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The Contingency as an Independent Variable of Social Interaction

K. Weingarten and F. Mechner

A unique feature of the behavioral sciences is their concern with a special type of independent variable: the contingency. Experimental psychologists use the term "contingency" to refer to the rules that specify what consequences behavior will have for the behaving individual (Skinner, 1953). These rules, which can constitute independent variables in experiments, are generally expressed in the form of "if, then" statements, the "if" clause specifying some aspect of behavior, the "then" clause a resulting state of affairs. The contingencies investigated by experimental psychologists range from relatively simple ones (e.g., if the rat presses the bar, a pellet of food is delivered) to complex elaborations involving temporal factors (e.g., if the rat presses the bar, a pellet of food will be delivered after 5 seconds), probabilities (e.g., if the rat presses the bar, there is a probability of .50 that a pellet of food will be delivered), associated stimuli (e.g., a pellet of food will be delivered only if the rat presses the bar in the presence of a light), series or chains of responses (e.g., if a rat presses a bar three times and then turns to the left, a pellet of food will be delivered), and the various permutations of these. However, there is a type of contingency to which experimental psychologists have given relatively little attention: that involved in social interaction. This type of contingency is the main subject of the present paper and will be discussed below.

It should be noted that such "if, then" statements as the above merely define independent variables; they are not empirical propositions (e.g., if a response produces an electric shock, the

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response will decrease in frequency) where only the "if" clause specifies the independent variable and the "then" clause specifies the dependent variable.

Readers who are unfamiliar with the concept of the contingency may challenge the status of the contingency as an independent variable on the ground that the event specified by the "then" clause can occur only if the subject responds in the designated manner (e.g., the pellet of food will be delivered only if the rat presses the bar). Since the response of the subject is not under the experimenter's control, it may appear that the independent variable is contaminated by the dependent variable, namely, the behavior being studied. This is not so, however, for neither food presentations nor any other actual occurrences function as independent variables. It is rather the contingencies determining the relationship between these occurrences and the subject's behavior that have this function, and these are entirely under the experimenter's control. Even in those experiments where the subject can "select" the contingencies under which he will operate, the rules that allow for this selection are also laid down by the experimenter and are independent of the subject's actual behavior.

The contingencies that are of concern to the psychologist are those that specify the consequences of behavior for the behaving individual. These consequences may be mediated either by electrical and mechanical devices or by the behavior of other individuals; but in every instance the mediating mechanism, whether animate or inanimate, reacts to the behavior of the subject in ways that are predetermined by the experimenter. The contingencies that are of special concern to the sociologist on the other hand, are those that specify the consequences that any individual's behavior, should it occur, will have for others (e.g., rat A's pressing a bar will produce a pellet of food for rat B, and rat B's pressing a bar will produce a pellet of food for rat A). As in the case of psychological experiments, these contingencies are independent of the subjects' actual behavior. In an experiment they would be entirely under the experimenter's control and would be established prior to the experiment's inception. They describe the structural constraints on the subjects' interaction.

This type of contingency bears the same relation to social interaction experiments as the contingencies listed earlier bear to single-subject psychological experiments. Social interaction involves an additional type of contingency, however, which has no obvious counterpart in the psychological experiments. It is the type of contingency produced by the actual behavior of the participants. Each participant's behavior creates contingencies for the other. These contingencies are not under the direct control of the experimenter as are the contingencies discussed above, but are entirely a function of the subjects' interaction. Since these contingencies are dependent on the actual behavior of the participants, they must be distinguished from those established by the experimenter. The contingencies established by the experimenter constitute independent variables. They will, therefore, be referred to as *independent contingencies.* On the other hand, contingencies generated by the interacting participants have the status of dependent variables (in the sense that they are not under experimental control and may be viewed as a consequence of the independent contingencies) and will accordingly be referred to as *dependent contingencies.* The independent contingencies may be viewed as setting bounds upon the dependent contingencies that can emerge during an interaction. A game of poker provides a familiar example of the distinction between independent and dependent contingencies. The rules of play and scoring define the constraints facing the players and constitute the independent contingencies of the situation. On the other hand, the particular patterns of interaction that might emerge during an evening's play would create the dependent contingencies. For instance, player A's tendency to "bluff" constitutes one of the dependent contingencies that emerge during the course of the game, and might come to affect the behavior of his opponents. In general, the behavior of each player contributes to the contingencies under which the others must operate. One task of experimental research on social interaction is to determine what, if any, dependent contingencies various types of independent contingencies produce.

There is also an approach to the study of social interaction exemplified by the work of Asch (1952), which regards the individual as functioning in a setting where the actions of others are treated as situational "givens." This approach features experiments that employ "pseudo-subjects" whose behavior in the experimental situation is predetermined by the instructions given by the experimenter. The conception of social interaction towards which the present paper is oriented, on the other hand, and the one that sets sociology apart from psychology, focuses on the complex behavioral interplay of two or more individuals. Experimental research within this framework is characterized by situations in which the co-participants are all regarded as subjects with the rules of interaction experimentally fixed (e.g., Azrin and Lindsley, 1956; Bales, 1950; Bavelas, 1950; Calhoun, 1962; Daniel, 1942; Lippitt and White, 1952; Miller and Dollard, 1941; Mintz, 1951; Sherif, 1936; Sidowski, Wykoff, and Tabory, 1956).

Recently, a diagrammatic notation system suitable for representing the contingencies investigated in psychological experiments was proposed (Mechner, 1959). This notation system, which utilizes a set of symbols borrowed from mathematics, logic, electronics, and psychology, was offered as a concise and unambiguous language for making the formal structure of contingencies explicit. The present paper will show how this notation system, originally intended for the description of contingencies involving only a single individual, may be adapted for the description and analysis of contingencies involving more than one individual, i.e., the in-dependent contingencies of social interaction.

Mechner's notation system consists of a set of abbreviations for acts and their consequences and of four symbols that specify the conditional and temporal relations between them. The "acts" of the participants are generally conceptualized as responses, abbreviated by the letter ***R.*** When a more general designation standing for long or complex series of responses is desired, the term "behavior," abbreviated ***B,*** may be substituted. It is usually necessary to identify these acts, whether designated ***R*** or ***B,*** according to the subjects who perform them. This is accomplished by the use of a capital letter *(**A, B, C,** . . . **N,*** one letter being assigned to each participant) written as a pre-subscript to the ***R*** or ***B***. For instance, ${}_{A}R$ would indicate a response made by subject ***A***. To distinguish between different classes or types of acts, lowercase letters written as a post-subscript will be used. Thus, ${}_{A}R_{c}$ is a response of type ***c*** made by ***A*** (in order to keep the diagram simple, a more thorough specification of the response class in question can be presented in a legend). If a response is to be repeated a specified number of times, this number is represented by the letter ***N*** prefixed to the ***R***. For example, $N_{A}R_{a}$ would read "***N*** responses of type ***a*** made by subject ***A***." If a specific value is assigned to ***N,*** the value may be substituted for ***N*** (e.g., $8_{A}R_{b}$ or $25_{C}R_{c}$).

Stimuli, abbreviated by the letter ***S***, require the same set of identifying modifiers as do ***R*** and ***B***. Thus, ${}_{A}S$ would indicate a stimulus which is directed at or perceived by subject ***A***. Lowercase letters in the post-subscript position designate types of stimuli (further specification again being reserved for an accompanying text). ${}_{B}S_{a}$, for example, represents a stimulus of type ***a*** for ***B***. Stimuli may also be classified according to their reinforcing (i.e., rewarding or punishing) properties. This stimulus property is indicated by a sign in the pre-superscript position, plus (${}^{+}S$) if reinforcement is positive, and minus (${}^{-}S$) if reinforcement is negative. The magnitude of a stimulus (i.e., any intensive dimension such as brightness, volume, amount of food or money received, etc.) is indicated by the letter ***M*** in the post-superscript position. Thus, S^{M1} and S^{M2} would be read "a stimulus of magnitude ***M1***," and "a stimulus of ***M2***," respectively. (Magnitude of response may be indicated in the same way.)

The first of the four relational symbols is the horizontal arrow, denoting an if-then relation between the events it connects. The $R_{a} \longrightarrow S_{c}$ expression

for instance, would be read "response ***a***, if it occurs, produces (or is followed by) stimulus ***c***." It is understood that the symbols ***R*** and ***B*** are always read "***R,*** if it occurs," and "***B,*** if it occurs." The entire notation system deals only with the "if, then" relations between behavior and its consequences. It does not allow for statements that an act *actually* occurs; only the consequences of potential acts can be denoted. This is the essence of the distinction between describing behavior and describing its controlling contingencies. The expression

$$R_a \longrightarrow R_b \longrightarrow S_c$$

for example, would *not* be read "Response ***a*** occurs and produces response ***b***, and response ***b*** produces stimulus ***c***," but rather, "Response ***a***, if it occurs, produces a condition where response ***b***, if it occurs, produces stimulus ***c***. In this instance response ***a***, if it occurs, produces neither another response nor a stimulus; it produces a contingency, i.e., a condition where another response, if it occurs, will produce a certain stimulus. It is possible, of course, to surround the contingency with parentheses in order to call attention to its status as a unit--e.g.,

$$R_a \longrightarrow (R_b \longrightarrow S_c)$$

--but if it is remembered that a response cannot be said to produce another response, the unity of the contingency will be apparent, and the parentheses may be omitted without any ambiguities resulting.

The second relational symbol is the letter ***T***, which represents a time interval of length ***T***. A time interval must always be initiated by a specific event, such as a response--although when this initiating event is irrelevant it may not be necessary to denote it--and the termination of the time interval always marks the occurrence of some other event, such as a stimulus change or the inception of a contingency. For example,

$$R \longrightarrow T \longrightarrow S$$

would mean that a response, if it occurs, initiates a time interval, at the conclusion of which a stimulus appears. If ***T*** is negligibly short or of no focal significance it may be omitted altogether. Common examples of time delays in behavioral situations are the intervals intervening between placing a bet on a horse race and the actual outcome of the race or between taking an examination and receiving a grade.

A bracket around two or more conditions that are written in vertical relation to one another indicates that these conditions go into effect simultaneously. The expression

$$\left[\begin{array}{l} R \longrightarrow S_b \\ T \longrightarrow S_g \end{array}\right.$$

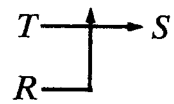
for example, would indicate that condition

$$R \longrightarrow S_b$$

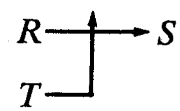
goes into effect simultaneously with the condition

$$T \longrightarrow S_g.$$

The fourth symbol is the vertical arrow intersecting a horizontal arrow. The event at which the vertical arrow originates prevents the occurrence of the event or condition to which the intersected horizontal arrow leads. In the expression

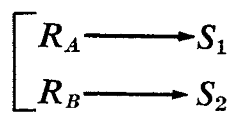


for example, the response, if it occurs prior to the termination of the time interval, prevents the occurrence of ***S*** at the conclusion of the interval. In the expression

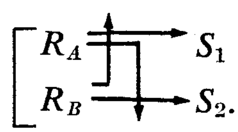


on the other hand, the response can produce the stimulus only if it occurs prior to the termination of ***T***.

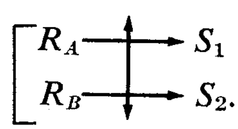
Suppose that two conditions go into effect simultaneously, as in the diagram.



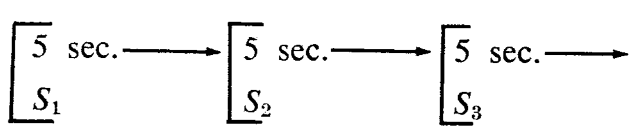
Suppose, however, that whichever condition is met first prevents or cancels the other. Thus if $\boldsymbol{R_A}$ occurs first, $\boldsymbol{S_1}$ is produced and $\boldsymbol{R_B}$ will no longer produce $\boldsymbol{S_2}$; if, on the other hand, $\boldsymbol{R_B}$ should occur first, then $\boldsymbol{S_2}$ is produced and $\boldsymbol{R_A}$ can no longer produce $\boldsymbol{S_1}$. This situation requires reciprocal vertical arrows for its description. The diagram could accordingly be written



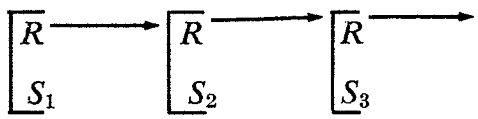
The need for reciprocal vertical arrows arises so frequently that a double-headed vertical arrow has been adopted as a convenient abbreviation:



Any stimulus or stimulus complex $\boldsymbol{S_i}$ is always understood to remain present until it is replaced by a designated successor, perhaps $\boldsymbol{S_{(i+1)}}$. The last indicated stimulus always replaces the current one and remains present until a further stimulus change is specified. No vertical arrow is needed to indicate that a stimulus terminates; all that is needed is the specification of a new stimulus. To show, for instance, that a stimulus change occurs every 5 seconds, a diagram of the form

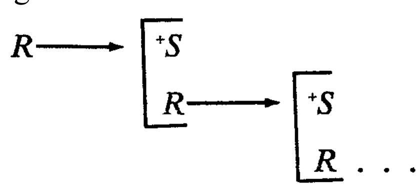


would be used. The horizontal arrows lead away from the time intervals rather than from the stimuli. Similarly, to show that stimulus changes depend upon the occurrence of responses, the diagram would read

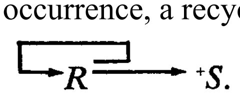


Therefore, no arrow ever leads away from a stimulus. In practice it is frequently not important or even desirable to specify the precise duration and termination point of every stimulus. This abbreviation will be used in most of the examples given in the present paper. Also, strictly speaking, there always has to be *some* stimulus present. When the reinforcing stimulus ends, some other stimulus complex replaces it: When a light goes out it must be replaced by other visual stimuli. Since this alternative stimulus is frequently of no focal significance, however, it too may be left unspecified. Such abbreviations as these are often convenient ways of simplifying the diagrams to highlight the relations that are of primary concern.

The illustrations thus far presented are non-repetitive; that is, the sequences, as described, may occur only once. In order to represent repetitive conditions no additional symbol is required. A horizontal arrow which recycles the sequence fulfills this function. For example, if a response is to produce a positive reinforcer (e.g., a pellet of food), and if this contingency is to go into effect repeatedly, rather than writing



With a separate representation for each occurrence, a recycling horizontal arrow may be used:



There are situations where a quantity, such as a required number of responses or a time interval, varies from trial to trial. This may be indicated by prefixing a ***v*** to the term--either ***N*** or ***T***--that stands for the quantity in question. For example,

would mean that the number of responses required to produce the reinforcing stimulus varies from trial to trial. In

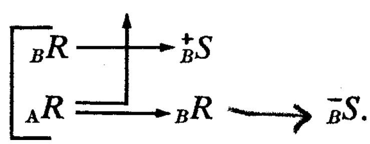
it is the time interval that varies. When actual values are substituted for these symbols, ***T*** and ***N*** can be replaced by the mean of the varying quantity. Thus ***v*3sec.** would indicate that the mean interval is 3 seconds, and ***v*10*R*** would indicate that the mean number of responses is ten. Additional information as to the nature of this variation would be given in a legend outside the diagram.

These are the basic features of the notation system.

The conditions of social interaction may be said to exist whenever an act of one individual, should it occur, will alter either stimulus conditions or contingencies for others. The case where stimulus conditions are altered may be notated as follows:

$$\left[\begin{array}{l} {}_{B}S_{a} \\ {}_{A}R \longrightarrow {}_{B}S_{b}\,. \end{array}\right.$$

Here ***A***'s response will change ***B***'s stimulus conditions from S_a to S_b. If it were desired to specify that the stimulus change involves an alteration from a negative to a positive reinforcer, ${}_{B}^{-}S$ would be substituted for ${}_{B}S_{a}$, and ${}_{B}^{+}S$ for ${}_{B}S_{b}$. We would then say that ***A*** has the power to reward ***B***. The other case where one individual can alter the contingencies for others involves either the creation or the termination of contingencies or a combination of these. An example of the latter is



Here a response by ***A*** can terminate the contingency under which ***B***'s response will produce a positive reinforcer and substitutes one where the same response will produce a negative reinforcer.

The above are instances of "one way" interaction. In mutual interaction the participants' ability to alter one another's stimulus conditions or contingencies is reciprocal (though not necessarily symmetrical) . A relatively simple example of this is the situation in which two subjects have the power to reward or to punish one another:

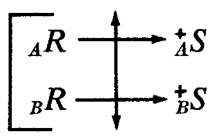
$$\left[\begin{array}{l} {}_{A}R_{a} \longrightarrow {}_{B}^{+}S^{M1} \\ {}_{A}R_{b} \longrightarrow {}_{B}^{-}S^{M2} \\ {}_{B}R_{a} \longrightarrow {}_{A}^{+}S^{M3} \\ {}_{B}R_{b} \longrightarrow {}_{A}^{-}S^{M4}. \end{array}\right.$$

These conditions frequently hold in normal face-to-face interaction; each participant usually has both flattery and insult at his disposal. Differentials in power between the two participants can be indicated by making use of the symbol for stimulus magnitude. For example, if M_1 is greater than M_3 and M_2 is greater than M_4, then A could be said to be more powerful than B.

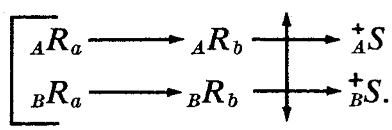
The independent contingencies of social interaction vary from the relatively simple to the extremely complex. The systematic analysis and development of these contingencies, and their consequences is beyond the scope of the present paper, but constitutes a challenging problem for future research. It would be impossible at this point to give an adequate sampling of the full range of these contingencies. The remaining portion of this paper will accordingly be restricted to a consideration of those relating to competition and cooperation.

COMPETITION

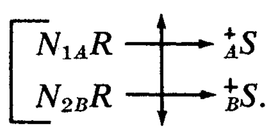
The independent contingencies that describe one simple type of competition specify that reinforcement is "scarce," so that the obtaining of reinforcement by one participant prevents others from obtaining it:



A and B cannot both be reinforced. Whichever participant responds first obtains reinforcement and prevents the other from doing so. (If we wished to represent a situation in which these conditions are repetitive, recycling arrows would be added to the diagram.) The behavior involved might be a series or chain of responses:

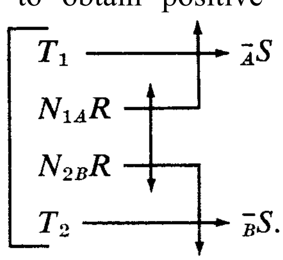


It could also involve repeated responses, where the rate of emission determines which participant will be reinforced:



If N_1 does not equal N_2, the participant with the larger quota is laboring under a handicap.

Comparable diagrams may be elaborated for competitive avoidance, i.e., contingencies where the participants are competing, not to obtain positive reinforcers, but to avoid negative reinforcers, for instance:



Punishment is impending for both participants (at the termination of interval T_1 for ***A*** and of T_2 for ***B***). Either can avoid punishment by completing his quota of responses before the termination of the relevant time interval *and* before his competitor's quota is completed. The winner avoids punishment for himself and prevents his opponent from doing the same. Where T_1 is not equal to T_2 a burden is placed upon the participant who must complete his quota within the shorter interval. Again the numbers of responses required of the competitors may be equal or unequal.

COOPERATION

The independent contingencies of cooperation are exemplified by the extremely wide variety of situations in which the behavior of more than one participant is required for the reinforcement of any. The simplest instance involves only two participants.

$$\left[\begin{array}{l} {}_{A}R \longrightarrow {}_{B}R \\ {}_{B}R \longrightarrow {}_{A}R \end{array}\right] \longrightarrow {}_{(A,B)}{}^{+}S$$

Here ***A***'s response produces a condition such that ***B***'s response will produce a positive reinforcement for both. This information is contained in the first line of the diagram. The second line indicates the same relationship with the identities of the individuals reversed. A simplification of this diagram is possible with the symbol $\frown$ —the logical product sign— which implies that the events which it connects must both occur (the sequence being irrelevant) in order to produce the indicated result. Utilizing this symbol, the above diagram would be rewritten:

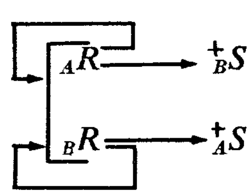
$${}_{A}R \frown {}_{B}R \longrightarrow {}_{(A,B)}{}^{+}S.$$

The case where more than one response is required from each participant would be diagrammed: N_1 and N_2 may be individually specified so that each participant must fulfill a designated quota;

$$N_{1A}R \frown N_{2B}R \longrightarrow {}_{(A,B)}{}^{+}S.$$

or, alternatively $N_1 + N_2$ may be set equal to a fixed number, stated in a legend. Or, the individual frequencies may be allowed to assume a variety of values, so long as their sum equals $N_1 + N_2$. This would be an example of a group quota.

It should be noted that certain independent contingencies which do not fall within the category of cooperation as it was defined above, may nevertheless produce behavior resembling that generated under a cooperation contingency. The condition



for instance, may produce a pattern of interaction where each participant reinforces his partner only if his partner reinforces him. In that case, each is operating under the dependent contingency

$$\rightarrow R \longrightarrow T \longrightarrow {}^{+}S$$

where T is the latency of the other participant's response. But the independent contingencies do not specify this behavior, as they permit the frequent reinforcement of one participant even in the event of complete absence of reinforcement for the other.

INTER-GROUP COMPETITION

Another interesting situation is that where a group of cooperating individuals competes against another similar group. The independent contingencies of such a situation are built up from contingencies that have already been described. The following diagram, for instance, shows competition between two dyads:

$$\left[\begin{array}{l} N_{1A}R \cap N_{2B}R \longrightarrow {}_{(A,B)}{}^{+}S \\ N_{3C}R \cap N_{4D}R \longrightarrow {}_{(C,D)}{}^{+}S \end{array}\right.$$

Each line comprises a cooperative dyad. The contingencies allow for the reinforcement of only one of them—whichever fulfills its quota first. This diagram as well as those above may be modified to include more subjects (e.g., ${}_{A}R \cap {}_{B}R \cap {}_{C}R \cap \ . \ . \ . \ \cap {}_{N}R$ would indicate a cooperative group with N members), although in the interests of simplicity interaction situations with only two subjects have been selected.

Inter-group competition of this sort may also be analyzed from the point of view of one of the competing groups, the rate of performance of the opposing group being represented by the time limit which the latter's performance sets for the former.

$$\left[\begin{array}{l} N_{1A}R \cap N_{2B}R \longrightarrow {}_{(A,B)}{}^{+}S \\ T \end{array}\right.$$

Here the quota must be met before the conclusion of the time interval if the subjects within that dyad are to be reinforced. They are, in a sense, "competing against the clock." In the laboratory the experimenter could manipulate this time interval systematically in order to establish the effects of various deadlines on cooperative behavior. For example, what are the effects upon performance rates of ample as against minimal time allowances? What happens when the time allowance is varied from trial to trial rather than held constant? (This would be indicated by substituting vT for T in the diagram and adding a recycling arrow.)

CONCLUSION

It is emphasized that the notation system is a purely descriptive and analytical tool, not a theory or calculus of propositions. The entire paper was concerned only with the analysis of the special contingencies which function as independent variables of social interaction. The actual effects of such contingencies upon interaction processes must be determined by empirical research. Only such research can give rise to viable theories.

Psychologists may be tempted to suggest that the ultimate analysis of social interaction will be carried out in the psychological laboratory, on the grounds that since all social interactions involve individual organisms responding to "complex and changing" contingencies, we need only investigate how these individual organisms behave under such conditions. (This is the reductionist argument.) The answer to this argument is that we do not know how to generate the relevant "complex and changing" contingencies in the laboratory except by actually introducing the second subject. To simulate this second subject realistically would require an exhaustive understanding of the all the laws of individual behavior. This answer is the same one that the psychologist gives when he is told that physiology is the key to understanding behavior and that the physiologist gives when chemistry is held up to him as the true path. In the light of our present limited knowledge of individual behavior, the soundest and most expedient way to develop a science of social interaction is to treat interaction as a subject of scientific investigation in its own right. It is even possible that dyads, triads, tetrads, and larger groups constitute different levels of analysis and will come to be regarded as separate major provinces of behavioral science. This is not to say that there are no unifying laws cutting across them all. Such laws will undoubtedly be uncovered, though this may take a great deal of empirical research. Psychologists have until now largely confined their attention to one of these levels: the monad. The reasons for this are probably historic rather than strategic. An understanding of social interaction is surely as important as an understanding of individual behavior, and our technological and conceptual resources are now adequate for the development of a fruitful methodology. Here too, the reductionist fallacy of insisting that dyads must receive attention before triads, and triads before tetrads will have to be avoided. Since these provinces are all of equally pressing concern, their investigation must proceed concurrently.

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Other notation systems for describing social interaction can be found in the following (Ed.):

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