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A COMPUTER SIMULATION OF THE EFFECTS OF VARIATIONS IN CONSTITUTIVE RULES AND INDIVIDUAL GOALS ON INTERPERSONAL COMMUNICATIONS

Aaron H. Brown
Corpus Christi State University, Corpus Christi, TX 78412
Charles J. Campbell
Memphis State University, Memphis, TN 38152
Eugene E. Kaczka
Memphis State University, Memphis, TN 38152

ABSTRACT: This paper is an extension of earlier work concerning the Coordinated Management of Meaning theory of interpersonal communication. Prior research has taken several paths. Among them have been laboratory experiments utilizing games to simulate conversations, computer simulations, and case studies of actual conversations. The research reported in this paper involves a detailed examination of relatively simple interpersonal communications systems. The results of the simulation will be used to evaluate selected theorems to develop protocols for further laboratory testing and to identify laboratory and field research necessary to develop a more accurate model of conversational behavior.

1. INTRODUCTION

This paper is an extension of earlier work concerned with the development of the Coordinated Management of Meaning (hereafter referred to as CMM) theory of interpersonal communication (Pearce, 1976; Cronen and Pearce, 1978). Research on the CMM theory has proceeded along several paths. Laboratory experiments with games to simulate conversations (Pearce, Cronen and Johnson, 1979; Johnson, 1979) have examined the logic of interpersonal systems and the reactions of participants to selected manipulations in the communication setting. Simulation has been used to replicate the laboratory experiments (Brown, Campbell and Kaczka, 1979) and to examine how variations between individuals might cause convergence or oscillation in conversations (Cronen, Kaczka, Pearce and Pawlik, 1978). A study of 32 real conversations (Cronen, Pearce and Snavely, 1979) confirmed the utility of rule structures in predicting perceived enmeshment in undesired episodes. Additional case study research has applied CMM to the analysis of communications in formal organizations (Harris and Cronen, in press). The research reported in this paper involves a detailed examination of relatively simple interpersonal communications sytems. The results of the simulation will be used to evaluate selected theorems (proposed by Cronen and Preace, 1978) to develop protocols for further laboratory testing, and to identify laboratory and field research necessary to develop a more accurate model of conversational behavior.

2. BACKGROUND

Extensive discussions of the theory of the coordinated management of meaning are available from several sources (Pearce, 1976; Cronen and Pearce, 1978). However, because the theory is relatively new and since at least a rudimentary understanding of its basic elements is necessary to appreciate the subsequent presentations, a brief summary of the theory will be presented.

CMM offers a rules-based approach to describe and explain the dynamics involved in interpersonal communications. Each person is regarded as holonic: systems in themselves which are components of a larger system. The individual behaviors interweave to form patterns of coordinated actions - an interpersonal system. Individual systems move toward the achievement of their respective goals through the dynamics of communicating with one another. In the most direct form, coordination involves the process of transferring and organizing information.

The communication process is viewed by the theory as consisting of a minimum of three systems. There

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are a minimum of two intrapersonal systems which manage (organize temporally and hierarchically) information into meanings. In addition, an interpersonal system is created when the individuals attempt to coordinate their meanings. The intrapersonal systems are integrated into the interpersonal system in the communication process. Since the manner in which individual systems assess information, efforts to coordinate meaning becomes problematic. A concern of the theory is the analysis of structural considerations which facilitate or inhibit conjoint activity.

The theory is summarized in propositional form.
1. Individuals act on the basis of their constructs of themselves, others and the situation.
2. Constructs of meanings are hierarchically organized.
3. Constructs of particular events take place according to the individual's rules systems for meaning and action.
4. Individual rule systems may differ in structure.
5. The juxtaposition of two or more persons produces an interpersonal rule system.

The first four propositions focus on the intrapersonal system and define the manner in which individuals are modeled in the simulation. The first proposition leads to a multilevel hierarchy ranging from raw sensory data to self-concepts which serve to successively define and contextualize lower level entities. The rule systems referred to in the third proposition are classified as two types. Constitutive rules link levels in the hierarchy and describe how information or meanings are transformed into meanings at the next higher level. They may be viewed as stating a "counts as" relationship, e.g. "Hello" counts as "a greeting', between levels. Regulative rules, on the other hand, constrain the range of possible actions at one level given the actions hwich have preceded. Given a certain message has been received, then the subsequent response may be obligatory or may be chosen from one of several possibilities. Thus, these rules guide structural behavior. The last intrapersonal proposition can be operationalized as viewing individuals as differing in either the structure of their regulative rules, their constitutive rules, or both. The final proposition states that the interpersonal system that results is determined by the fit between the intrapersonal rule systems and is not a simple sum of its parts. In the communication process, the alternation between individuals produces a system where one person's message is interpreted by the constitutive rules of another and serves as the antecedent condition for the others regulative rules. The regulative rules guide the selection of the next action in the context of individual goals which may differ. The patterns which result from the communication may result in a satisfactory termination of the interaction for one or both of the conversants or in the involvement in undesirable oscillatory behavior.

2.1 Problem Statement

Various laboratory experiments and case studies have demonstrated the utility of CMM theory in explaining behavior of individuals engaged in conversations. The operational definition of abstract concepts permits testing of propositions generated by the theory about humans and their social systems. An analogue of selected aspects of the theory of CMM in the form of a conversation simulation game has been developed and utilized in the laboratory setting (Pearce, Cronen, Johnson, Jones and Raymond, 1978). The game requires explicit specification of rules and goals and thus affords a higher level of control to permit testing of the theory's propositions. The game allowed two levels of hierarchy: index cards containing colored shapes represent speech acts and four-turn sequences of speech acts represent episodes. Regulative rules specified allowable speech acts following each antecedent, e.g. which index cards might be used following the card used by the counterpart in the conversation, and constitutive rules specified the possible interpretations of each of the speech acts, e.g. a red square means A or B. In addition, participants engage in conversation to achieve a desired goal - an episode represented by a pattern of meanings.

The experimenter can manipulate individual rules and goals by varying their complexity and can vary the extent of the fit between the intrapersonal systems. Thus individuals may enter into a conversation with differing goals, and rules structures which are not symmetrical and which differ in levels of complexity. Even in a two person game, the number of possible communication systems that could be examined can grow quite large. A simulation model which embodies the elements of the game can be used to systematically examine the impact of changes in goals and rule structures on the simulated conversation. Using a simplified model of individual behavior, one can identify interpersonal systems which lead to uninteresting patterns of conversation and select potentially more fruitful structures for subsequent laboratory experimentation. These simulated results permit identification of communication games which will facilitate the development of a more complex model of adaptive individual behavior, e.g. what coping behaviors are employed when communications become oscillatory.

The model described in the subsequent section was used to examine the following questions:
1. What forms of communication will occur given varying degrees of differences in goals among conversants?
2. What forms of communication will result given differences in constitutive rules among conversants?

The patterns generated will serve as a basis for laboratory experimentation examining the question:
3. What repair/coping procedures do individuals employ under various rule structures to achieve coherence when conversations begin oscillatory behavior?

2.2 Overview of the Model

In describing communication games, Cronen and Pearce (1978) consider a game to be simple if each rule specifies a one-to-one relationship between meanings and messages or between antecedents and consequents. A complex game is one where a message may have more than one possible meaning or a regulative rule may allow more than one response to an antecedent message. Asymmetrical refers to a lack of congruence among the rule structures of conversants. A general purpose model was developed which permits the specification of complex, asymmetrical rule structures for conversants whose goals may differ. In addition, the size of the message set and meaning set may be varied. An example of a symmetrical complex conversation game is shown in Figure i.

Figure i. Example of Constitutive and Regulative Rules for a Symmetrical Complex Conversation Game

	Player 1		Player 2
Constitutive Rules	α ε ω	(Messages)	α ε ω
	A B C	(Meanings)	A B C
Regulative Rules	If α, then α or ω If ε, then ε If ω, then α or ε		If α, then α or ω If ε, then ε If ω, then α or ε

The simulated conversation proceeds by alternately permitting the transmission and interpretation of messages by conversants. A prespecified string of meanings is the goal of each participant. The game terminates either when one or more conversants realizes its goal or when obvious cycling has occurred. The determination of subsequent messages involves consideration of individual goals and regulative rules. The flowcharts in Figures ii, iii, and iv provide a more detailed description of the operation of the model.

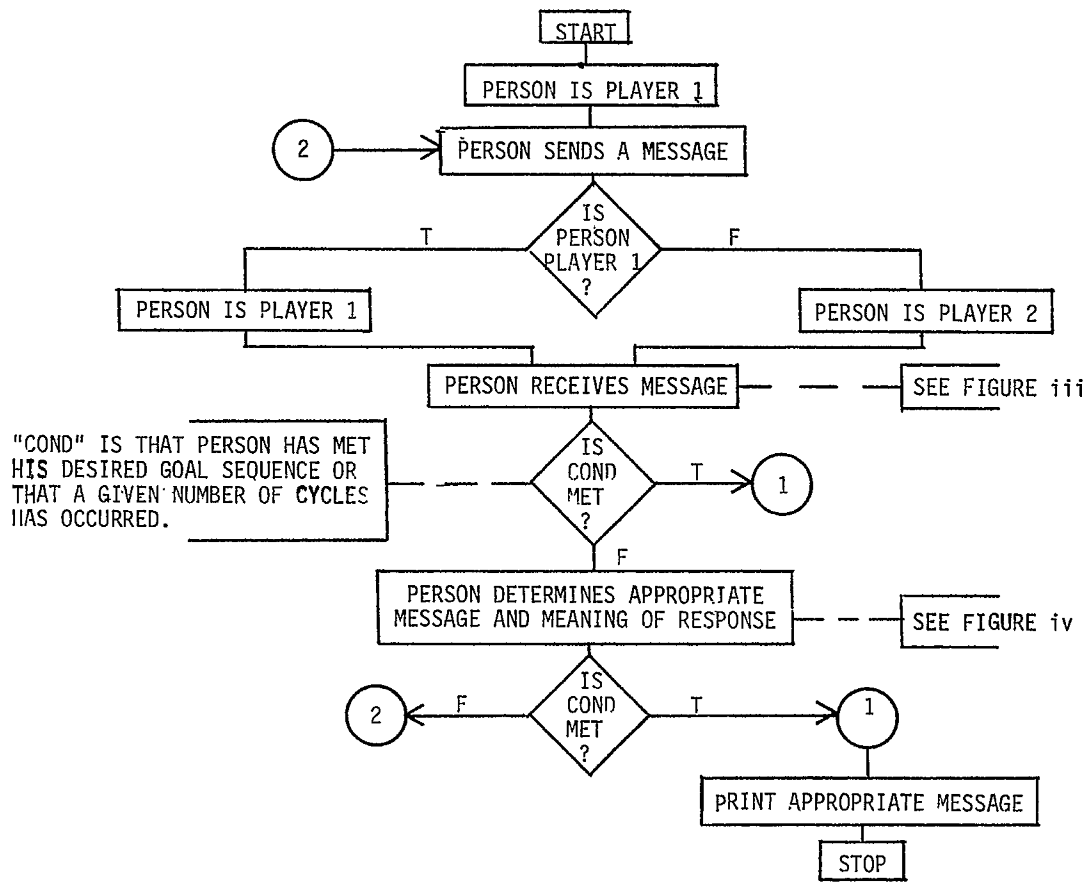


Figure ii. Communication Model General Flowchart

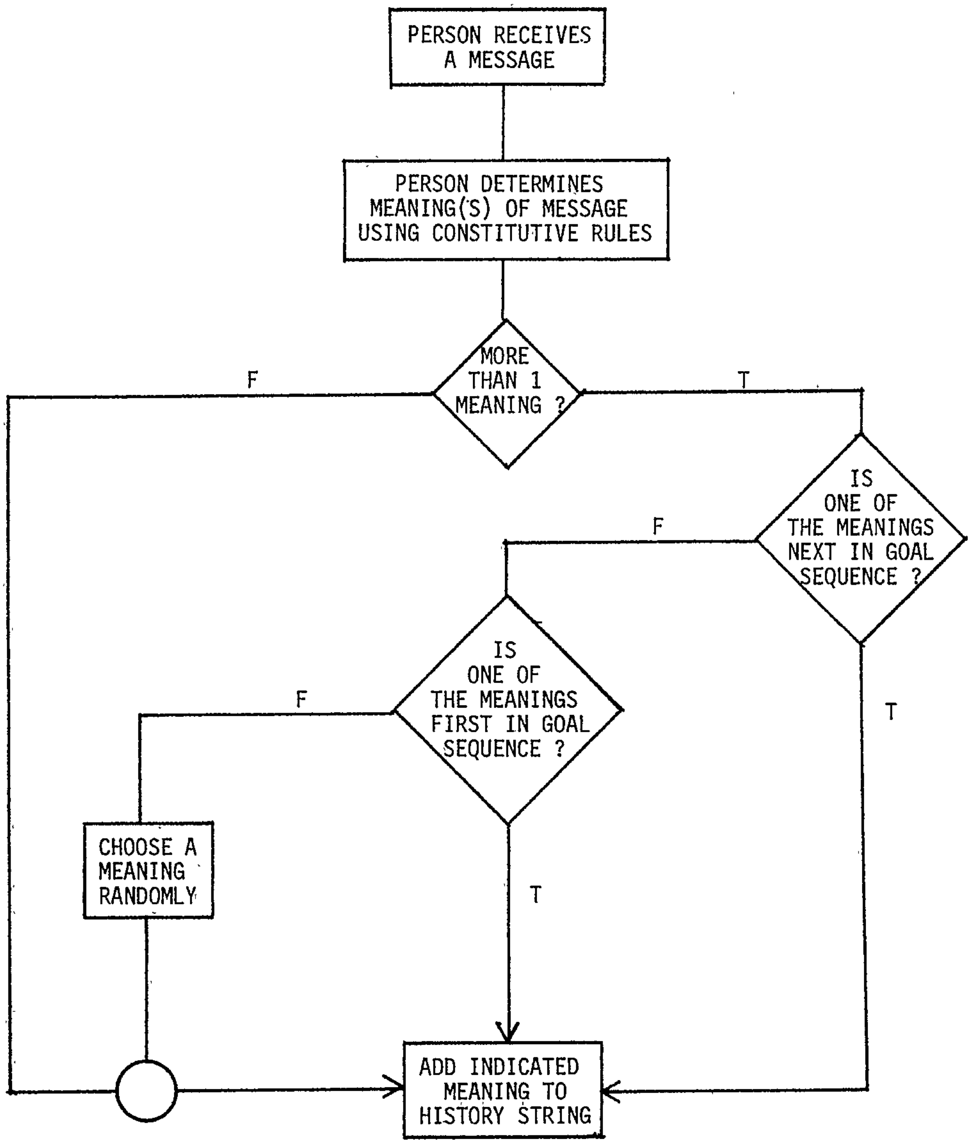


Figure iii. Communication Model Message Received Evaluation

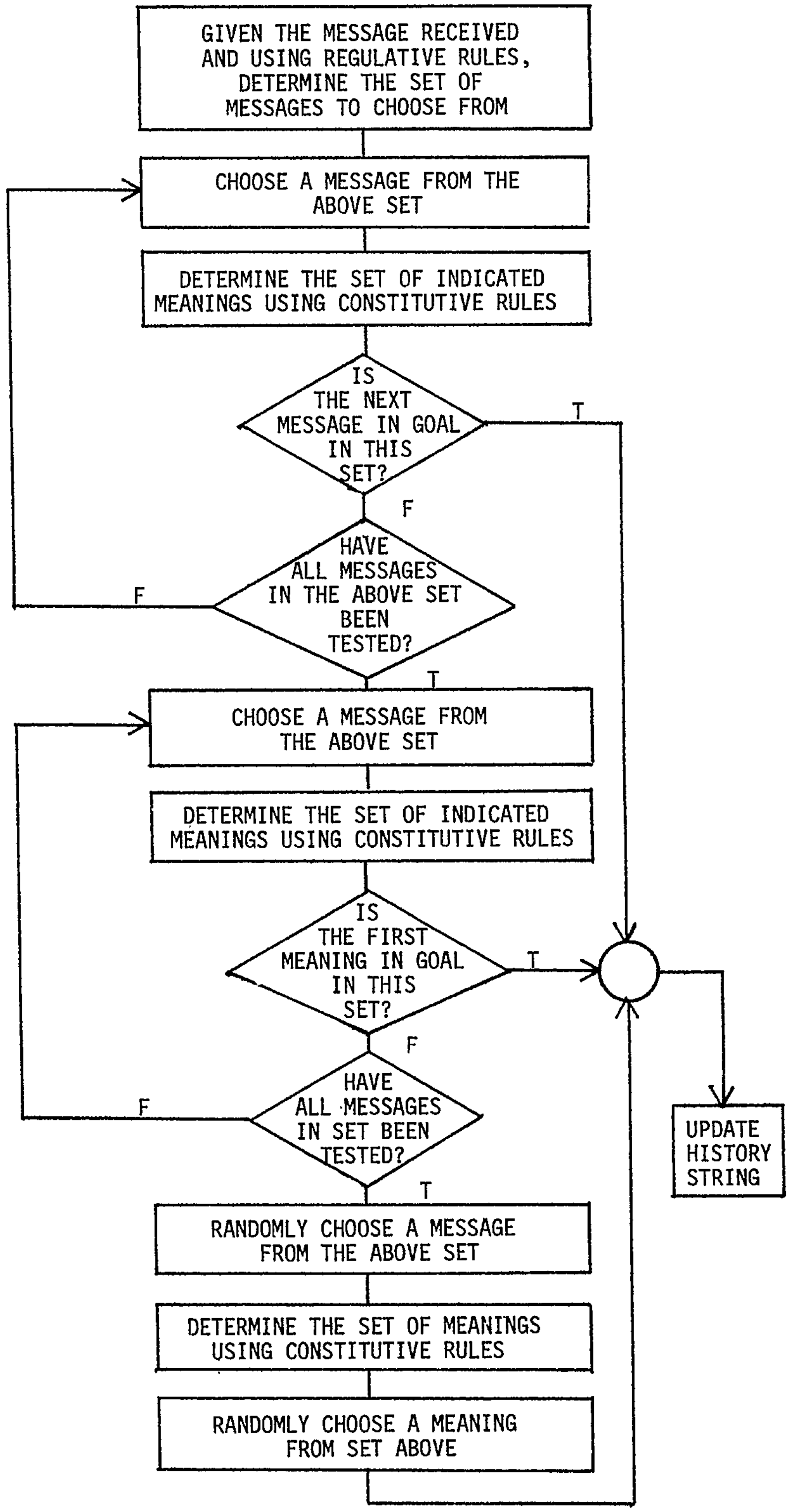


Figure iv. Communication Model Determination of Message Sent and Meaning

2.3 Illustration of the Model

Consider the game with the rules presented in Figure i. Suppose that player 1 and player 2 enter into conversation with the goals of realizing the sequence of meanings (A,B,C) and (B,C,A) respectively. Moreover, suppose player 1 initiates the conversation. Since player 1's goal is an episode (a sequence of meanings) beginning with A, the apparent way to achieve this end, given his set of constitutive rules, is to send the message α. When player 2 receives the message α, he interprets the message using his constitutive rules. For him, α has possible meanings A or B. Since his goal begins with B, he takes that as the indicated meaning. He goes to his set of regulative rules where the message α requires a response of α or ω. Since he has an option of sending message α or ω, he returns to the constitutive rules to interpret the meaning of each possible message. The meanings may be compared to the goal string to determine the most appropriate message. Player 2 discovers the message ω has the next desired meaning in his goal string, C. Therefore, he transmits message ω to player 1. Hence, he has accomplished B,C of his desired goal string (episode) of B,C,A. Play continues in this manner until the goal of player 1 or player 2 is met (illustrated for this case in Figure v) or until cycling has occurred as shown in Figure vi.

Figure v. Goal Satisfaction for Player 2

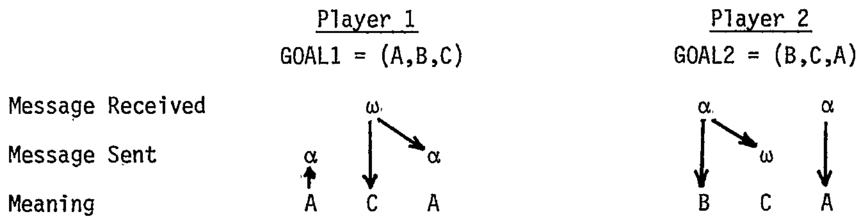
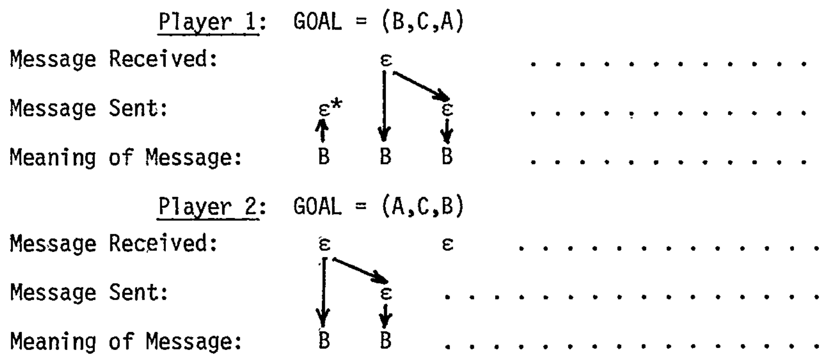


Figure vi. Cycling Behavior



* If Player 1 had initiated the conversation with α, the goals would have been achieved.

The simulation model that has been developed as an APL program to represent the conversational game is presented in Appendix 1.

3. EXPERIMENTAL PROCEDURE AND ANALYSIS

To provide an extensive study of the effects of rules and goal changes it was decided to initially confine the analysis to three meaning episodes. Even this small case consumed a considerable amount of computer time. This is the smallest episode that would appear to be of theoretical interest. A detailed analysis at this stage was anticipated to reveal sufficient information for subsequent laboratory study as well as identify structures that could be disregarded in subsequent runs when more complicated episodic conditions are studied.

The simulated conditions examined assumed symmetrical regulative rules and constitutive rules for the two conversants. The episodes examined included symmetrical and asymmetrical situations. While regulative rules were held constant, constitutive rules were varied to include simple and all possible complex cases. The regulative rules used were complex and included three types. First, there was a simple trapping rule. In this case, the consequent message is the same as the antecedent message, e.g., if ε then ε. Second, a complex rule was used that allowed repetition but did not trap, e.g., if α then α or ω. Finally, a complex rule that did not allow repetition was employed, e.g., if ω then α or ε.

In the case of symmetrical constitutive rules and asymmetrical goals, the number of possible games is on the order of 10,000. For each set of constitutive rules, 36 different conversation games are possible due to variations in the goals of the conversants. The number of possible variations in constitutive rules is 343. However, a number of these, 72, automatically lead to unresolvable games, namely games which require a meaning which cannot be realized with the possible message set. Of the 9,756 remaining games a sample of 1,800 communications games were simulated.

In the games that were simulated the regulative rules were used in conjunction with the constitutive rules to determine which episodes were feasible. Analysis thus concentrated on the examination of those cases where at least one of the conversants possessed a goal that could be achieved. Satisfactory resolution of the conversation is possible for at least one of the conversants in these cases. Cases where successful resolution of conversations resulted were compared with unsuccessful conversations to identify factors which contribute to oscillatory behavior.

3.1 Results

The message streams of the simulated conversations were classified according to the amount of flexibility (the degree of equifinality and mulitfinality) in the constitutive rules. The least flexibility was exhibited in the four sets of constitutive rules classified as simple games. In each of the four cases of thiryt-six, eleven goal sets (episodes) had the possibility of being realized (non-oscillatory behavior). In each case, seven of the eleven converged while four exhibited oscillatory behavior.

The largest portion of the games came from the next group with the next higher level of flexibility (equifinality and multifinality) in the constitutive rules. This group provided eighteen sets of thirty-six games. The constitutive rules are grouped according to the number of messages in the episodes which are permitted to be realized.

Potentially Realizable Episodes	Number of Constitutive Rule Sets	Average Percent of Goals Realized
11	8	68.75%
20	3	61.5 %
27	6	78.3 %
35	1	45.7 %

Table i. Summary of Episodes Realized Under Similar Constitutive Rules

Since the constitutive rules are similar in all cases, and since each set of constitutive rules is examined with all possible combinations of goal sets, results suggest the importance of the interaction between regulative rules and constitutive rules in determining the likelihood of successfully completing the conversation.

A similar pattern is observed as the flexibility of the constitutive rules increases the probability that at least one of the participants will realize his goals. Table ii summarizes the results for four sets of similar constitutive rules of thirty-six simulated conversations.

Potentially Realizable Episodes	Number of Constitutive Rule Sets	Average Percent of Goals Realized
32	2	68.75%
36	2	95.8 %

Table ii. Summary of Episodes Realized Under High Levels of Constitutive Rules Flexibility

The variation again points the importance of the regulative rules in constraining the realization of goals.

In general, the results confirm that increased flexibility in constitutive rules result in increased likelihood of the successful resolution of the conversation. They do point to an important interaction between goals, constitutive rules and regulative rules.

A detailed analysis of individual games revealed that shared goals, even if the goals are feasible, is no guarantee that any one of the conversants will successfully realize the goals. Where the participant has a choice he/she may choose a message which leads to an oscillatory or trapping state. A detailed analysis of the message and meaning strings indicated the importance of the opening messages to convergence of the message string.

Analysis of the results suggested specific games which can lead to either goal satisfaction or oscillatory behavior for use in the laboratory in the analysis of coping behaviors when conversants move into an oscillating pattern. These simulated conversation games cound be used and protocols of participants collected to develop operational rules for incorporations in the simulation.

There are numerous areas for subsequent analysis. The experimental design currently calls for examination of the impact of variations in regulative rules on the ability of conversants to realize their goals. Subsequently asymmetrical rule structures will be examined. The results of laboratory experimentation will be employed to incorporate empirically-based rudimentary forms of learning and adaptive behaviors into the model. This model will then be evaluated in terms of its ability to predict laboratory behaviors.

APPENDIX 1

In the APL simulation program, the use must define the following arrays in work space prior to program execution:

RMESS1: The vector of perceivable messages which may be received by player 1.

SMESS1: The vector of messages which may be transmitted by player 1.

MRMESS1: The vector of meanings which will be associated with the elements of RMESS1.

MSMESS1: The vector of meanings which will be associated with the elements of SMESS1.

RMESMEAN1: An array with dimension ρ(RMESS1) x ρ(MRMESS1). Elements of the array are formed by the following function:

RMESMEAN1 (X;Y) = 1 if perceivable message received X has meaning Y; 0 otherwise

SMEANMES1: An array with dimensions ρ(SMESS1) x ρ(MSMESS1) which associates the set of messages player 1 may send with meanings by the following rule:

SMEANMES1 (X;Y) = 1 if message to send X has meaning Y; 0 otherwise

The reader should note that arrays RMESMEAN1 and SMEANMES1 form the set of constitutive rules for player 1.

GAME2RULE1: Is an ρ(RMESS1) x ρ(SMESS1) array which forms the regulation rules for player 1 using the following function:

GAME2RULE1 (X;Y) = 1 if X·RMESS1 implies Y SMESS1; 0 otherwise

GOAL1: The set of sequential meanings which player 1 desires to achieve in the conversation. It is also necessary to enter a similar set of arrays for player 2

The array names are:
RMESS2
SMESS2
MRMESS2
MSMESS2
RMESMEAN2
SMEANMES2
GAME2RULE2
GOAL2

```
      ∇DRIVER2[⎕]∇

    ∇ DRIVER2
[1]   P1I←P2I←0
[2]   FLAG←0
[3]   HISTMEAN1←HISTMEAN2←0⍴' '
[4]   PLAYSTART
[5]   L1:RECEIVE1
[6]   →(FLAG≠0∨100=⍴HISTMEAN1)/L2
[7]   RULEA1
[8]   →(FLAG≠0∨100=⍴HISTMEAN1)/L2
[9]   RECEIVE2
[10]  →(FLAG≠0∨100=⍴HISTMEAN2)/L2
[11]  'PLAY ';(⍴HISTMEAN1)÷2;' COMPLETED'
[12]  RULEA2
[13]  →(FLAG≠0∨100=⍴HISTMEAN2)/L2
[14]  →L1
[15]  L2:⎕←' ';'END OF GAME:';⎕←' ';⎕←' '
[16]  'MEANINGS STRING FOR PLAYER 1:';⎕←' ';⎕←' '
[17]  ⎕←HISTMEAN1;⎕←' ';⎕←' '
[18]  'MEANINGS STRING FOR PLAYER 2';⎕←' ';⎕←' '
[19]  ⎕←HISTMEAN2;⎕←' ';⎕←' '
    ∇


      ∇PLAYSTART[⎕]∇

    ∇ PLAYSTART
[1]   E1←MSMESS2⍳GOAL2[1]
[2]   P2I←1
[3]   E2←+/SMESMEAN2[;E1]
[4]   E3←⍒(⍴SMESS2)⍴SMESMEAN2[;E1]
[5]   E4←E2↑E3
[6]   E5←SMESS2[E4]
[7]   MSG←E5[?E2]
    ∇


      ∇RECEIVE1[⎕]∇

    ∇ RECEIVE1
[1]   I1←RMESS1⍳MSG
[2]   C1←+/RMESMEAN1[I1;]
[3]   IN1←⍒(⍴MRMESS1)⍴RMESMEAN1[I1;]
[4]   N1←C1↑IN1
[5]   →((MRMESS1[N1]⍳GOAL1[P1I+1])>C1)/L1
[6]   P1I←P1I+1
[7]   HISTMEAN1←HISTMEAN1,GOAL1[P1I]
[8]   →(P1I=⍴GOAL1)/L3
[9]   →0
[10]  L1:→((MRMESS1[N1]⍳GOAL1[1])>C1)/L2
[11]  P1I←1
[12]  HISTMEAN1←HISTMEAN1,GOAL1[1]
[13]  →0
[14]  L2:HISTMEAN1←HISTMEAN1,MRMESS1[N1[?C1]]
[15]  P1I←0
[16]  →0
[17]  L3:⎕←' ';⎕←' ';⎕←'GOAL SEQUENCE MET BY PLAYER 1';⎕←' ';⎕←' '
[18]  FLAG←1
[19]  →0
    ∇
```

```
      ∇RULEA1[⎕]∇

    ∇ RULEA1
[1]   R1←RMESS1⍳MSG
[2]   C1←+/GAME2RULE1[R1;]
[3]   C2←⍉(⍴RMESS1)⍴GAME2RULE1[R1;]
[4]   C3←C1↑C2
[5]   POSSEND1←SMESS1[C3]
[6]   LOCMEAN1
    ∇


      ∇LOCMEAN1[⎕]∇

    ∇ LOCMEAN1
[1]   Z1←1
[2]   L3:R11←SMESS1⍳POSSEND1[Z1]
[3]   C11←+/SMESMEAN1[R11;]
[4]   C21←⍉(⍴SMESS1)⍴SMESMEAN1[R11;]
[5]   C31←C11↑C21
[6]   MPOSSEND1←MSMESS1[C31]
[7]   →((MPOSSEND1⍳GOAL1[P1I+1])>C11)/L1
[8]   MSG←POSSEND1[Z1]
[9]   HISTMEAN1←HISTMEAN1,GOAL1[P1I+1]
[10]  P1I←P1I+1
[11]  →(P1I<⍴GOAL1)/L2
[12]  FLAG←1
[13]  L2:→0
[14]  L1:Z1←Z1+1
[15]  →(Z1≤⍴POSSEND1)/L3
[16]  LOCAMEAN1
    ∇


      ∇LOCAMEAN1[⎕]∇

    ∇ LOCAMEAN1
[1]   Z1←1
[2]   L3:R11←SMESS1⍳POSSEND1[Z1]
[3]   C11←+/SMESMEAN1[R11;]
[4]   C21←⍉(⍴SMESS1)⍴SMESMEAN1[R11;]
[5]   C31←C11↑C21
[6]   MPOSSEND1←MSMESS1[C31]
[7]   →((MPOSSEND1⍳GOAL1[1])>C11)/L1
[8]   MSG←POSSEND1[Z1]
[9]   HISTMEAN1←HISTMEAN1,GOAL1[1]
[10]  P1I←1
[11]  →0
[12]  L1:Z1←Z1+1
[13]  →(Z1≤⍴POSSEND1)/L3
[14]  LOCBMEAN1
    ∇


      ∇LOCBMEAN1[⎕]∇

    ∇ LOCBMEAN1
[1]   MSG←POSSEND1[?⍴POSSEND1]
[2]   D1←SMESS1⍳MSG
[3]   D2←+/SMESMEAN1[D1;]
[4]   D3←⍉(⍴SMESS1)⍴SMESMEAN1[D1;]
[5]   D4←D2↑D3
[6]   HISTMEAN1←HISTMEAN1,MSMESS1[D4[?D2]]
[7]   P1I←0
[8]   →0
    ∇
```

```
      ∇RECEIVE2[⎕]∇

    ∇ RECEIVE2
[1]   I1←RMESS2⍳MSG
[2]   C1←+/RMESMEAN2[I1;]
[3]   IN1←⍋(ρMRMESS2)ρRMESMEAN2[I1;]
[4]   N1←C1↑IN1
[5]   →((MRMESS2[N1]⍳GOAL2[P2I+1])>C1)/L1
[6]   P2I←P2I+1
[7]   HISTMEAN2←HISTMEAN2,GOAL2[P2I]
[8]   →(P2I=ρGOAL2)/L3
[9]   →0
[10]  L1:→((MRMESS2[N1]⍳GOAL2[1])>C1)/L2
[11]  P2I←1
[12]  HISTMEAN2←HISTMEAN2,GOAL2[1]
[13]  →0
[14]  L2:HISTMEAN2←HISTMEAN2,MRMESS2[N1[?C1]]
[15]  P2I←0
[16]  →0
[17]  L3:⎕←' ';⎕←' ';⎕←'GOAL SEQUENCE MET BY PLAYER 2';⎕←' ';⎕←' '
[18]  FLAG←1
[19]  →0
    ∇



      ∇RULEA2[⎕]∇

    ∇ RULEA2
[1]   R1←RMESS2⍳MSG
[2]   C1←+/GAME2RULE2[R1;]
[3]   C2←⍋(ρRMESS2)ρGAME2RULE2[R1;]
[4]   C3←C1↑C2
[5]   POSSEND2←SMESS2[C3]
[6]   LOCMEAN2
    ∇

      ∇LOCMEAN2[⎕]∇

    ∇ LOCMEAN2
[1]   Z1←1
[2]   L3:R11←SMESS2⍳POSSEND2[Z1]
[3]   C11←+/SMESMEAN2[R11;]
[4]   C21←⍋(ρSMESS2)ρSMESMEAN2[R11;]
[5]   C31←C11↑C21
[6]   MPOSSEND2←MSMESS2[C31]
[7]   →((MPOSSEND2⍳GOAL2[P2I+1])>C11)/L1
[8]   MSG←POSSEND2[Z1]
[9]   HISTMEAN2←HISTMEAN2,GOAL2[P2I+1]
[10]  P2I←P2I+1
[11]  →(P2I<ρGOAL2)/L2
[12]  FLAG←1
[13]  L2:→0
[14]  L1:Z1←Z1+1
[15]  →(Z1≤ρPOSSEND2)/L3
[16]  LOCAMEAN2
    ∇
```

```
      ∇LOCAMEAN2[⎕]∇

    ∇ LOCAMEAN2
[1]   Z1←1
[2]   L3:R11←SMESS2⍳POSSEND2[Z1]
[3]   C11←+/SMESMEAN2[R11;]
[4]   C21←⍒(⍴SMESS2)⍴SMESMEAN2[R11;]
[5]   C31←C11↑C21
[6]   MPOSSEND2←MSMESS2[C31]
[7]   →((MPOSSEND2⍳GOAL2[1])>C11)/L1
[8]   MSG←POSSEND2[Z1]
[9]   HISTMEAN2←HISTMEAN2,GOAL2[1]
[10]  P2I←1
[11]  →0
[12]  L1:Z1←Z1+1
[13]  →(Z1≤⍴POSSEND2)/L3
[14]  LOCBMEAN2
    ∇


      ∇LOCBMEAN2[⎕]∇

    ∇ LOCBMEAN2
[1]   MSG←POSSEND2[?⍴POSSEND2]
[2]   D1←SMESS2⍳MSG
[3]   D2←+/SMESMEAN2[D1;]
[4]   D3←⍒(⍴SMESS2)⍴SMESMEAN2[D1;]
[5]   D4←D2↑D3
[6]   HISTMEAN2←HISTMEAN2,MSMESS2[D4[?D2]]
[7]   F2I←0
[8]   →0
    ∇
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