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Reviewed work(s):
Source: *Behaviour*, Vol. 44, No. 1/2 (1973), pp. 89-112
Published by: BRILL
Stable URL: http://www.jstor.org/stable/4533482
Accessed: 18/11/2012 14:04

NON-METRIC ANALYSIS OF BEHAVIORAL INTERACTION SEQUENCES IN CAPTIVE JACKALS (*CANIS AUREUS* L.)

by

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(With 14 Figures)

(Rec. I-XII-1971)

INTRODUCTION

During the 4 months preceding copulation, Golden Jackal (*Canis aureus* L.) pair-mates perform certain sequences of behavior that seem significant to their precopulatory activity. These sequences last from several seconds to a minute or more, and include an abundance of actions which are performed by both pair-mates while circling each other in a specific manner (GOLANI & MENDELSSOHN, 1970). The variability in the combinations of the different actions calls for the use of special methods of fine-grain analysis. The present paper deals with a preliminary attempt to analyze behavior sequences with the use of a new non-metric computer technique, namely the Guttman-Lingoes Multidimensional Scalogram Analysis (MSA-I) (see also BLOOMBAUM & MILTON, 1968; GUTTMAN, LEIBLICH & NAFTALI, 1969).

The units of observation are discrete behavioral events which are themselves relatively stereotyped. Because they occur in highly variable combinations, one cannot easily justify their inclusion under the concept of "a behavior pattern executed by the whole animal" (BAERENDS, 1957). Intuitively these behavioral events seem to be significant, in the sense

1) Part of a Ph. D. thesis submitted to the Tel-Aviv University.

2) I wish to thank the Tel-Aviv University Research Zoo employees for their help with the animals, Mr A. PELLEG for technical assistance and Prof. P. H. KLOPFER of Duke University for encouragement and critical reading of the manuscript. Mr U. CHAIM and the staff members of the Institute for Applied Social Research helped a lot in the data processing. Mr G. HAR'EL did part of the programing. The contribution of Dr J. FRIED of the Mental Health Clinic in Ramat Chen, Israel, to the methodological framework, was invaluable. Thanks are also due to my supervisors, Prof. H. MENDELSSOHN of Tel-Aviv University and Prof. L. GUTTMAN of the Hebrew University. This work was supported by the Ford Foundation, grant B-4. Dr C. LEWINSOHN wrote the german summary.

that they affect the behavior of both pair-mates. The objectives of the analysis are to discern the extent to which the splitting of the behavioral stream into discrete events is arbitrary (*e.g.*, whether raised tail and horizontal tail are two different patterns which affect behavior in different ways, or might be included under one pattern: "tail not lower than horizontal"), to determine the degree to which these events are mutually constrained, and to describe their significance in terms of their relatedness to other events.

Jackal behavior is viewed in this paper as a mosaic of discrete behavioral events, though one of the fruits of the analysis is a verification (or refutation) of the significance to the animals themselves of those elements the human observer believes to be "discrete".

SUBJECTS AND METHODS

Two pairs of jackals were kept in separate enclosures at a distance from one another. For the purpose of observation, each pair was released into a separate courtyard where they were accustomed to have their daily exercise. Whenever the pair-mates approached each other, starting thereby a precopulatory display, termed in this paper a "T-sequence" (GOLANI & MENDELSSOHN, 1970), it was filmed by a movie camera at a speed of 24 frames per second. Later, the films were projected with a film-analyzer, and stopped every 24 frames (*i.e.*, each second). The behavior observed every 24 frames was described and recorded in terms of observed simultaneous behavior events. This degree of resolution was chosen because at that time it seemed that for this type of behavior, the sample of one out of 24 frames avoids any significant loss of information. The observed behavioral events, the list of which is given in Table 1, were codified and written as a "profile of numbers" and termed a "system event" (see Fig. 1).

Each system event represents an instant of behavior of a pair of jackals, or a sample of one second of behavior. The components of the system events are the "items". The behavior of each jackal is described in terms of 12 items. Thus a profile includes 24 items—the first 12 describe the behavior of the male; the other 12—the behavior of the female at an instant. Each item has from 3-9 "categories" and each category represents a behavioral event, with a total of 72 behavioral events for each pair-mate. Items and categories are operationally distinguished, in that the former consist of movements, stances, *etc.*, which can be simultaneously present, while the latter consist of mutually exclusive actions. Thus, "bristling", "tail position" and "body position"

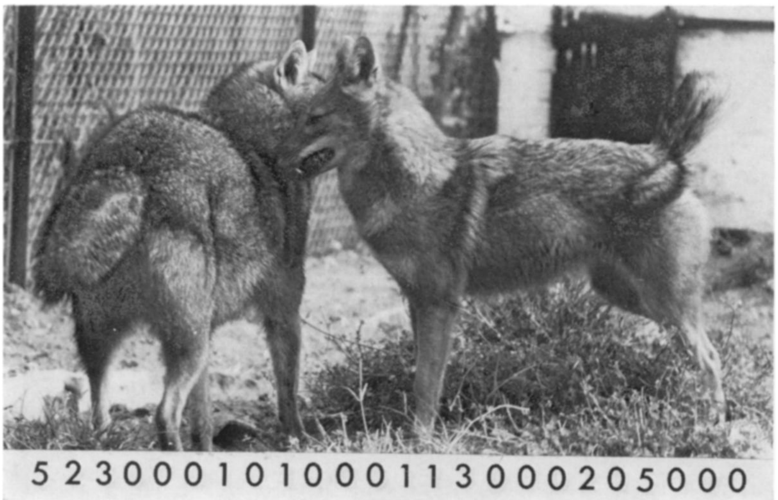

Fig. 1

TABLE 1

List of discrete behavioral events that form a "T-sequence"

Category \ Item	1	2	3	4	5	6	7	8	9	10	11	12
1	slight bristling	raised tail	ears turned forwards	mouth puckered	sniffing of inguinal region	approaching pair-mate	forming the top of the "T"	placing forelegs on mate's back	turning of head backwards	relaxed gaze	gaping	puckered nose
2	slight bristling and arching of back	horizontal tail	ears turned backwards	lips extended sideways	sniffing of mouth corner	following	forming the base of the "T"	"drumming" with forelegs on mate's back	turning head in opposite direction to pair-mate	facing away	baring of teeth	slanted eyes
3	arching of back	oblique tail	ears turned sideways	nuzzling of body	sniffing of neck	chasing	anti-parallel position	rising on hind legs in a two-footed clinch	head retracted onto shoulders	head rotated	1 & 2 together	1 & 2 together
4	strong bristling	drooped tail	flattened ears	nuzzling of head	sniffing above mate's foreleg	sideways jump	facing	contact of genitalia	lowered head	staring at pair-mate		
5	strong bristling and arching of back	tail uplifted while approaching mate		placing head on mate's back	sniffing of torso	neck nipping	retreating	pressing of chest to ♀'s hindquarters	head pointing forwards			
6		tail averted sideways		nipping of scruff	sniffing of anal region	circling mate	circling in place					
7		tail averted upwards		nipping of hindquarters	licking of mate's penis	slapping with hindquarters	standing behind mate					
8		tail flagging			licking of mate's vulva	running around	mounting					
9		angled tail			sniffing of ground		parallel position					

are items, while "strong bristling", "slight bristling" and "slight bristling and arching" are categories of the item "bristling". "Raised tail" and "Horizontal tail" are two of the several possible categories of the item "tail position". No importance is attached to the terms themselves except insofar as they serve to label mutually exclusive or non-exclusive events. Nor are any assumptions made as to whether or how "slight bristling" is physiologically related to "strong bristling".

Behavior is viewed as a sequence of successive configurations or system events and written down as observed "categories" of items. (Table 2). 3000 such system events, which represent 3000 seconds of behavior, selected out of 6000 feet of filmed material, were recorded for two pairs,

TABLE 2

1st sec.	1 4 3 0 0 8 0 0 0 0 0 0 0 1 2 1 0 0 2 0 0 0 0 0 2
2nd sec.	5 2 3 0 5 0 2 0 0 0 0 0 2 1 1 0 0 0 1 0 1 1 0 0
3rd sec.	5 2 3 0 6 0 2 0 0 0 2 1 5 1 1 0 0 0 1 0 1 3 1 1
.	.
.	.
.	.

during three successive seasons. The question is, what is the structure of relations between the different events and how are the system events to be compared without any *a priori* weighting system?

STATISTICAL METHOD

In order to outline the principles of the Guttman-Lingoes Multidimensional Scalogram Analysis (GUTTMAN, 1966; LINGOES, 1966a, 1966b), the concept of contiguity, as applied in this technique, has to be explained. The following simplified example explains this concept. Let 121; 111; 221; 212; 222; 211; 111 represent successive imaginary behavior configurations performed by a jackal during successive seconds. The hundreds digits represent slight (1) and strong (2) bristling, the tens digits represent drooped (1) or uplifted (2) tail, and the ones digits represent ears turned forward (1) or backward (2). The system event 111, for instance, occurs twice and represents a jackal with slight bristling, drooped tail and ears turned forward.

In the first part of the MSA program, the system events, which represent behavioral configurations during specific seconds of behavior, are sorted into profiles in such a way that identical system events are represented by one and the same profile. The seven system events in the above example may be represented by the following six profiles: 121; 111; 221; 212; 222; 211, which may be scaled in the following way (Fig. 2):

In this two-dimensional scale, the profiles are arranged in a partial order relation. It has the property that each item partitions the space into two continuous areas. The area above line number 1 includes profiles with number 1 as the hundreds digit. The area under line number 1 includes profiles with number 2 as the hundreds digit. If all the six

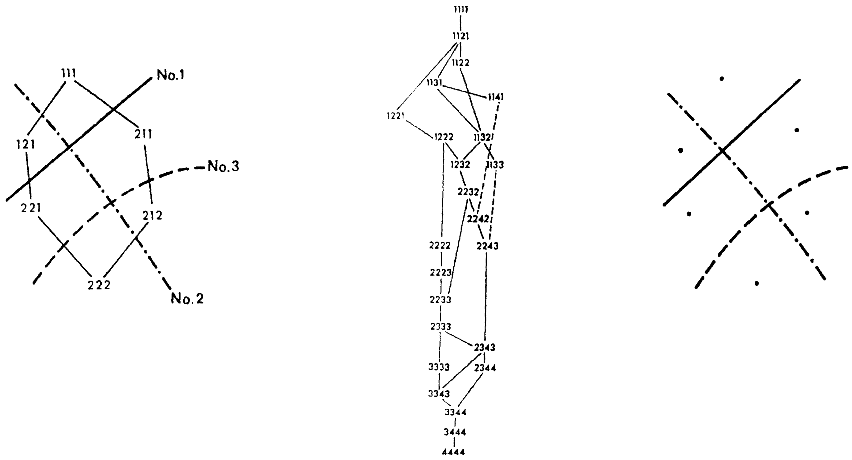

Fig. 2-4

profiles represent bristling, then the area above the line represents "slight", whereas the area under the line represents "strong" bristling. In the same way, the second item also divides the space into 2 contiguous areas; one for drooped (number 1 as the tens digit) and one for raised (number 2 as the tens digit) tail, *etc.* By overlapping the different partitions on the same space diagram, the context in which each behavioral unit is performed can be traced. For instance, it can be observed that in the six profiles, "ears turned backwards" occur only when the jackal is strongly bristled (2 as the ones digit—the area under line No. 3—is mapped into 2 as the hundreds digit—the area under line No. 1).

In the above example, partial order between the profiles can be demonstrated by a two-dimensional scale. This is not the case, however, in the example given in Fig. 3. (*N.B.* In Fig. 3 the line between 1133 and 2243 should be continuous instead of broken).

In order to arrange the profiles given in this example in partial order with full contiguity, three dimensions are needed. If, however, this three-dimensional scale is projected to a two-dimensional representation, one profile, namely 1141 becomes a deviant point. 1141 is deviant because it lies outside the area of contiguity of 4 as the tens digit. Note that contiguity in a two-dimensional representation can be achieved only when there are certain regularities in the composition of the profiles. Otherwise, contiguity is lost by the projection of an n-dimensional scale onto a n-k-dimensional scale. In the above example various two-dimensional representations can be drawn, either by changing the position of the deviant point or by making other points deviant (this can be achieved by projecting the three-dimensional scale onto a two-dimensional scale from a different angle). If, however, a large number of profiles with a greater number of items is analysed, the "tension" between the profiles is greater, *i.e.*, the position of each profile is contingent on the position of a large number of profiles, thus providing one single solution, and only one two-dimensional representation. This is, of course, contingent on the fact that regularity in the composition of the profiles does exist.

By putting points instead of profiles in the scale which was presented in Fig. 2, (Fig. 4), a two-dimensional space diagram ensues, with the same properties as the scale. The position of the points is significant only topologically, whereas the Euclidean distances between the points are insignificant.

These distances become partly significant only when a large number of profiles with a greater number of items is analysed thus increasing the "tension" between the points.

The Multidimensional Scalogram Analysis - I program, which is based upon a similar principle, can analyse up to 150 profiles with 28 items in each profile. The relations of the profiles to each other, in terms of similarities and dissimilarities, are represented in the MSA in a Euclidean space; each profile is represented by a point, whereas the similarities between profiles are represented indirectly by the Euclidean distances between the points (see Fig. 5). This Euclidean representation is termed a space diagram. An "event" is here defined as the subset of all profiles which possess the same category of the same item. In the space diagram, an "event" is represented by the subset of all the points (which represent the profiles) which possess the same category. For instance, the item "bristling of male" (Fig. 6) allows the space of all points to be partitioned into the different categories of slight bristling, strong bristling, strong bristling plus arching, slight bristling plus arching. The subset of points

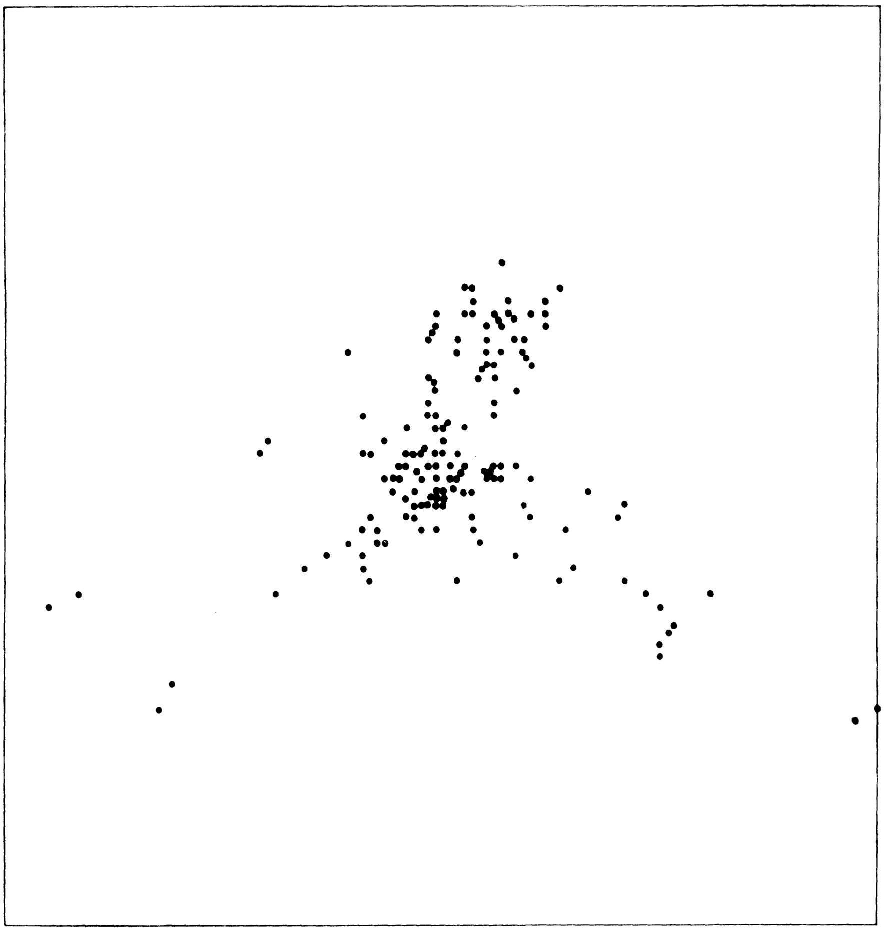

Fig. 5

which are identical on the same category, say "strong bristling of male", are grouped together and represent this behavioral event (Fig. 6). This subset represents all the seconds of behavior in which the male was strongly bristled. In the same way, other categories are also represented by subsets of points which are grouped together. The computer prints the same picture many times, each picture serving a different item. It prints on each point the category that appeared in that profile on that item, *e.g*, bristling in Fig. 6 or body position in Fig. 8. The grouping of points in the Euclidean space is a result of a demand which is made in the program to concentrate all the points which are identical on each category in non-overlapping areas of contiguity. The same demand is

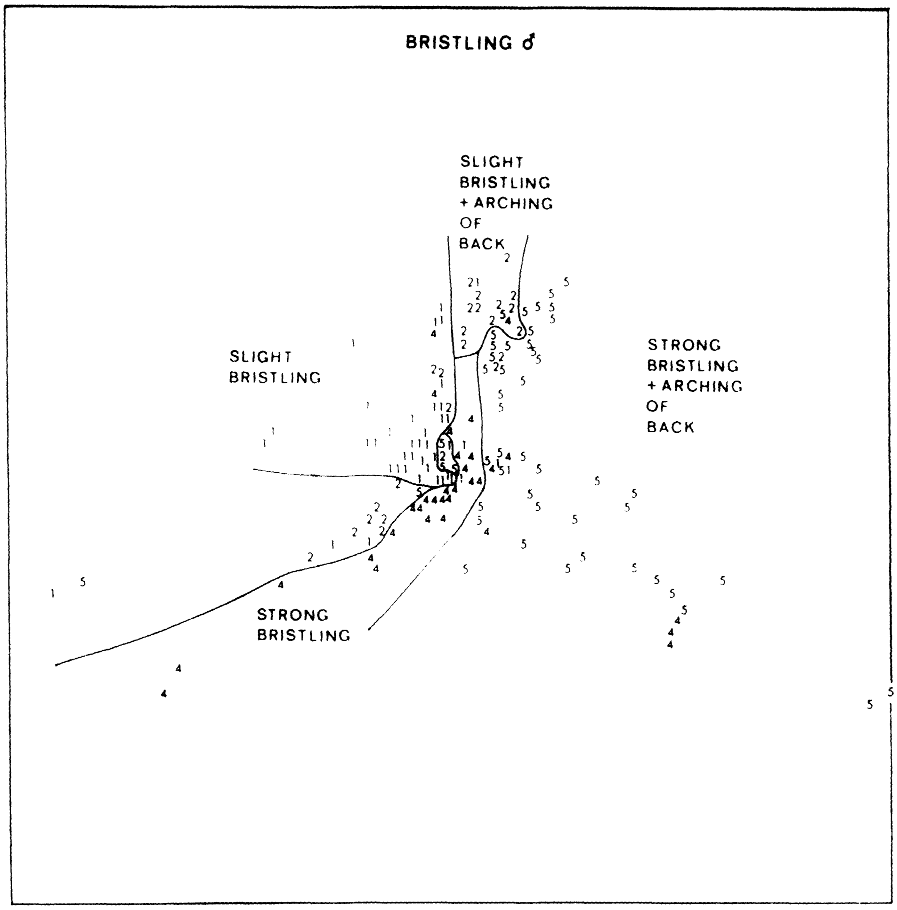

Fig. 6. 1 — slight bristling; 2 — slight bristling and arching of back; 4 — strong bristling; 5 — strong bristling and arching of back.

made simultaneously for all the categories of all the items. For each category the computer attempts to keep together all the points that are identical on it into one group. This is done in an optimal manner in order not to disturb this contiguity requirement for the other categories of other items. Since this contiguity requirement is made simultaneously for all the categories of all the items, each point in the space diagram is situated in a location that takes into account its degree of similarity to all the other points in the system. The result is a free-floating system of points which does not depend upon any particular location of co-ordinate axes (see Fig. 5). In this system identical system events are represented by the same point, and profiles that have many common categories in the same items are closer than profiles which differ from each other. It should be noted that no demand was made that two profiles that differ in only one item should be closer than profiles that differ in more than one item. Such an assumption would imply *a priori* weighting. Thus, the Euclidean distances between the points do not represent directly the similarities and dissimilarities between profiles and are an indirect result of the contiguity requirement.

RESULTS

Out of 2000 system events, which were collected during three successive seasons, and represent the precopulatory behavior of one pair of jackals during these years, only 30 profiles occurred more than once. For each 100 additional system events that were performed, only 0-8 system events occurred before in the recorded history of this pair. The same results were obtained for a second captive pair, as well as for pairs observed in the field. The stable rate of production of original system events, which is independent of the accumulation of system events that have already occurred in ontogeny, indicates the heterogeneity of this system, in which each system event is an extremely rare occurrence. In such a system, the question of constancy in composition and the question of the significance of events should be asked in a new frame of reference.

In the following example, 150 system events performed by two pairs during the season of 1966/67 were analyzed by the aid of the MSA-I program. The scalogram for bristling of males (Fig. 6) suggests that each of the four categories which describe bristling, appears in a definite group of similar profiles. The occurrence of each category (behavioral event) in a given, specific context gives to the observer's choice of these events as descriptive entities the confirmation of the animals themselves. In a sense, the animals slice the flux of behavior—in this case bristling behavior—in a similar way to the observer.

If we superimpose the pictorial representations of ♂ bristling and ♀ bristling, we obtain the following example (Fig. 7), which demonstrates that slight bristling of males is mapped into slight bristling of females, *i.e.*, when the male is slightly bristled, the female is also slightly bristled. Strong bristling and arching of back of female is mapped into the same category of the male, *i.e.*, whenever the females perform this event, the males perform it too. These results may be summarized by concluding that when the male is strongly bristled, the female has three possibilities

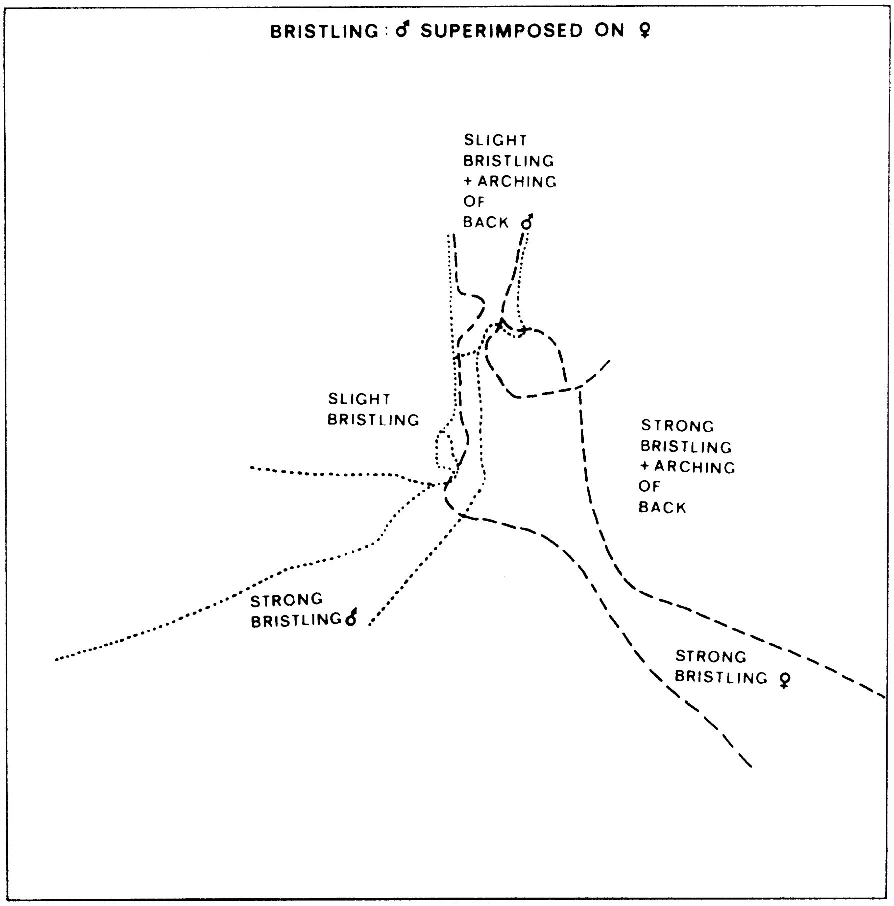

Fig. 7

concerning bristling, but when the male is slightly bristled she has only one possibility, namely slight bristling.

The item of the male's body position in relation to the pair-mate gives the following groups of contiguity (see Fig. 8):

Here again there are areas of contiguity. This suggests that the relative position of the pair-mates is strongly related to the behavioral context. In particular, "facing" is mapped into "strong bristling and arching of male"; the last event occurring also when the pair-mates form a "T" (Fig. 9). The gradient in the diagram (Northwest to Southeast) from "slight" to "strong bristling" conforms partly to relative body position: from male forming the horizontal stroke, through no particular position of bodies, to pair-mates "facing", and male forming the "base" of the "T".

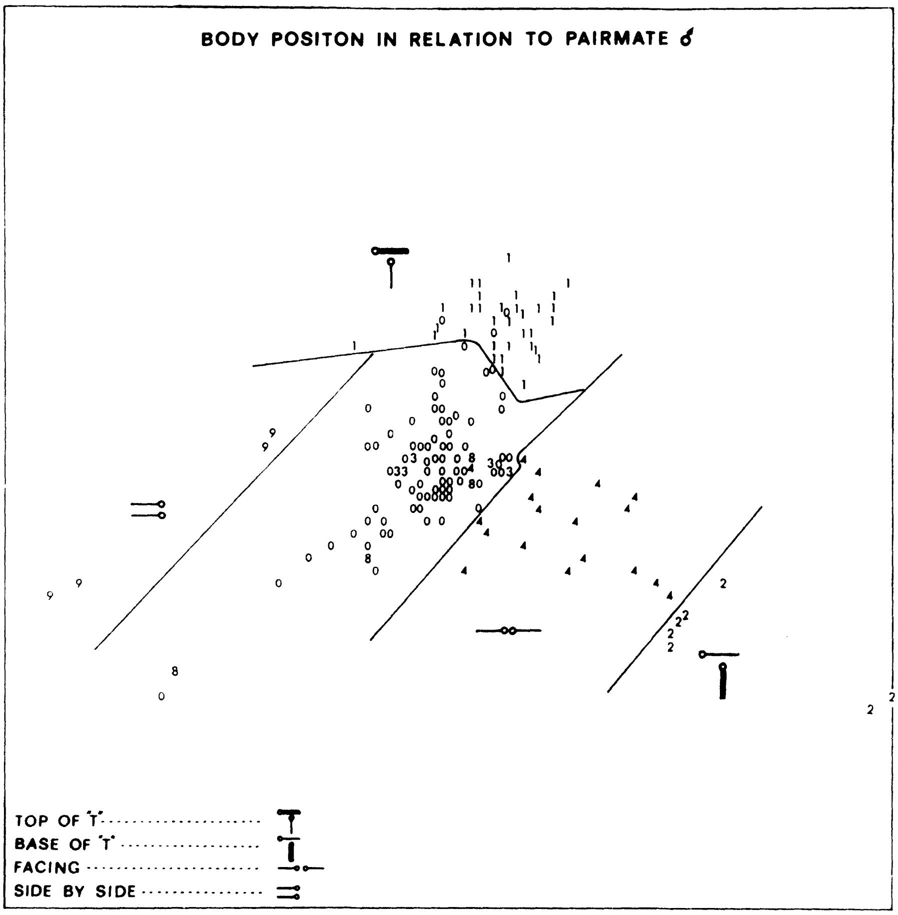

Fig. 8. 0 — no particular body position; 1 — forming the top of the "T"; 2 — froming the base of the "T"; 3 — antiparallel position; 4 — facing; 8 — mounting; 9 — side by side.

By superimposing the pictorial representation of 3 items: bristling, position of tail, and the relative position of the jackal to his pair-mate, Fig. 9 is obtained for the male and Fig. 10 for the female.

From these pictorial representations it can be seen that while standing in the base of the "T", the males have two possibilities with regard to bristling, and while forming the top of the "T", the males have three possibilies. By comparing the females, it is possible to see that while facing the pair-mate, the males are always strongly bristled, whereas the females have three possibilities with regard to bristling.

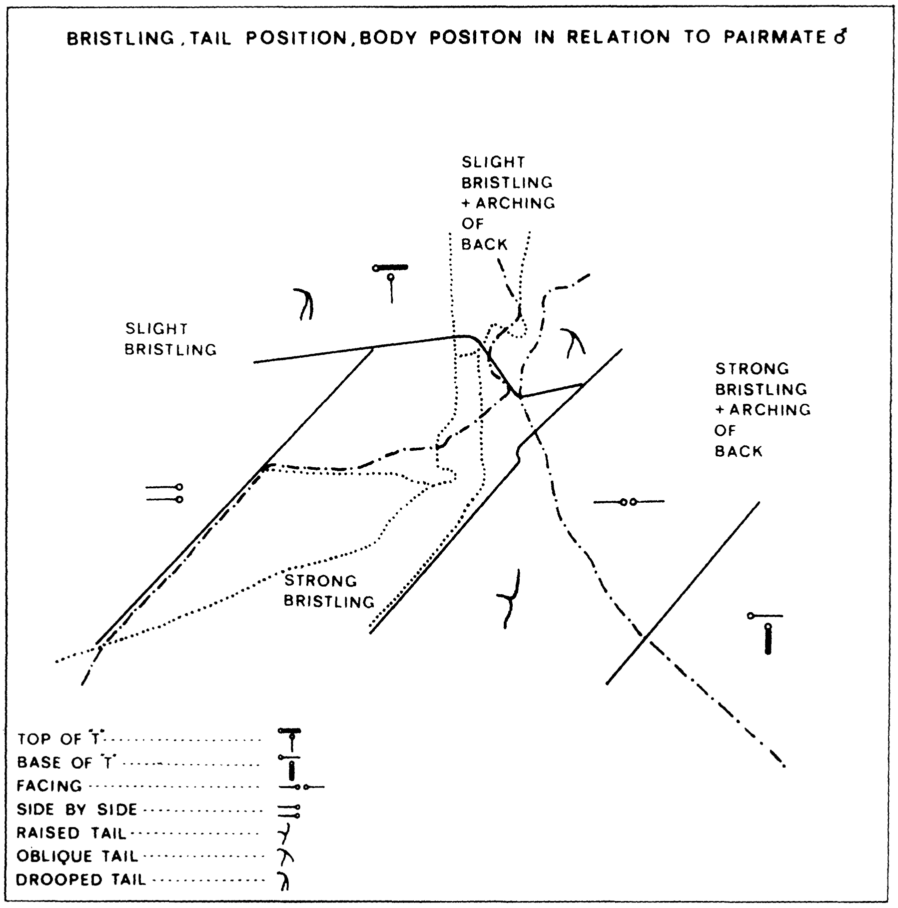

Fig. 9

The trajectory in time may be given by connecting the points that represent successive system events in time. This method enables us to follow the sequence in time in relation to the diversity of system events, and offers a tool for sequence comparisons (Fig. 11).

This program also enables us to check to what extent the division of the flux of behavior into events coincides with the division made by the animals themselves: tail aversion of the female while being licked by the male was divided into 2 distinct events—tail averted sideways, and tail averted upwards—but it appears in the scalogram in one area of contiguity in which both are broadly spread (Fig. 12). While the human observer splits this pattern into two distinct events, the jackals apparently refer to them as synonymous (Synonymity is defined here as occurrence

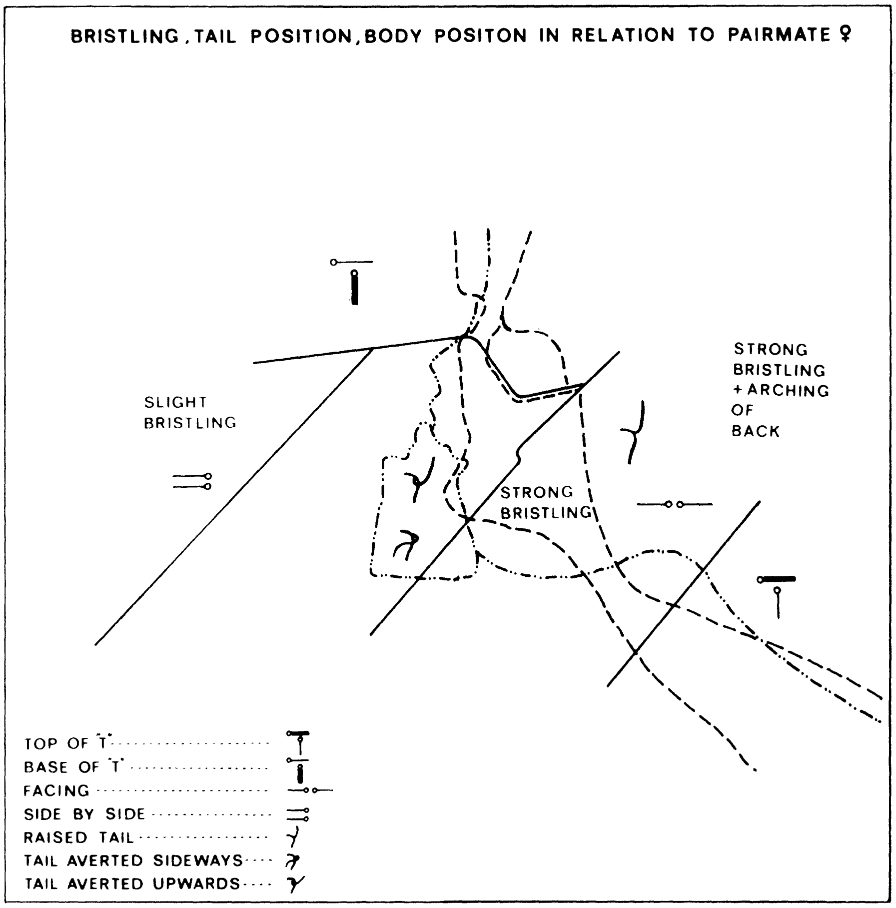

Fig. 10

in similar system events. The same events may not be synonymous from the point of view of temporal significance).

On the other hand, it is possible that one category will be represented by two separate contiguous areas, which would mean that a similar event occurs in separate contexts or that a significant event that was ignored during the descriptive phase will be indicated by the results. During the first part of the present study, "standing behind the pairmate" was not designated as an event, and was classified as "no particular relative body position", and denoted as zero. No demand is made in this program to concentrate "zero" which denotes "no event occurred" in one area of contiguity. If, in spite of this, contiguity is achieved for zero, then "not doing anything" acquires the significance of the particular

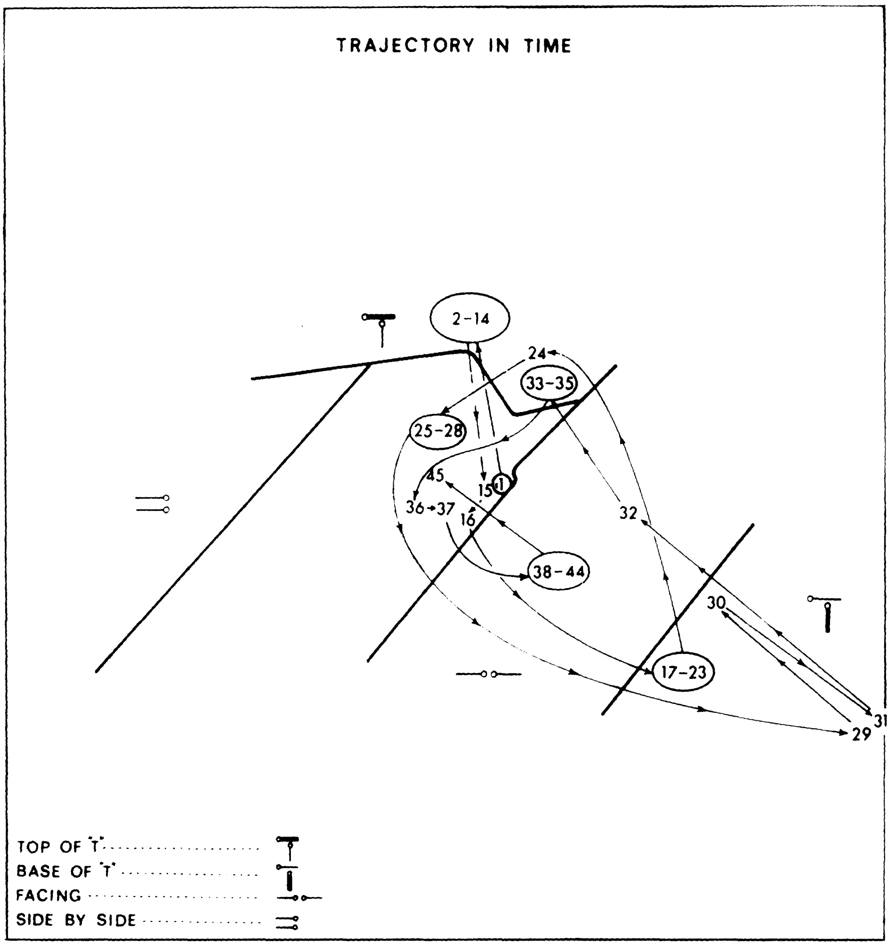

Fig. 11. The numbers describe successive profiles in time. Spatially adjacent points represent similar system events. For reasons of simplicity, temporally and spatially contiguous points are represented by ovals. e.g. The sequence starts at the area of of contiguity of "no particular body position", then shifts into the area of contiguity of "male forming the top" for 13 similar successive system events etc. Note that a series of small changes are followed by a large change which again is followed by a series of small changes, etc.

context in which it did (not) occur. All the system events in which standing behind the male occurred were concentrated in one area of contiguity (Fig. 8), which is mapped into "female averts her tail", thus lending it significance.

Another possible differentiation of context dependence of behavioral events is given in Fig. 13. Ear positions were notated as three discrete

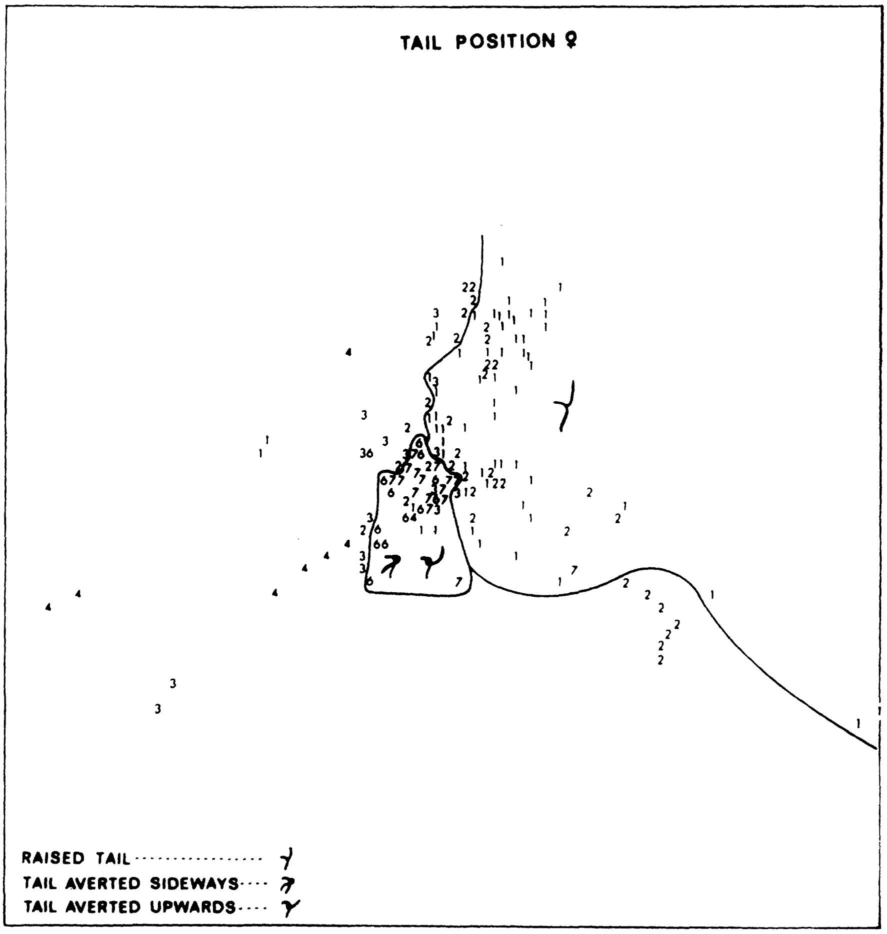

Fig. 12. 1 — raised tail; 2 — horizontal tail; 3 — oblique tail; 4 — drooped tail; 6 — tail averted sideways; 7 — tail averted upwards.

events: ears turned forwards, backwards and sideways. Whereas the first two (Nos. 1 and 2) occur in particular contexts which provide a partition of the space, and may therefore be defined as belonging to the display or the patterning, the third one (No. 3) is broadly spread over the whole space.

The analysis presented here deals with only a few minutes of behavior. The question that arises, of course, is: To what extent does it represent the regularities in the composition of events of T-sequences in general? Table 3 presents a comparison of results for sequences performed by the same pair during successive dates. Each line describes the relationships of "male forming the top of the T" to other simultaneous events,

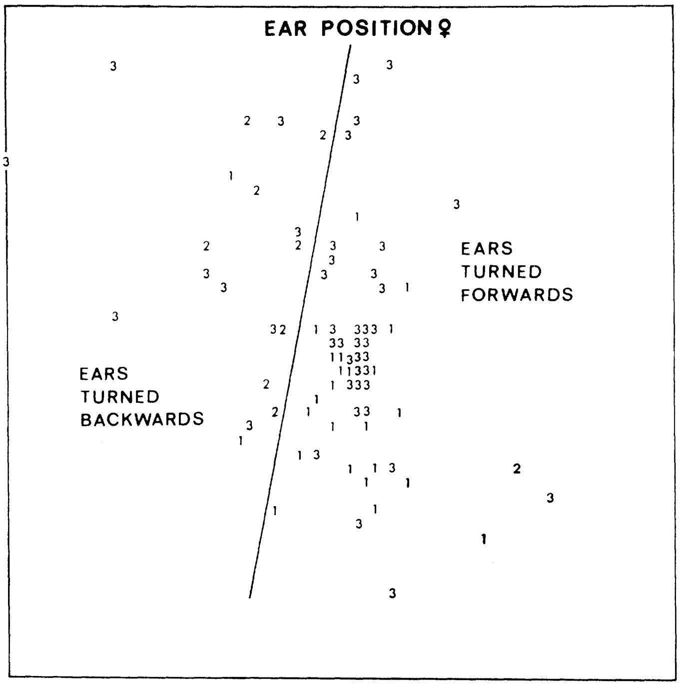

Fig. 13. 1 — ears turned forwards; 2 — ears turned backwards; 3 — ears turned sideways.

performed during the same sequence; the columns describe the change in time. The lines were obtained from the pictorial representations of sequences performed during successive dates, by formalization of some topological properties of the area of contiguity of "male forming the top of the T". The relationships between two areas of contiguity (or between the two events which they represent) may be graphically represented by Venn diagrams in the following way: if p is the event under consideration, its area of contiguity may be a subset of the area of contiguity of q, the event to which it is compared (a situation designated by 1 in Table 3); p and q may be congruent (2); q may be a subset of p (3); they may partly overlap (4); they may be disjoint (5); or q may not occur at all during the whole sequence (0). Thus, the first line in Table 3 indicates that in all T-sequences recorded during the 4th of Nov., 1967, "male forming the top" partly overlapped "strong bristling" of male, was disjoint with "raised tail" of male, was a subset of raised tail of female, *etc.* The change in the relationships of this item to "strong bristling without arching of back" is given in the first column. At first these two events partly overlapped, then strong bristling without arching did not

TABLE 3

Relationships of "male forming the top of the T" to other simultaneous events performed during the same sequence. Comparison of sequences performed during successive dates

1967	strong bristling ♂	strong bristling and arching ♂	raised tail ♂	horizontal tail ♂	oblique tail ♂	drooped tail ♂	ears turned forwards ♂	ears turned backwards ♂	ears turned sideways ♂	strong bristling ♀	strong bristling and arching ♀	raised tail ♀	horizontal tail ♀	oblique tail ♀	drooped tail ♀	ears turned forwards ♀	ears turned backwards ♀	ears turned sideways ♀
Nov. 4	4	4	5	4	5	4	5	0	1	4	4	1	5	0	0	0	0	1
Nov. 5	0	1	0	4	5	3	5	0	1	4	4	4	4	0	0	0	0	1
Nov. 7	4	4	0	4	4	0	5	0	1	4	4	4	4	5	0	0	0	1
Nov. 12	4	4	4	5	5	4	1	0	5	3	4	4	4	0	5	4	0	4
Nov. 13	4	4	5	4	0	0	5	0	1	5	1	1	0	0	0	5	0	1
Nov. 18	1	5	5	1	5	5	0	0	1	4	4	1	5	5	5	5	5	1
Nov. 20	1	0	0	5	1	0	0	0	1	1	0	1	0	5	0	0	0	1
Nov. 27	4	4	0	1	5	5	5	0	1	5	1	1	5	0	0	5	0	1
Dec. 4	5	1	5	5	1	0	0	0	1	1	0	3	4	0	4	4	0	4
Dec. 5	5	1	0	0	1	5	5	5	1	5	1	0	0	5	1	0	4	4
Dec. 24	1	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	1
Dec. 26	1	5	0	0	5	1	5	5	1	1	5	4	4	5	0	5	4	4
Dec. 28	5	1	0	1	5	0	5	0	1	0	1	1	5	0	0	5	0	1

1 — p *is a subset of* q; 2 — p *and* q *are conruent*; 3 — q *is a subset of* p; 4 — p *and* q *partly overlap*; 5 — p *and* q *are disjoint*; 0 — q *does not occur*. (See p. 104).

occur at all, then they partly overlapped again for three successive recordings, then "male forming the top" was a subset of "strong bristling", *etc*. Except for the columns of ears turned backwards ♂ and oblique tail ♀, which show consistency, there is a considerable change in relationships (similar results are obtained for other events as well).

These results raise the question as to the nature of the change from one constancy to another, rather than the question of the nature of structure *per se*. The change may be traced by treating each line in Table 3 as a profile which describes the topological relationships of a particular event to other events, performed during a particular sequence. The successive profiles may again be analyzed by the MSA-I program, and describe the change of these relationships in time.

The significance of a behavioral event may be described by pointing out the relevance of the event to phylogenetic and ontogenetic contexts. In ontogeny, significance may be constructed from the totality of contexts in which the particular event occurred during the life history of the individual. The significance of an event has an intrinsic character, which depends on the nature of the event, *per se*, and an extrinsic character, which is disclosed by the relatedness of the event to other events. This relatedness, which lies in the very nature of behavior, *is* the extrinsic significance, when viewed unidirectionally, in terms of relationships of a given event to other events. The relationships of an event to the totality of system events in which it occurred represents the extrinsic significance of the event as disclosed by simultanous context; its relationships to the sequence of successive events represent the extrinsic significance of the event as disclosed by temporal context.

The operational use of the concept of the extrinsic significance of an event as disclosed by temporal context, is given in the following example:

The sequence of body positions that follow "male forming the top of the T" were recorded to form profiles of six items each. In each profile, the first item represents the relative body position that was performed by the pair after the male has formed the top of the T, the second item represents the body position that followed second, *etc.*, so that each profile represents six steps forward, or six body positions that followed successively a particular "male forming the top". Out of a thousand behavior profiles, which represent a thousand seconds of behavior performed during one season, 19 such profiles were collected. These profiles, which occurred only once each, represent all the sequences of body positions that followed "male forming the top", whenever it occurred during the observation period. The profiles include six items each,

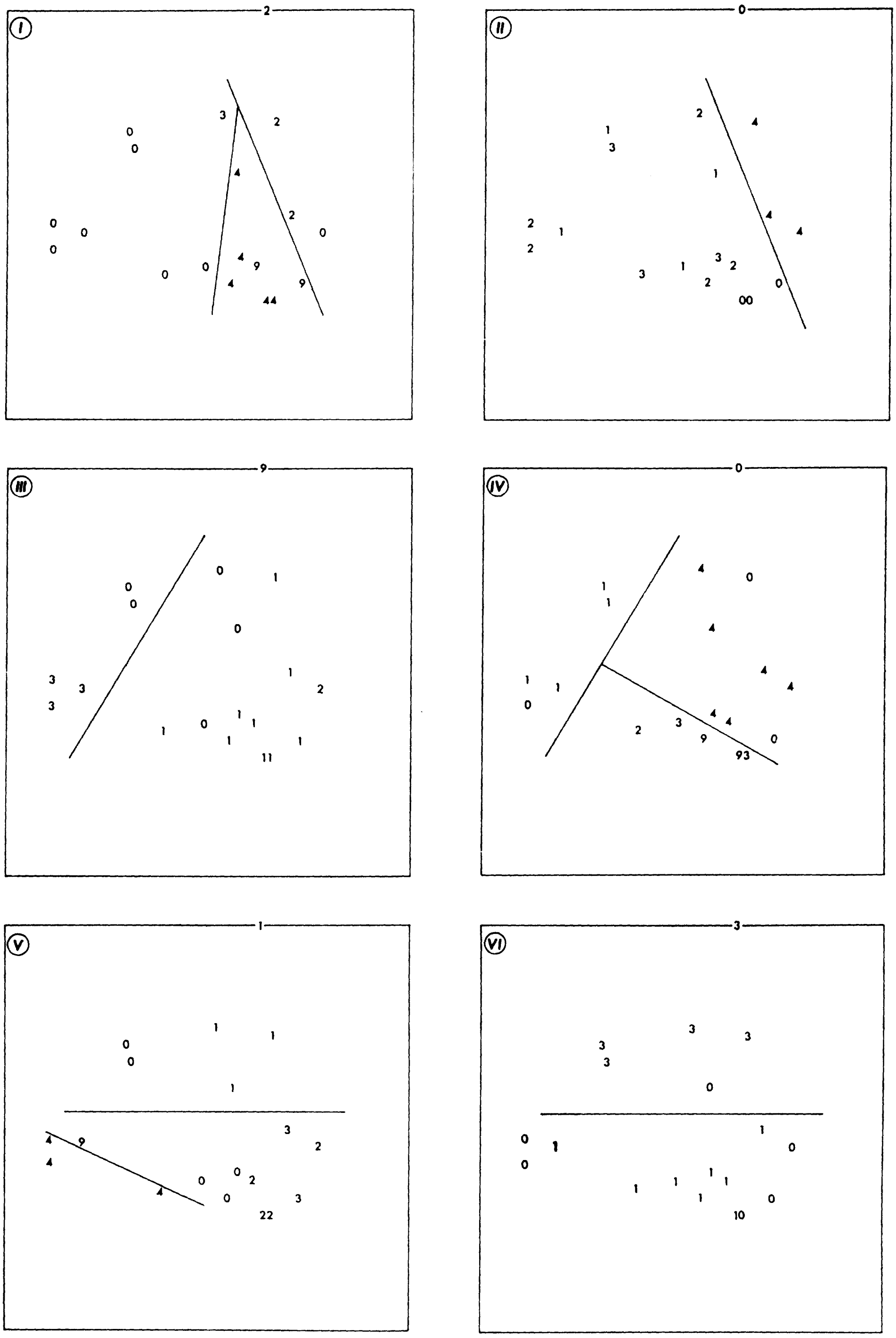

Fig. 14. The forward significance of "male forming the top of the T", 6 steps forwards. Roman numerals indicate successive steps forwards. 0 — no particular body position; 1 — male forming the tope of the "T"; 2 — male forming the base of the "T"; 3 — antiparallel position; 4 — facing; 9 — side by side.

because longer sequences were too few for analysis. The analysis of these profiles by the MSA program provides a pictorial representation of the extrinsic forward significance of "male forming the top" (Fig. 14). This representation indicates, that once "forming the top of the T" by the male was performed, the third and sixth steps forward were either the same, or an antiparallel body position. The transition from the "zero" event to the third and from the third to the sixth event were through variable body positions. The results obtained for profiles which were constructed of body positions "six steps backwards" indicate that male forming the top has a symmetric temporal significance, i.e. its forward and backward significances are similar in relation to body positions, which is not the case for other body positions.

DISCUSSION

The great variability of precopulatory behavior in jackals was demonstrated in the detailed ethograms of 5 pairs of captive and wild individuals (GOLANI & MENDELSSOHN, 1970). Variability was demonstrated at the level of the individual, the pair, the pair in successive years, and also during the same year but varying with the time of year. The tremendous heterogeneity of the data demonstrated by the fact that every additional hundred system events include an average of 98.5 system events that have never occurred before is in many respects reminiscent of other highly complex biological systems (WEISS, 1958; ELSASSER, 1966). The fact that in spite of the tremendous heterogeneity, constancy is still achieved for small fractions of the material, is indeed identical to the character of individuality, which is also a fundamental attribute of biological systems.

Conventionally, mammalian behavior is viewed as a sequence of one behavior pattern at a time (*e.g.*, ALTMAN, 1965). Once a behavior pattern, intuitively conceived as performed by the whole animal, is fractionated (*e.g.*, into tail position, ear position, bristling, *etc.*), constancy disappears. We then move into what ELSASSER calls a "highly heterogeneous universe of discourse" (1966) with a high degree of openness. To find regularity in such a fractionated system is difficult because once different sequences with different regularities are brought together into one "pool" and analyzed as one universe of discourse, the different regularities may average each other out and structure "dissolves" into a kind of "behavioral homogenate". But if each sequence is treated as a separate universe of discourse, its distinct structure will be retained and it will be possible to relate it to other observed regularities.

In the method proposed in this paper, specific "slices" of behavior, *e.g.*, specific sequences, can be analyzed separately. The temporal extent of each slice may vary from a few seconds to minutes; such slices may be combined in various ways so as to form a class whose membership consitsts of one and the same individual or one and the same pair taken at various points in time. Each such class consists of abstracted "system events" (a term proposed by ELSASSER, 1966)—an assembly of instantaneous "cuts" through specific behavior patterns.

However, instantaneousness is a complex logical concept, where an instant is conceived as deprived of all temporal extension: in our context all behavioral events at an instant. The concept of instantaneousness is successfully applied in mathematics and physics, but its application to behavior is incompatible with another assumption made in the present work—namely, that a pair of animals are conceived of as one universe of discourse. This assumption implies that perception and sense awareness are involved in the process, and behavior as immediately known or posited to perception involves some temporal thickness. Thus, a significant behavioral event retains within itself the passage of behavior and includes within it antecedents and consequents. Therefore, another method of abstraction should be employed in behavioral studies, which will imply *simultaneity*—as posited for sense awareness, and not *instantaneousness*, which is unduly copied from the methodology of physics and mathematics. The differentiation between instantaneousness and simultaneity is proposed and eleborated by WHITEHEAD, The Concept of Nature (1964), pp. 56-57. WHITEHEAD's concept of simultaneity is operationally used in a study now being carried out in our department, applying the Eshkol-Wachman movement notation to the description of jackal behavior (GOLANI, ZEIDEL & ESHKOL, 1969). In the Eshkol-Wachman notation, behavior is notated as a series of continuous and discrete events occurring simultaneously. A system-event may be constructed of events according to different culling rules, in different "directions", with differing temporal thicknesses which are not dependent on an outer clock, the rules of abstraction dictated by behavioral phenomena, rather than by the logical consideration of behavior at an instant.

Now that the behavior pattern is fractionated and cut in various directions, the question arises as to the significance of the events that form it. The extrinsic significance of these events is disclosed in their relatedness to other events and may be described in terms of general context dependence or temporal context dependence, such as forwards (in time), backwards, and simultaneous context dependence. To mention only a few concepts that disclose such significance—redundancy and patterning describe certain aspects of context dependence (BATESON, 1968) and the consummatory act implies high context dependence backwards for an individual or for a pair. Whereas these concepts imply vague, fixed extrinsic significance, NELSON (1964) indicates that a consummatory act should be defined in terms of the specific behavior patterns to which it is consummatory, whether performed by the same animal, or by its partner. There is no reason why parallel concepts will not be developed for forwards and simultaneous specific extrinsic significances.

In order to establish the relatedness of an event to other events, a vocabulary of all the contexts in which it occurred should be constructed. Since we are dealing in the present paper with a highly heterogeneous universe of discourse, the contexts in which a particular event occurs are so variable that neither the life history of a pair of jackals, nor the life histories of other pairs suffice to complete the vocabulary of contexts, in the sense that new contexts will fall into the categories of old contexts. It is not possible, therefore, to obtain a vocabulary which is complete, self-contained and closed. The context changes with the age of the jackals, with the length of the period they know each other, with the time of the year, and with various environmental factors (GOLANI & MENDELSSOHN, 1970). A new pair provides new contexts (new system events), which are also changed accordingly. Each system event is an extremely rare occurrence. Each new pair, each season, and even each day provides new contexts that have never occurred before. Accordingly, there is an incessant change in extrinsic significance. Thus, unlike the model proposed by W. J. SMITH (1969), who bases his analysis on the "anatomy" rather than the "histology" of behavior, and suggests a small amount of messages conveyed by vertebrate displays, each display having a relatively fixed message and a finite number of meanings, we are here dealing with extrinsic significance as a mutable entity, which shows an incessant change in time (during the life time of the individual and the pair) and in space (for various pairs). Note that SMITH's model, besides being based on motivational and functional assumptions, analyzes the extrinsic significance of displays, *i.e.*, their relatedness to direct functtional activities, whereas the present work deals with the intrinsic significance of displays: that is, the relatedness of events that are comprised in a display to each other. In order to describe this intrinsic significance of a display, the extrinsic significance of its components has to be described (For a discussion of the "inside-outside" or intrinsic-extrinsic problem in perceptual processes see ALLPORT, 1955, pp. 111, 280, 549); for a discussion of the concept of change see FRIED, in prep.

Operationally, the existence of a change in the extrinsic significance of events means that analysis should be aimed at pointing out the nature of the change rather than to look for non-mutable significances. In order to be able to trace this change, the structural intricacies of significance should be retained, as they are in the pictorial representations of the MSA and not dissolved by general theory-loaded, all-embracing concepts.

SUMMARY

A new method is used for the analysis of precopulatory display of jackals. Behavior patterns are described as sequences of configurations. Each configuration is composed of discrete, simultaneous events, such as specific ear position, specific tail position, specific body position, *etc.* With the aid of a non-metric computer technique, it is demonstrated that the recurrence of any particular configuration of behavioral events, performed by a pair of jackals during display, is extremely rare (30 out of 2000). In spite of this heterogeneity of configurations, there is, within short periods of time, some regularity in the composition of the events which form a configuration.

This paper explores the question, to what degree the events that form a configuration are discrete to the jackals themselves, as distinguished from the observer, *i.e.* to what degree they possess a particular significance to the animals, and what is the nature of this significance. The significance of a specific event is defined in this paper as its relatedness to other events both in the configuration and in the temporal sequence. The permanent change in the regularity of composition implies a permanent change in the significance of specific events. This indicates that it is necessary to trace the nature of the change from one significance to another, rather than to look for stable, unchanging significances.

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ZUSAMMENFASSUNG

Zur Analyse des Balzspieles von Schakalen wird in dieser Arbeit eine neue Methode benutzt. Verhaltensweisen werden als eine Reihenfolge von „Verhaltenseinheiten" beschrieben. Jede Einheit setzt sich aus getrennten, gleichzeitig auftretenden Ereignissen zusammen, wie zum Beispiel einer bestimmten Ohrenstellung, Schwanzstellung, Körperstellung u.s.w. Mit Hilfe einer nicht metrischen Computertechnik wird gezeigt, dass eine Wiederholung einer bestimmten Verhaltenseinheit durch ein Schakalenpaar während des Balzspieles ausserordentlich selten ist (dreissig von zweitausend untersuchten Fällen). Wohl tritt innerhalb kurzer Perioden eine gewisse Regelmässigkeit in der Zusammensetzung der eine Verhaltenseinheit bildenden Ereignisse auf.

Diese Arbeit befässt sich mit der Frage, in welchem Masse die Teile einer „Verhaltenseinheit" auch für die Schakale getrennt erscheinen, d.h. in welchem Grade sie eine bestimmte Bedeutung für die Tiere haben und was die Beschaffenheit dieser Bedeutung ist. Darunter verstehen wir die Beziehung der Ereignisse zueinander, sowohl innerhalb einer Verhaltenseinheit wie in der Zeitfolge. Der fortwährende Wechsel in der Zusammensetzung der Verhaltenseinheiten bedingt auch einen ständigen Wechsel der Bedeutung eines bestimmten Ereignisses. Es ist also notwendig, die Art des Wechsels von einer Bedeutung zur anderen zu verfolgen und nicht dauerhafte, starre Bedeutungen zu suchen.