 (NV HE-LE), 9 (V LE-HE), and 4 (NV LE-HE)

The abovementioned results showed that, in general, the performance of dyads is comparable between V and NV groups only when

instructions are highly explicit. The differences in performance were more clearly observed during increased levels of ambiguity in the task (i.e., medium and low explicit conditions), only those dyads that were allowed to talk were shown to produce less incorrect products in those conditions. The HE-LE V group's performance was somewhat different from the other three experimental groups, in that their number of incorrect products did not differ significantly across experimental conditions. In terms of average incorrect products for each condition, only the V group showed a decrease in incorrect product generation as ambiguity decreased, while the NV group showed the opposite effect from ME_2-LE_2 for HE-LE group and from ME_1 to LE_1 for LE-HE group.

Verbal interactions of dyads

A total of five dyads from V HE-LE group and five dyads from V LE-HE group were analyzed[3]. Dyads in HE-LE group showed various patterns of verbal interactions throughout the experimental session, predominantly, cooperation (69.89%), persuasion (11.83%), aesthetical appeal (8.60%), amuse (6.45%), and teach (2.23%). Comparatively, dyads in V LE-HE group showed mainly patterns of cooperation (66.67%), persuasion (18.60%), aesthetic appeal (8.53%), teach (4.65%) and amuse (1.55%). Few instances of support interactions were observed in dyads of both groups. Frequency and variability of verbal interactions in dyads in both groups occurred at the beginning of the experimental session, but later fewer types occurred with more frequency (e.g., cooperation, persuasion) while others stop occurring all together (e.g., teach). These data indicate that cooperative secondary verbal adjustments were predominant across dyads, however, other types of verbal interactions were also observed throughout the session and these differed between groups.

3. Technical issues (e.g., partial recording of a session due to equipment malfunction) prevented our analysis of verbal interactions across all dyads. Dyads with complete data sets were used in this analysis.

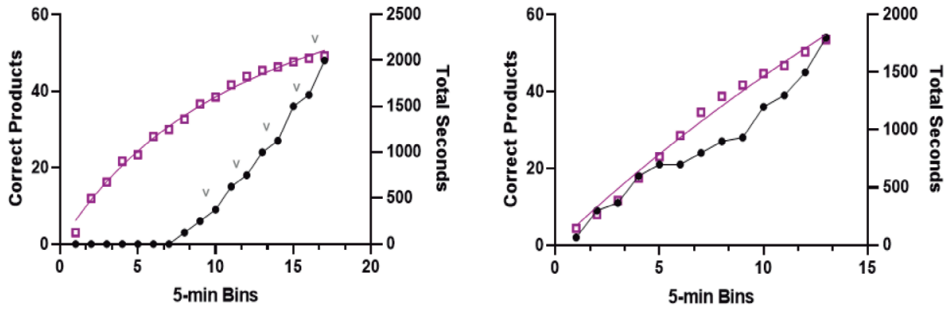
Figure 4 shows cumulative verbal interactions (plotted in right y axis) and correct products (plotted in left y axis) throughout the experimental session, for one dyad in V HE-LE group (*left*) and V LE-HE group (*right*). In order to provide an analysis of covariance between verbal interactions and coordination of actions, session time was divided into 5-minute intervals, measuring allocation of dyads' IBs in progressive cuts of time, plotted against the x axis. All dyads in the V HE-LE group showed primarily verbal patterns of cooperation (i.e., communicating with the intend of solving a problem or achieve a goal), established early in the session and decelerated after 20-minute mark.

Table 7 shows both nonlinear and linear regression results for cumulative seconds of cooperative verbal activity across 5-minute intervals for dyads in both V groups, where a and b were fitted parameters. These curves were fitted for the whole task, regardless of condition. We fitted each model to each dyad's cumulative seconds of cooperative secondary adjustments. Akaike's corrected information criterion (AICc; Burnham & Anderson 2002) was then used to assess the relative goodness of fit of each model. Across all dyads, cumulative seconds of cooperative adjustments was better represented by a hyperbolic function ($Y = aX/1+bX$) than a linear function ($Y = aX+b$) in terms of both R^2 and AICc, although sometimes only slightly.

For some dyads, though, increasing patterns of cooperation for a longer period of time were observed. These dyads also seem to have had a more irregular generation of correct products. Although time spent communicating diminished over time, individuals did not stop cooperating altogether until the end of the experimental session. Other secondary verbal adjustments were also observed in these dyads. Some of these secondary adjustments occurred sporadically (e.g., teaching), while others occurred with more regularity (e.g., persuading), but significantly less than cooperative patterns.

Figure 4

Total correct products and seconds spent talking



Note. Total correct products and seconds spent talking across 5-min bins for an exemplar dyad in the V HE-LE (*left*) and V LE-HE (*right*) group. Black circles denote cumulative correct products whereas squares denote cumulative cooperative verbal activity in seconds.

Dyads in the V LE-HE group also showed predominate patterns of cooperation, but with important differences in terms of maintenance of these interactions. Dyads 12, 16, and 26 showed cooperative patterns extending over the 60-minute mark and decelerating over the course of the last condition in the session (HE_2). By contrast, dyads 16.2 and 17 showed a less pronounced curve, spending less than half the task time (total seconds plotted in right y axis) than other dyads in the same group. These three dyads also completed correct products in a faster rate as well. Overall, these results suggest that dyads' performance covaried with certain patterns of verbal patterns, namely, cooperating and (to a lesser degree) persuasion. Most of the cooperative verbal interactions were allocated during the first conditions (HE_1 or LE_1), decelerating over the course of the experimental session, however, curves differed between groups. Dyads that were first introduced to most ambiguous conditions (LE-HE) spent more time cooperating before completing correct products, while dyads that are gradually introduced to ambiguous circumstances (HE-LE) generated correct products sooner in the session, while also spent less time communicating overall and their cooperative patterns decelerated faster than dyads in the V LE-HE group. Orderly behavioral patterns were observed,

suggesting that communication among individuals is also influenced by internal dynamics of metacontingencies.

Table 7

Linear and nonlinear regression of cumulative minutes of cooperative secondary adjustments across all trials by dyads in V groups

			Hyperbolic ($Y = aX/1+bX$)					Linear ($Y = aX+b$)				
Group	**Dyad**	**df**	**a**	**b**	**R^2**	**SS**	**AICc**	**a**	**b**	**R^2**	**SS**	**AICc**
V	4	11	171.5	0.02	.99	40467	113.2*	142.3	38.19	,98	65808	119.6
HE-LE	7	11	116.3	0.07	.96	27970	108.4*	58.90	103.1	.91	59261	118.2
	11	7	126.8	0.02	.95	36263	85.51*	107.4	4.722	.94	42414	86.92
	20	12	315.2	0.40	.98	4932	90.50*	28.77	328.9	.81	45454	121.6
	33	9	69.69	0.01	.99	5016	76.77*	61.16	19.47	.99	5196	77.16
V	12	16	109.9	0.01	>.99	26994	139.3*	86.62	64.74	.99	44831	148.5
LE-HE	16	8	306.2	0.15	.98	18506	85.23*	102.4	286.8	.93	63191	97.51
	17	10	249.2	0.14	.97	31824	103.6*	75.57	275.5	.88	109228	118.4
	26	15	243.7	0.06	.99	60698	146.9*	113.9	307.9	.95	277477	172.8
	38	12	105.7	0.02	.99	18840	109.3*	80.38	67.90	.99	20785	110.6

Note. AICc = Akaike's corrected Information Criterion for small samples; * = preferred model; HE = High explicit; ME = Medium explicit; LE = Low explicit; V = Verbal; and NV = Nonverbal.

Discussion

Researchers have examined ways verbal behavior may function as antecedent or consequent stimuli that select cultural units in metacontingency arrangements (e.g., Hosoya & Tourinho 2016; Sampaio et al., 2013). Previous research studying effects of various forms of rules on interindividual performance using a metacontingency analog task showed that dyads' communication positively affected their behaviors (Smith et al., 2011).

With regard to the effect of ambiguous rules on interlocked behaviors, the findings of this study showed that the level of ambiguity of rules presented to individuals at the beginning of each trial affected the levels of accuracy and duration of their interlocked behavioral responding. These data support findings reported by Ribes-Iñesta and Martínez-Sánchez (1990), and later by Smith et al. (2012), in which

exposure to inaccurate rules resulted in highly variable verbal interactions (secondary verbal adjustment) as well as variable levels of performance. Moreover, the findings of this study suggest that when dyads work together and simultaneously communicate, their performance is increasingly efficient and certain types of verbal interactions (secondary verbal adjustments) seemed to recur under various ambiguous circumstances. Dyads from the V group acquired patterns of producing correct products that persisted across different experimental conditions (i.e., rule type). Inversely, Dyads from NV group were able to complete correct products occasionally and mostly under highly explicit rule conditions. In this context, the observed interactions of participants in dyads from NV group may be called 'parasocial behaviors', defined as interindividual relations regulated by simultaneous, but independent variables (Ribes-Iñesta 2001).

The results of this study also demonstrated that while the contingent relation between IBCs and production of APs can be established to some extent in dyads that can't communicate, only dyads from V group demonstrated consistent patterns of interlocked behaviors across conditions. Although dyads in both groups generated APs, the consistency and coordination between individuals' actions expected in social episodes was mostly observed in dyads from V group. Our findings also showed that the generation of correct and incorrect products varied as a function of the achievement criterion (i.e., type of rule) imposed in each condition, and the presence or absence of verbal interactions. Similar findings have been reported where the experimental task limits the range of verbal interactions that can occur (Pulido-Avalos et al., 2020).

In addition, the secondary verbal adjustments that contributed to the generation of aggregate products recurred, while those that did not decreased in frequency and duration over time (e.g., persuasion). To this end, the role of secondary verbal adjustments in selection of IBs in dyads is unclear and warrants further examination. The secondary verbal adjustment function of verbal behavior may be further examined by arranging experimental conditions under which individuals can interact in multiple ways besides the designed referential interactions

with respect to generating APs. Previous research has also found that under highly ambiguous circumstances, secondary adjustment functions of verbal interactions such as rumor can negatively affect generation of APs (Smith et al., 2012; Johnson et al., 2010).

IBs, IBCs & Cultural Milieu

The concept of the cultural milieu may offer a point of entry to examine how cultural environmental factors (psychological, anthropological, ecological/biological) affect the acquisition of IBs in the context of IBCs (Houmanfar et al., 2010). According to Houmanfar et al.'s elaborated account of the metacontingency (2010, in press) the selecting environment constitutes the cultural milieu which includes the consumers of the aggregate product in addition to overarching cultural beliefs, material resources, governmental policies, rules, traditions, morals, institutions, technological progress, and environmental competition. More specifically, the cultural milieu constitutes the collection of the distinctive stimulus functions such as post covid-19 pandemic changes in training procedures, policies associated with social distancing, wearing mask, and stated political values during the coinciding presidential election in the United States of America (USA). These stimuli influenced the acquisition and maintenance of IBCs such as Applied Behavior Analytic (ABA) training processes in the United States (USA), associated IBs (employees' level of stress and implicit political biases affecting interprofessional interactions), and behaviors of individuals (students who received ABA training in USA) that interact with the associated aggregate products (e.g., training packages, workshops, etc.). Behaviors of consumers in this context can be discussed as macrobehavior (socially learned operant behavior observed in the repertoires of several members of a cultural system) of knowledgeable ABA practitioners who work in school districts and the associated cumulative effect demonstrated by improved cases of maladaptive behaviors of children in selected school settings (i.e., macrocontingency).

Future metacontingency studies may examine the effects of different cultural milieu factors on the dynamics of IBs in IBCs, and the impact on their generation of aggregate products. For example, experiments have shown that under situations of choice between working in shared contingencies or alone, the content of instructions delivered to participants prior the beginning of experimental session affected their selection of contingencies (Pacheco-Lechón & Carpio 2014). According to these experiments, individuals worked together despite changes in external selection processes (e.g., losing points or money) in conditions that provided shared contingencies (Pulido-Avalos et al., 2015, Rangel et al., 2015).

Additionally, based on the data provided herein, we may also suggest that the standard sequential task in metacontingencies mainly promotes patterns of verbal behavior established with respect to achievement criteria (e.g., cooperation, persuasion). The "interlocked" element of IBCs may also be manipulated by altering the sequential nature of the experimental task and, in doing so, verbal problem solving, and factors associated with the shared contingencies can be determined.

Limitations & Future Research

The major limitations of this study were the number of dyads and their unequal distribution across experimental conditions. In addition, although the experimental task employed allowed the manipulation of IBCs and measurement of IBs, a more complex task may better approximate socio-cultural situations as they occur in natural settings, including how different types of verbal phenomena (e.g., organizational rules, verbal interactions) participate in the development of certain kinds of IBs in IBCs. Future studies should also consider more precise ways to assess the level of ambiguity of the rules (low, medium, and high). It is possible that the difference in number of incorrect products observed across groups may have been influenced by the perceived ambiguity of the rules, including the order in which they were presented (*see* Appendix C). The results indicating incorrect products

increased as ambiguity decreased in some conditions for some dyads, suggests that some rules may have been perceived as more ambiguous than we anticipated. This issue may be prevented by conducting a pre-assessment of rules or talk aloud procedures to determine their level of ambiguity.

As discussed by Houmanfar et al. (in press), at the psychological level, the term IB highlights the critical role that individual participants' histories play in the interaction of individuals within a given IBC and, ultimately in the selection process associated with the metacontingency. Said another way, an analysis of the close interrelationship between psychological and sociological factors in metacontingencies may lead to a better understanding of social interactions, including how structure (e.g., IBCs) interacts with networks of individuals (e.g., IBs). For example, Molm et al. (2009) demonstrated that some structures of exchange relations (i.e., reciprocal) and contextual factors (perceived risk and uncertainty) influence the development of certain psychological factors (e.g., resilient trust) in interpersonal relations. The metacontingency has the great potential for providing the platform for analysis of these types of interlocked factors in complex behavioral systems.

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Appendix A

Instructions read to participants in verbal group

"You two will be working together as a team to design and generate products with two specific dimensions. These dimensions will be given to you before every trial in the form of rules stating COLOR and SIZE. These rules, although vague and complex, are always accurate with respect to the correct dimensions of the product. Notice that a correct product in this case means that BOTH of you must submit correct color/size. You will receive feedback for every product you submit informing you whether the product has met specifications or not. The feedback will not tell you if your individual responses were correct or incorrect. Therefore, do not assume that you are doing your part "right" since it might be the case that your partner is the one doing things right and you are not. The vagueness of the rule in either of the dimensions (color or size, or both), means that each of you should try to vary your choices from trial to trial in order to arrive to the correct product. It is your job to find the best strategy to understand the rules presented throughout the study, including detecting patterns, similarities, or other hints that may appear among the dimensions of the correct products.

As your team completes this task, each of you will earn money for the correct products. For every three correct and consecutive products, you will earn revenue in the amount of 10 cents each, and this also will allow you to move on to the next rule. Any revenue you earn during the study is yours to keep upon completion of the study.

"Your verbal interactions with one another will be recorded throughout the study using video and voice recorders. You will be left alone in this room until the computer program stops, at which time a message will appear alerting you that the study is done. At the time the research assistant will return and stop the program. The research assistant will provide a debriefing of the study, as well as pay you your revenues in cash.

Instructions read to participants in nonverbal group

"You two will be working together as a team to design and generate products with two specific dimensions. These dimensions will be given to you before every trial in the form of rules stating COLOR and SIZE. These rules, although vague and complex, are always accurate with respect to the correct dimensions of the product. Notice that a correct product in this case means that BOTH of you must submit correct color/size. You will receive feedback for every product you submit informing you whether the product has met specifications or not. The feedback will not tell you if your individual responses were correct or incorrect. Therefore, do not assume that you are doing your part "right" since it might be the case that your partner is the one doing things right and you are not. The vagueness of the rule in either of the dimensions (color or size, or both), means that each of you should try to vary your choices from trial to trial in order to arrive to the correct product. It is your job to find the best strategy to understand the rules presented throughout the study, including detecting patterns, similarities, or other hints that may appear among the dimensions of the correct products.

As your team completes this task, each of you will earn money for the correct products. For every three correct and consecutive products, you will earn revenue in the amount of 10 cents each, and this also will allow you to move on to the next rule. Any revenue you earn during the study is yours to keep upon completion of the study.

"You are not allowed to communicate with each other during this study. Please wear these noise-cancelling headphones until the computer program stops. If there are any sounds, I will come in and remind you about the conditions of the study. Otherwise, you will be left alone in this room until the computer program stops, at which time a message will appear alerting you that the study is done. At the time I will return and stop audio recording. I will provide a debriefing of the study, as well as pay you your revenues in cash.

Appendix B

Product criteria and statements

Rule type	Color requirement	Size Interval	Statement
High explicit (HE)	Purple	1-100	"Your product must be PURPLE in color and within Q size range."
	Yellow	401-500	"Your product must be YELLOW in color and within A size range."
	Green	301-400	"Your product must be GREEN in color and within L size range."
	Blue	201-300	"Your product must be BLUE in color and within Z size range."
	Pink	101-200	"Your product must be PINK in color and within N size range."
	Pale orange	1-100	"Your product must be PALE ORANGE in color and within Q size range."
Medium explicit (ME)	Light blue	301-400	"Your product must be LIGHT BLUE in color and LARGE ENOUGH in size."
	Orange	101-200	"Your product must be ORANGE in color and SOMEWHAT SMALL in size."
	Pink	201-300	"Your product must be PINK in color and NEITHER TOO SMALL NOR TOO LARGE in size."
	Pale purple	301-400	"Your product must be A SHADE OF PURPLE in color and SOMEWHAT LARGE in size."
	Yellow	1-100	"Your product must be YELLOW in color and the SMALLEST in size."
	Green	101-200	"Your product must be GREEN in color and SMALL ENOUGH in size."

Rule type	Color requirement	Size Interval	Statement
Low explicit (LE)	Blue	401-500	"Your product must be the COLDEST primary color and within HIGHER size range."
	Pale pink	101-200	"Your product must be the color of FLAMINGOS and within LOW size range."
	Pale yellow	301-400	"Your product must be the color of LEMONS and within HIGH size range."
	Orange	1-100	"Your product must be a color created by MIXING RED AND YELLOW and within LOWER size range."
	Blue	201-300	"Your product must be the COLDEST of the three primary colors and within MID size range."
	Purple	101-200	"Your product must be the color of PLUMS and WITHIN LOW size range."

Appendix C

Rule order presentation

Condition	Statement
Group HE-LE	
HE_1	"Your product must be PURPLE in color and within Q size range."
	"Your product must be YELLOW in color and within A size range."
	"Your product must be GREEN in color and within L size range."
ME_1	"Your product must be LIGHT BLUE in color and LARGE ENOUGH in size."
	"Your product must be ORANGE in color and SOMEWHAT SMALL in size."
	"Your product must be PINK in color and NEITHER TOO SMALL NOR TOO LARGE in size."
LE_1	"Your product must be the COLDEST primary color and within HIGHER size range."
	"Your product must be the color of FLAMINGOS and within LOW size range."
	"Your product must be the color of LEMONS and within HIGH size range."

Condition	Statement
HE_2	"Your product must be BLUE in color and within Z size range."
	"Your product must be PINK in color and within N size range."
	"Your product must be PALE ORANGE in color and within Q size range."
ME_2	"Your product must be A SHADE OF PURPLE in color and SOMEWHAT LARGE in size."
	"Your product must be YELLOW in color and the SMALLEST in size."
	"Your product must be GREEN in color and SMALL ENOUGH in size."
LE_2	"Your product must be a color created by MIXING RED AND YELLOW and within LOWER size range."
	"Your product must be the COLDEST of the three primary colors and within MID size range."
	"Your product must be the color of PLUMS and WITHIN LOW size range."
Group LE-HE	
LE_1	"Your product must be the color of PLUMS and WITHIN LOW size range."
	"Your product must be the COLDEST of the three primary colors and within MID size range."
	"Your product must be a color created by MIXING RED AND YELLOW and within LOWER size range."
ME_1	"Your product must be GREEN in color and SMALL ENOUGH in size."
	"Your product must be YELLOW in color and the SMALLEST in size."
	"Your product must be A SHADE OF PURPLE in color and SOMEWHAT LARGE in size."
HE_1	"Your product must be PALE ORANGE in color and within Q size range."
	"Your product must be PINK in color and within N size range."
	"Your product must be BLUE in color and within Z size range."
LE_2	"Your product must be the color of LEMONS and within HIGH size range."
	"Your product must be the color of FLAMINGOS and within LOW size range."
	"Your product must be the COLDEST primary color and within HIGHER size range."

Condition	Statement
Group LE-HE	
ME_2	"Your product must be PINK in color and NEITHER TOO SMALL NOR TOO LARGE in size."
	"Your product must be ORANGE in color and SOMEWHAT SMALL in size."
	"Your product must be LIGHT BLUE in color and LARGE ENOUGH in size."
HE_2	"Your product must be GREEN in color and within L size range."
	"Your product must be YELLOW in color and within A size range."
	"Your product must be PURPLE in color and within Q size range."

Compliance with Ethical Standards

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical Approval All procedures performed in this study involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments.

Informed Consent Informed consent was obtained from all individual participants included in this study.

Data Availability The datasets analyzed during this study are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

José G. Ardila-Sánchez: Conceptualization, Writing - original draft, Formal analysis, Investigation, Methodology, Project administration, Visualization. **Ramona A. Houmanfar:** Conceptualization, Methodology, Laboratory Resources, Writing – review & editing. **Will Fleming:** Software, Data curation, Formal analysis.