Situational Effects on the Syntax of Speech and Gaze Behaviour in Dyads[1]

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ABSTRACT

A substantial literature exists on the coordination of speaking and looking behaviour and their significance as indicators for the production and reception of social information. Within this framework, the temporal organisation of such behaviour has been shown to reflect both the coordination within the individual and between participants in a situation.

In this paper, it is proposed that observed behavioural sequences may be formally described by rules of syntax, thus implying the likelihood of structural organisation as opposed to, for example, linear time dependence between behavioural states. This being the case, differing sets of rules and grammars respectively can be expected for various social situations.

Clinical interviews and discussions between couples on a topic of marital conflict were analysed, the on-off patterns of speech and gaze being taken as data.

The resulting behavioural repertoire was regarded, in the sense of a formal grammar, as the terminal vocabulary. A set of rewriting rules was determined and their associated probabilities inferred.

The situational conditions were found to be reflected in the syntactic features of the grammatical model - the terminal vocabulary, the production rules and the production probabilities.

Key Words

Social interaction; verbal and nonverbal communication; mathematical linguistics; grammar; rules of syntax; behavioural analysis; pattern recognition; social psychology.

INTRODUCTION

It is well known that the behaviour observed during social interaction is influenced by such factors as the internal states and mental capacities of the partici-

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1. The work reported in this paper was supported by the Deutsche Forschungsgemeinschaft, Antrag El 67/1

pants, the dominance relationships between participants and the situational demands. This has been variously reported for both verbal and nonverbal behaviour (Cicourel, 1973; Scheflen, 1967). In this context, the significance of the temporal coordination of speech and gaze behaviour has been recognised (Jaffé and Feldstein, 1970; Argyle and Cook, 1976). It is proposed here that examination of behavioural sequences involving verbal and nonverbal behaviour - in the present case, speech and gaze - should yield results which conform to a structural or syntactic model. That is, as Duncan (1969) has suggested "an underlying system or set of rules somewhat analogous to those for languages" may be sought. A similar approach has been recently described by D. D. Clarke (1979) for the verbal aspects of conversation and Slama-Cazacu (1976) has suggested a "mixed syntax" for the verbal and nonverbal components of interaction.

Various possibilities for the formalisation of such a model have been developed in mathematical linguistics and pattern recognition (Fu, 1976). The methods discussed here attempt to exploit both the structural and the external variable approaches for the formal analysis of speaking and related looking behaviour.

This approach therefore involves implications about the regularity of behavioural sequences and their rules of syntax. That is to say, beyond a taxonomy of behavioural units yielding statistical descriptors of frequency, duration, etc. whether rules of syntax can be formulated for the observed behavioural sequences. It is maintained here that the observed behaviour during social interaction should reflect, on the one hand, factors such as the situational conditions and the participants' understanding of their roles, and on the other, internal states of the participants such as arousal level and mental capacity. The influence of these factors may be likened to a form of rule-governing, and the internal states may be seen as contributing to the manner in which the rules are followed. How these aspects are compounded remains to be clarified. An example of such a rule for speech and gaze behaviour could be that during a clinical interview, only the physician may pose questions. At a micro level in the behavioural hierarchy the effect of the participants' internal states could, for example, be thus described: when the mental load associated with speech preparation or production is too high, in terms of cognitive or emotional capacity, eye contact with social partner must be reduced. According to the concept of rule governed behaviour, it can be argued that during dyadic interaction each participant will assume a role, and behave according to his understanding of the rules which govern that role. Also, this rule dependence should become evident in those aspects of verbal and nonverbal behaviour which are understood by the participant as belonging to his role. Thus, what may be likened to an underlying, or deep structure of the interaction is reflected in the observed behaviour.

Observed material and data

The material being analysed involves videorecordings of clinical-psychiatric interviews with depressive patients which have been made for a number of single case, longitudinal studies (see Ellgring, Wagner and Clarke, this volume). Further material includes extracts of conversations between couples attending marital therapy. In principle, the data transcription involves the scoring of the presence, respectively absence, of the speech and gaze of the two participants. This yields four binary channels of data, corresponding to a possible behavioural repertoire of sixteen combinatorial states (Clarke, Wagner, Rinck and Ellgring, 1979) The sixteen possible states in the behavioural repertoire can be ordered into four subgroups corresponding to the four possible speech activity conditions, namely: a) mutual silence, (b) participant A speaking, (c) participant B speaking, and (d) simultaneous speaking. Each of these subgroups contains each of the four possible gaze combinations, namely: (a) no one looking, (b) participant A looking at B, (c) participant B looking at A, and (d) mutual gaze.

This coding scheme gives a complete description of the sequence of behaviour at the level of observation. The states defined are mutually exclusive and represent the behavioural elements in the subsequent analysis (see Appendix 1).

Structural model

As a formal model, a probabilistic grammar, based on a Chomsky Type 2 grammar has been explored (see Appendix 2). Thus, for each analysed episode the interaction is described by means of: a repertoire, or terminal vocabulary of behavioural elements, a structural description in the form of a set of rewrite rules, to which a set of probabilities is allocated.

A probabilistic grammar was selected as a model following the assumption that the observed strings of behavioural elements represent 'noisy images' of ordered structures. Accordingly, the behavioural strings are generated on a grammatical level, and to some extent deformed on the probabilistic level (Grenander, 1969).

The grammars are constructed in practice as follows:

1) The behavioural repertoire is defined by the 16 possible combinations of the binary coded channels. These behavioural states are taken as terminal syntactic elements.
2) It is assumed that the observed strings of syntactic elements can be structurally described by the rewrite rules of a corresponding grammar. The observed strings thus represent the units of analysis (in contrast to the unit of analysis with grammars of natural language, which is the sentence, it is generally the case here that the unit of analysis corresponds to an exchange between participants).
3) Each of the rewrite rules of the grammar may be allocated a probability estimated for each analysed episode according to the frequencies of occurrence of the observed strings.

For each observed episode a sequence of approximately 300 - 400 behavioural elements is recorded. This sequence is examined for recurring behavioural strings. Examples are shown in Figures 1a and 1b. The strings which are found may be described by a derivation of the type shown in Figure 1. This is equivalent to the structural description in terms of rewrite rules. The set of rewrite rules required for the complete episode yields a qualitative description of the structure of the observed sample.

Thus, for Figure 1a, a dialogue exchange (nonterminal element: D) can be "rewritten as consisting of the floortime or turn of participant A (nonterminal element A) and the turn of participant B (nonterminal element B)". Similarly the turns of each participant can be rewritten as required, as consisting of those states during which the participant actually speaks (A_S, B_S) and in pauses (Pa). These states can then be rewritten as terminal elements (10, 2, 6).

In turn, the frequences of occurrence of the behavioural strings yield the frequencies of application of each of the rewrite rules for the generation of the observed sample. This takes into consideration the probabilistic aspect or noisiness, of the behaviour, and represents a quantitative description of the structural relationships between behavioural elements.

Two grammars, constructed from the data from (a) a clinical interview and (b) a conversation between a marital couple, are listed in Table 1. As can be seen the grammars (G) are defined as quintuples (V_N, V_T, P, S, p), differing from phrase structure grammars in that a set of probabilities (p) is included. To

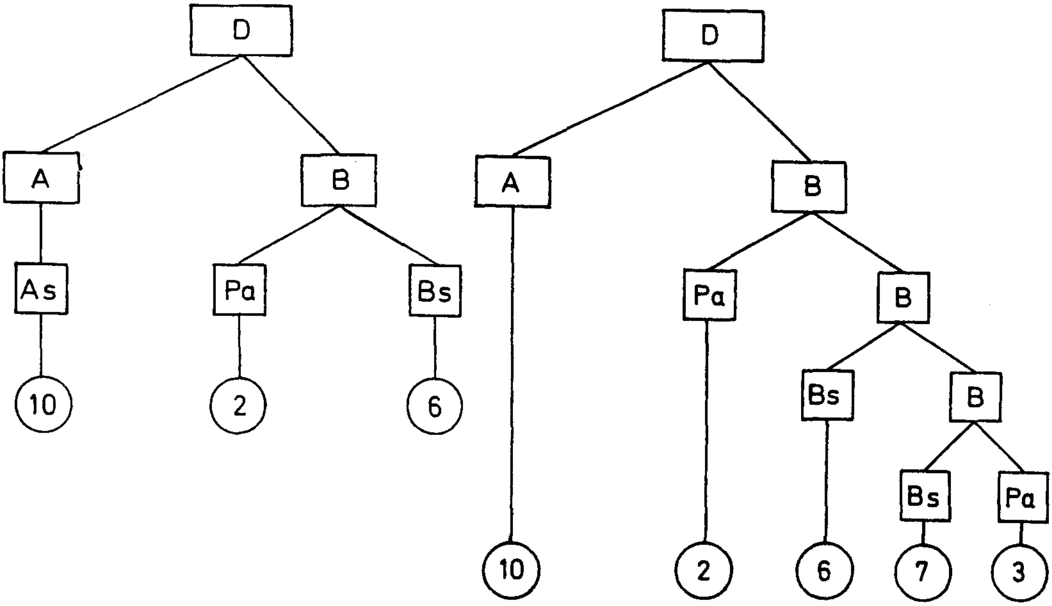

Fig. 1 Examples of possible structural derivations of strings involving three and five behavioural states.

each rewrite rule in the set (P) a probability is allocated. In the nonterminal vocabulary (V_N) the element (Ch) refers to interpersonal speech pauses, whilst the element (Pa) refers to intrapersonal pauses.

In each grammar rule 1 defines the exchange between participants - floortime A (A), speaker switch (Ch), floortime B (B).

In the case of the interview (where part. A is the interviewer, part. B the patient), it can be seen that the terminal vocabulary (V_T) consists of a repertoire reduced to only 5 of the possible 16 behavioural states. This can largely be attributed to the depressive state of the patient at the time of the interview. This is further reflected by the number of pause states (0,2,3) and the number of rewrites involving pausing (rules 6, 8-11).

The probability values indicate that the interviewer spends most of his floortime speaking (rules 2, 3) with little pausing, and further that while speaking his gaze is directed at the patient (rule 4). On the other hand, the patient spends less of his floortime speaking (e.g. rule 6), and when speaking, his gaze is always directed away from the interviewer (rule 7). The probabilities relating to the pause behaviour indicate that all interpersonal pauses (rule 12) involve state 2 - the interviewer looking at the patient and the patient not looking at the interviewer. The majority of the intrapersonal pauses also involve this state (rules 8-11).

In connection with the single case, longitudinal studies mentioned earlier, a matrix can be constructed which contains the rewrite probabilities for each of the series of interviews. This enables measurement of intraindividual changes in behavioural repertoire, coordination, structural complexity, etc.

The second grammar describes a conversation between a marital couple. In this example, the nonterminal vocabulary (V_T) includes 11 of the 16 possible states.

TABLE 1 Probabilistic grammars for a) a clinical interview, and b) a conversation between a marital couple.

a) Interview: Fe1m03

$G = (V_N, V_T, P, S, p)$

$V_N = (D, A, B, Ch, Pa, As, Bs)$

$V_T = (0, 2, 3, 6, 10)$

1) $D \longrightarrow A\ Ch\ B$

2) $A \xrightarrow{.85} As$

3) $A \xrightarrow{.15} Pa\ As$

4) $As \xrightarrow{1.0} 10$

5) $B \xrightarrow{.46} Bs$

6) $B \xrightarrow{.54} Bs\ Pa$

7) $Bs \xrightarrow{1.0} 6$

8) $Pa \xrightarrow{.22} 2\ B$

9) $Pa \xrightarrow{.62} 2$

10) $Pa \xrightarrow{.07} 2\ 3$

11) $Pa \xrightarrow{.09} 2\ 0$

12) $Ch \xrightarrow{1.0} 2$

b) Dialogue: 5455

$G = (V_N, V_T, P, S, p)$

$V_N = (D, A, B, Ch, As, Bs)$

$V_T = (1, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14)$

1) $D \longrightarrow A\ Ch\ B$

2) $A \xrightarrow{.44} As$

3) $A \xrightarrow{.56} As\ A$

4) $As \xrightarrow{.12} 8$

5) $As \xrightarrow{.44} 9$

6) $As \xrightarrow{.20} 10$

7) $As \xrightarrow{.24} 11$

8) $B \xrightarrow{.49} Bs$

9) $B \xrightarrow{.51} Bs\ B$

10) $Bs \xrightarrow{.29} 4$

11) $Bs \xrightarrow{.19} 6$

12) $Bs \xrightarrow{.40} 5$

13) $Bs \xrightarrow{.12} 7$

14) $Ch \xrightarrow{.41} 13$

15) $Ch \xrightarrow{.20} 1$

16) $Ch \xrightarrow{.39} 14$

Also, more rewrite rules are required than for the interview, and the more symmetrical structure of the situation is reflected. The terminal vocabulary includes only one pause state (1), and this always occurs as an interpersonal pause (rule 15). From the estimated probabilities for rules 14-16 it can be seen that speaker switching occurs mostly via states 13 and 14 - states involving mutual speaking and one participant with directed gaze. The symmetry of the situation is indicated by the closely matched rules 2-7 (part A) and 8-13 (part B). For the rules 2, 3 and 8, 9 the probabilities are comparable. It is possible to calculate a measure of symmetry with respect to asymmetry from the rewrite probabilities of the complementary rules within a grammar. Without going into detail, the measures of asymmetry found for the examples described were, for the conversation 0.05, and for the interview 0.36. This measure of asymmetry is of particular interest in the study concerning marital couples. For the interview situations it seems more useful to calculate a difference measure from interview to interview as mentioned earlier.

CONCLUSION

The present study has been concerned with the application of such concepts as rule governed behaviour and the hierarchical organisation of behaviour to the description of the process of dyadic interaction. The use of a grammatical, or linguistic model has been explored. However, this should be distinguished from the linguistic analogy of Birdwhistell; the present approach is to be understood within the framework of generative grammar, as opposed to the earlier structuralist grammar to which the so-called linguistic analogy subscribed. This distinction applies, above all, to the emphasis on the importance of the syntactic rules and the description of the underlying structural relationships. The model of a probabilistic grammar furthermore provides a quantitative measure of these relationships.

This corresponds to the research strategy recently proposed by Duncan and Fiske (1978), in which both structural and statistical aspects of the interaction process ought to be taken into consideration. However, whether the model can be further developed to include reference to the semantic aspect of the behavioural elements remains to be shown.

The features of the probabilistic grammar, namely the behavioural repertoire, the structural description and the probability measure enable the determination of structural changes in the interaction process, both for situational and for role dependencies. On the basis of these features, such measures can be obtained as comparison of situation - determined by the quantitative changes in the rule probabilities between situations; or, symmetry of interaction - calculated from the probabilities of the complementary rules within a grammar.

Generally, the approach has explored and to some extent demonstrated the practicability of the grammatical model for behavioural sequence analysis. Although the examples described involve a particular type of observational data, it seems quite feasible that the method be implemented for most types, given that some sequential order is to be expected.

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Appendix 1. Repertoire of behavioural states (0 = on, 1 = off)

Speech A	Speech B	Gaze A	Gaze B	State	Speech A	Speech B	Gaze A	Gaze B	State	Speech A	Speech B	Gaze A	Gaze B	State
0	0	0	0	0	0	1	0	1	5	1	0	1	0	10
0	0	0	1	1	0	1	1	0	6	1	0	1	1	11
0	0	1	0	2	0	1	1	1	7	1	1	0	0	12
0	0	1	1	3	1	0	0	0	8	1	1	0	1	13
0	1	0	0	4	1	0	0	1	9	1	1	1	0	14
										1	1	1	1	15

Appendix 2.

A probabilistic grammar G is defined as a quintuple: $G = (V_N, V_T, P, S, p)$ where V_N is a finite, non-empty set of non-terminal elements; V_T is a finite, non-empty set of terminal elements; P is a set of rewrite rules; S is the start symbol.

$V_N \cap V_T = \emptyset \qquad V_N \cup V_T = V$ P, the set of rewrite rules is composed of three elements (α_i, β_j, p_i), where p_{ij} is a real number indicating the probability that a given element α_i will be rewritten as β_j. p_{ij} is termed the production probability.