Schema Theory: An Information Processing Model of Perception and Cognition*

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I. Introduction

A. The Idea of a Schema

The world is complex, and yet people are able to make some sense out of it. A national or international political arena, for example, is so huge and so complex that to make any sense out of it seems to be a superhuman task. And yet national leaders and even the man in the street do make more or less intelligent interpretations about political events and relationships. How do they do this?

One of the most important tools that people use is a schema. A formal definition will be given later, but informally a schema is a "preexisting assumption about the way the world is organized."[1] When new information becomes

In reviewing the psychological literature I have relied heavily on Gardner Lindzey and Elliot Aronson, eds., *The Handbook of Social Psychology,* second edition (Reading, Mass.: Addison-Wesley, 1968, 1969), especially the chapters by Berger and Lambert "Stimulus-Response Theory in Contemporary Social Psychology," I, 81–178; Seymour Rosenberg, "Mathematical Models of Social Behavior," I, 179–244; Robert B. Zajonc, "Cognitive Theories in Social Psychology," I, 320–411; Leonard Berkowitz, "Social Motivation," III, 50–135; Henri Tajfel, "Social and Cultural Factors in Perception," III, 315–394; and George A. Miller and David McNeill, "Psycholinguistics," III, 666–794.

[1] Jerome E. Singer, "Consistency as a Stimulus Process Mechanism," in *Theories of Cognitive Consistency: A Sourcebook,* ed. Robert P. Abelson, Elliot Aronson, William McGuire, Theodore Newcomb, Milton Rosen-

available, a person tries to fit the new information into the pattern which he has used in the past to interpret information about the same situation. If the new information does not fit very well, something has to give.

Balance is an important example of a commonly used schema, and its use can be illustrated by friendship relationships. A person has a balanced set of beliefs about his acquaintances if he believes that all of his friends like each other, all of his enemies also like each other, and each of his friends dislikes and is disliked by each of his enemies. Thus a balanced set of friendship relationships provides a tidy view of the world in "black and white" terms. It implies that friends of friends are friends, enemies of friends are enemies, and enemies of enemies are friends. More formally, balance can be defined in terms of a set of objects and a set of relationships between them. The whole collection is balanced if the objects can be classified into no more than two nonoverlapping sets (e.g., "friends" and "enemies") so that all the relationships which exist between members of the same set are positive (such as "likes") and all the relationships which exist between members of differing sets are negative (such as "dislikes").

Suppose a person interprets the relationships between his acquaintances as fitting a balanced schema. Then if he receives new information about a particular relationship or about several relationships he can try to fit this new information into the old interpretation. If the new information fits exactly into his previous expectations, there is no problem. If it does not fit exactly, he has a variety of tactical choices. He can try to use the same schema as before with the same interpretation of who are his friends and who are his enemies. This will require discounting the new discrepant information. He might also use the same schema of balance, but respecify which people are his friends and which are his enemies. Or he may use another schema entirely, and interpret the information as indicating (for example) that there are three different clusters of people (rather than two)

who all like other members of the same cluster and dislike anyone not in their cluster.[2]

This paper is written with three audiences in mind. For the general political scientist interested in the policy-making process, the paper integrates a variety of psychological research into an organizing framework which can be used as an introduction to a number of relevant subfields of psychology. For the political scientist who is specifically concerned with attitudes and beliefs or the role of perceptual and cognitive processes in politics, the paper is offered in the hope of providing new insights into how people can and should cope with the highly complex environments typical of political arenas. For the experimental and social psychologists whose work is being used, this paper offers an information-processing model of perception and cognition which I call "schema theory." This schema theory has theoretical implications that go beyond the particular findings used. For all readers, the schema theory is meant to raise new questions that can guide further empirical as well as theoretical work. In this way the inaccuracies and overgeneralizations of the current model can be discovered, alternatives proposed, and our knowledge advanced.

At the start it is best to have clearly in mind what the schema theory is about and what it is not about. It is about how a single person observes and makes sense out of a complex environment. Therefore it describes the perceptual and cognitive processes of a single person; it does *not* describe the functioning of a small group, let alone a social movement or a government. Furthermore, it describes how a person processes information and tries to make sense out of it, but it does not describe how he makes policy decisions. This paper is designed to stand alone, but it can also be regarded as part of a larger project which deals with groups as well as individuals and with decision making as well as information processing. The structure of such a larger project is suggested in the author's *Framework for a General Theory of Cognition and Choice.*[3] An application of part of that framework to the decision-making pro-

cess in an actual governmental committee is given in the author's "Psycho-algebra: A Mathematical Theory of Cognition and Choice with an Application to the British Eastern Committee in 1918."[4] The present paper focuses on the information-processing aspects of the overall framework. It employs findings from experimental and social psychology to help formulate a schema theory which provides falsifiable substance to that part of the framework.

The schema theory itself takes the form of a partially specified model of how people process new information. Once the model is presented with the help of a flow-chart, a variety of findings from experimental psychology will be cited to support some of the decisions which went into the construction of this version of the model. Then further empirical findings will be cited to show that some of the predictions which the schema theory makes are valid at least in certain circumstances. The approach used here will then be compared to some other theoretical approaches, and consideration will be given to some of the outstanding research questions raised by the theory. Finally, a few illustrations from international relations and especially foreign policy formation show that this model of how people make sense out of a complex world can be directly relevant to the study of important political processes.

B. *The Elements of the Model*

The input to the model is a *message,* which contains several types of information. Each message has a known *source,* which may be one's own direct observation or another person. The heart of the message is some *information* about a particular case, such as the state of the friendship relationships between a certain group of individuals. The *type of case* (for example "friendship relationships") is also known. Thus a message in this model might take the form, "Mr. Smith says, 'Joe likes Bill, and Bill likes Sam.'" A full description of this particular case would indicate who likes whom and who dislikes whom among the whole set of relevant people, although the message itself need not contain a complete specification.

A *schema* in this model is defined as a subset of all the possible specifications of cases. A schema can be arbitrarily defined as any subset of the specifications, but typically a schema is defined in terms of the set of all specifications which have certain stipulated properties. For

[2] For a formal treatment of balance see Frank Harary, Robert Norman and Dorwin Cartwright, *Structural Models* (New York: Wiley, 1965). For a treatment of clusters see James Davis, "Clustering and Structural Balance in Graphs," *Human Relations,* 20 (May, 1967), 181–187; and James A. Riley, "An Application of Graph Theory to Social Psychology," in *The Many Facets of Graph Theory,* Lecture Notes in Mathematics, No. 110 (New York and Berlin: Springer Verlag, 1969).

[3] Robert Axelrod, *Framework for a General Theory of Cognition and Choice* (Berkeley: Institute of International Studies, University of California, 1972). Also to appear in *Theories of Collective Behavior,* ed. Julius Margolis and Henry Teune, forthcoming.

[4] Robert Axelrod, "Psycho-Algebra: A Mathematical Theory of Cognition and Choice with an Application to the British Eastern Committee in 1918," *Papers of the Peace Research Society (International),* 18 (1972), 113–131.

example, the schema of *balance* is defined as the collection of all specifications which divide objects into two nonoverlapping groups with positive relationships only within groups and negative relationships only between groups. A larger schema would be *symmetry,* in which the only requirement is that whatever A's relationship is to B, B has to have the same relationship to A. Obviously, any complete specification which is balanced is also symmetric, but not vice versa.

A *case* is a specific instance in time. A particular case might represent, for example, the friendship relationships among a given group of people at the present time. An *interpretation* of a case in terms of a schema is a treatment of the case as if it belonged to that schema, perhaps by ignoring the information that might indicate otherwise.

A *complete specification* of a case is the listing of all the details of a case using an interpretation of the case in terms of a given schema. For example, a complete specification of a case of friendship relations using a balanced schema would list all the liking and disliking relationships among the set of people. Notice that if the case were interpreted as fitting a balanced schema, the complete specification could be determined simply by listing to which of the two groups each person belonged.

A specification of a case is never completely certain for a person, so each specification carries a certain degree of confidence; thus a specification of a case represents a belief which is held with more or less confidence by the person.[5] The *accessibility* of a schema for a particular type of case is the order in which that schema is checked for its fit to the information. A highly accessible schema is checked before a fit with a less accessible schema is attempted. The critical assumption of this model is that the person tries to find a schema which provides a satisfactory fit to the case at hand. How this is done is described in the next section.

C. The Dynamics of the Model

Figure 1 is a flow-chart of the model. The process starts when a message is received about a case (box 1). The first question is then whether there is already an interpretation of this case (box 2).[6] If there is, then the new in-

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[5] For simplicity, the present model makes the unrealistic assumption that each of the separate relationships within a specification is believed with the same degree of confidence.

[6] The present model assumes that new information can be assigned to a case and that each case can be assigned to a known case type. Quite possibly these assignments involve a process similar to the interpretation process described within the model.

formation is checked to see if it fits sufficiently well any of the old specifications based on that interpretation (box 3). If it does fit the old interpretation, there is no problem, and the new information gets interpreted with the help of the old schema (box 11). If the new information does not fit the old interpretation, then blame is affixed by comparing the credibility of the source of the new information with the confidence of the old interpretation (box 4). If the new message is blamed, the credibility of the new source is downgraded for future reference, and the process ends with the old interpretation and specification maintained unchanged (box 5). If the old interpretation is blamed, the source of the old information has *its* credibility downgraded, and the old interpretation is cancelled (box 6). Whatever can be remembered of the old information is then taken at face value without any schema to interpret it and is combined with the new information in the new case to provide a partial specification of the case at hand (box 8). This combining process (box 8) would also occur if there had been no previous interpretation of the case but there had been some old uninterpreted information on the case (a "Yes" after 7).

From either path (whether from box 6 or 7), the person gets to the step of seeking a schema which will provide a satisfactory fit to the available information at hand (box 9). This step uses a "satisficing subroutine" which will be described separately because it is so important to the model. If the search process fails to find a schema which provides a sufficiently good fit, the source is downgraded (box 10), and the process ends without an interpretation of the case: i.e., the person is baffled.

If the search for a satisfactory schema is successful, this schema is then used to specify further the case at hand (box 11). The specification stage (box 11) is also reached if an interpretation of the case at hand already existed in terms of some schema and if the new information fit the old specification sufficiently well (i.e., "Yes" after box 2 and "Yes" after box 3). The interpretation is made by first modifying the new information if necessary so that it will coincide exactly with the selected schema. For example, if the selected schema is balance, then all the inconsistencies (such as "A likes B and C, but B doesn't like C") are resolved to correspond to the schema of balance. This gives a modified partial specification of the case. Next this perfectly fitting partial specification is extended with the further use of the selected schema. For example, if the partial specification includes the information that Joe likes Sam, and Sam likes Bill, and the selected

Enter

1
Receive a message:
    source name
    partial specification
        of a case
    case type.

2
Is there already an inter-
pretation of this case?

Yes

No

3
Does the new information
fit any of the old specifi-
cations sufficiently well?

7
Is there any old
uninterpreted infor-
mation on this case?

Yes

No

Yes

No

4
Affix blame by comparing
source credibility to in-
terpretation confidence.

8
Combine the old and
new information.

5
Blame new message:
downgrade source
credibility.

6
Blame old interpretation:
downgrade old source's
credibility, cancel
previous interpretation.

9
Satisfice: seek a schema
which provides a satisficing
fit to the partial specifi-
cation of the case.

Exit with old
interpretation.

Succeed

10   Fail
Downgrade source
credibility.

11
Specify: modify and extend
specification using the
selected schema, upgrade
accessibility of the schema,
upgrade source credibility,
upgrade confidence in the
interpretation.

Exit without.
interpretation

Exit with new interpretation

Figure 1. Process Model for Schema Theory.

schema is one of balance, then several infer-
ences can be drawn. One is that Sam likes Joe
(since relationships in a balanced schema are
symmetric) and another is that Joe likes Bill
(since positive relationshps in a balanced
schema are transitive). These additional infer-
ences allow the person to extend his specifica-
tion of the current case.

Together with this modification and exten-
sion of the partial specification of the case
there are some bookkeeping operations which
allow the person to benefit in the future from
his experience of finding a satisfactory fit (box
11). He upgrades the accessibility of the se-
lected schema, he upgrades the credibility of
the source of the message, and he upgrades the
confidence in the current interpretation of the
case. If there was already an interpretation of

this case and the new information fits this interpretation, then the confidence in that interpretation will be increased. On the other hand, if there was no previous interpretation of the case, then the certainty of the present interpretation depends directly on the credibility of the source of the current message and the goodness of the fit of the new information to the selected schema. Once the interpretation is made and the bookkeeping is performed, the process ends with the new interpretation and specification as the primary output.

The satisficing subroutine (box 9) is presented in greater detail in Figure 2. This subroutine describes how a person seeks a schema
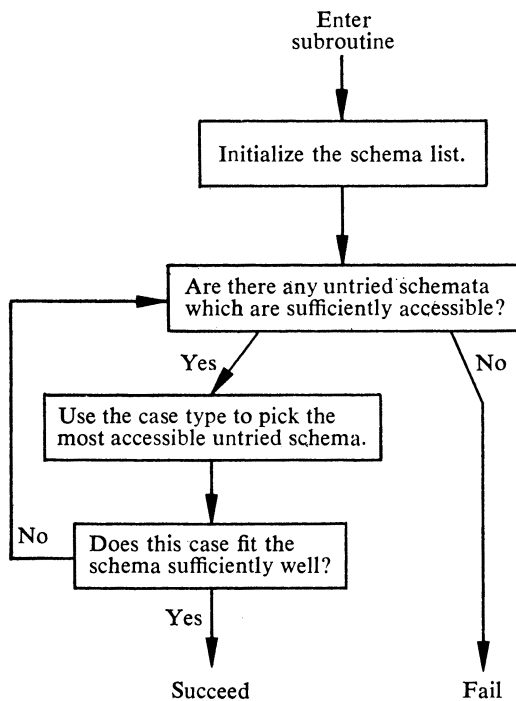
Enter
subroutine

Initialize the schema list.

Are there any untried schemata
which are sufficiently accessible?

Yes   No

Use the case type to pick the
most accessible untried schema.

No   Does this case fit the
schema sufficiently well?

Yes

Succeed   Fail

Figure 2. The Satisficing Subroutine.

which will provide a satisfactory fit to the available information on the case at hand. A person does not try out every conceivable schema in an attempt to find the best fit of all. Instead he uses his knowledge of the type of case it is to pick out the most accessible schema for that type of case. Then if the fit with this schema is not sufficiently good, he tries the next most accessible schema, and so on. He continues this process until either he finds a schema which provides a satisfactory fit or he exhausts the schemata which are sufficiently accessible for this type of case. Thus the process of trying to

fit the information about a case to a schema is a process of "satisficing" (to use the apt term of Simon) [7] rather than maximizing.

This, then, is the model of how a person makes sense out of a complex world. Once he has interpreted a case in terms of a schema he achieves four things:

(1) He modifies some of the information in the light of his old interpretation (if there was one) and the rest of his information. This allows him to change his beliefs about those parts of the information which may have been wrong for one reason or another. Whether these changes are corrections or distortions depends upon the accuracy of the new interpretation and specification.

(2) He usually achieves a more complete specification of the case than he was given by the information in the original message or messages. This allows him to make predictions about previously unobserved aspects of the case. These predictions can be helpful for decision making since the partial specification of the case (even when modified) might not have constituted an adequate guide for behavior. The degree to which the extended specification can serve as a guide for action depends upon whether the selected schema contains parameters that can help a person identify and choose among future courses of action. For example, a balanced interpretation of a set of friendship relationships which includes oneself is a powerful guide to action, since it allows one to orient oneself postively or negatively toward each of the other people without any ambiguity.

(3) He reduces his memory requirements by interpreting the separate bits of information about the current case in terms of the parameters of a schema. For example, it takes n^2 bits of information to remember an arbitrary set of binary friendship relationships between n people, but it takes only $n-1$ bits of information to remember a set of friendship relationships which fits a balanced schema of friends and enemies. The amount of the reduction in the memory requirement depends upon the "size" of the schema, a characteristic which is further explored in VI, A below.

(4) He uses the results of the current case to provide feedback which will affect the processing of information in the future. In particular, he makes adjustments for the future interpretations of this or other cases by updating the accessibility of the schema, the credibility of the source, and the confidence in the specification of the current case. Whether these modifi-

[7] Herbert Simon, *Models of Man* (New York: Wiley, 1957).

cations will be a help or a hindrance in the future depends upon whether he has drawn the right conclusions from the current message.

Now that the model has been presented, the relevant evidence for this schema theory will be discussed in the next two sections. The first of these sections (Part II) offers the evidence which deals with specific features of the process, as indicated by references to specific boxes in the flow-chart of Figure 1. Part III offers evidence on the overall system performance of the model. These two parts of the paper and the two parts that follow them are written in outline form in order to better display the structure of the presentation.

II. Evidence Relating to Specific Parts of the Model

A. *Use of Prior Interpretations (Figure 1, Boxes 2 and 3)*

1. *Claim:* A prior interpretation of a case (if one exists) is highly accessible.

   Evidence: There is a primacy effect in impression formation, which means that a first impression carries more weight than later impressions.[8]

B. *The Blaming Process (Boxes 4, 5, and 6)*

1. *Claim:* When new information gives a bad fit to the old interpretation, one possibility is that the old interpretation can be maintained by downgrading the credibility of the source of the new information.[9]

   Evidence: Information which is discrepant with previous beliefs tends to be perceived as less informed and less fair.[10]

2. *Claim:* The greater the source credibility, the more likely the old interpretation is to be blamed for any discrepancy.

   Evidence: When the same message is attributed to sources of differing credibility, differing amounts of attitude change are produced

with the more credible sources producing the greater attitude change.[11,12]

3. *Claim:* The greater the source credibility, the less likely the source is to be blamed for any discrepancy.

   Evidence: A given message is judged more fair and more fully documented when it comes from a high credibility source rather than a low credibility source.[13]

4. *Claim:* Sources whose messages are likely to have been interpreted with an accessible schema tend to have high credibility.

   Evidence: Attribution of knowledge, intelligence, education and social status give credibility to an unknown source.[14]

   But it is not clear whether the old interpretation and the new source can both be blamed at once.[15]

5. *Claim:* When an old interpretation is blamed, the schema used in the old interpretation becomes somewhat less accessible for future cases of the same type and perhaps for other types of cases as well.

   Evidence: Children can learn with experience to switch the order in which they test hypotheses.[16]

   But even adults have greater difficulty developing nonlinear hypotheses to explain evidence when linear hypotheses repeatedly fail.[17]

C. *Combining Information (Boxes 7 and 8)*

1. *Claim:* Old and new information about

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[8] S. E. Asch, "Forthcoming Impressions of Personality," *Journal of Abnormal and Social Psychology*, 41 (July, 1946), 258–290; and N. H. Anderson, "Primacy Effects in Personality Impression Formation Using a Generalized Order Effect Paradigm," *Journal of Personality and Social Psychology*, 2 (July, 1965), 1–9.

[9] Note that the present model does not treat the effects of limited or inaccurate memory.

[10] J. E. Dietrich, "The Relative Effectiveness of Two Modes of Radio Delivery in Influencing Attitudes," *Speech Monographs*, 13 (1946), 58–65; C. I. Hovland, O. J. Harvey, and M. Sherif, "Assimilations and Contrast Effects in Communication and Attitude Change," *Journal of Abnormal and Social Psychology*, 55 (September, 1957), 242–252; and Anne S. McKillop, *The Relationship Between the Reader's Attitudes and Some Types of Reading Response* (New York: Columbia University Press, 1952).

[11] L. R. Anderson, "Discrediting Sources as a Means of Belief Defense of Cultural Truisms," *American Psychologist*, 21 (July, 1966), 708.

[12] A more complex model would take account of other source factors as well as credibility. The new information could then be regarded as having a confidence parameter which was determined by factors including the attractiveness and the power of the source as well as the source's credibility. For a review of source factors in attitude change see William J. McGuire, "The Nature of Attitudes and Attitude Change," in *Handbook of Social Psychology*, ed. Lindzey and Aronson, III, 136–314.

[13] C. I. Hovland and W. Mandell, "An Experimental Comparison of Conclusion-drawing by the Communicator and by the Audience," *Journal of Abnormal and Social Psychology*, 47 (July, 1952), 581–588; and C. I. Hovland and W. Weiss, "The Influence of Source Credibility on Communication Effectiveness," *Public Opinion Quarterly*, 15 (Winter, 1951), 635–650.

[14] Carl I. Hovland, Irving L. Janis, and Harold H. Kelley, *Communication and Persuasion* (New Haven: Yale University Press, 1953).

[15] C. E. Osgood and P. H. Tannenbaum, "The Principle of Congruity in the Prediction of Attitude Change," *Psychological Review*, 62 (January, 1955), 42–55.

[16] Neal E. Miller and John Dollard, *Social Learning and Imitation* (New Haven: Yale University Press, 1941).

[17] Mats Bjorkman, "Predictive Behavior: Some Aspects Based on Ecological Orientation," *Scandinavian Journal of Psychology*, 7 (1966), 43–57.

the same case are combined using a weighted average.

Evidence: The impression of a sequence of trait adjectives is the weighted average of the impressions of the separate adjectives and of an assumed nonzero initial impression.[18] The existence of the initial impression is supported by the finding that even without specific information, people have non-neutral expectations, e.g., that two people will like rather than dislike each other.[19]

D. Selecting a Schema (Boxes 9 and 10)

1. *Claim:* The selection of a schema with which to interpret information about a case is a process of satisficing rather than maximizing the fit.

Evidence:

a. Some pictures are multistable so that the same person can give several different but temporarily stable interpretations of the same ambiguous picture.[20]

b. The Socratic effect seems to exist in which a person who is asked to state his opinions on related issues changes his opinions to achieve logical consistency.[21,22]

c. Nonrandom distortions are introduced when a person is asked to reproduce a message.[23] For example, incongruous or unusual details are either forgotten *or* exaggerated (presumably because either no schema was found to fit them *or* a relatively inaccessible schema was selected).

Note: There is as yet little evidence to indicate just what type of suboptimal process is used to select a schema from among those which are more or less accessible and which provide a better or worse fit to the initial partial specification of the current case. The use of a satisficing process in a model of schema selec-

tion seems suitable but must be regarded as conjectural. For the use of satisficing processes in the choice of alternative courses of action see Simon,[24] March and Simon,[25] and Cyert and March.[26]

2. *Claim:* The accessibility of a schema is independent of the input and output modes.

Evidence: The accessibility of a schema is relatively insensitive to the manner in which the message is presented[27] or the manner in which the response is elicited.[28]

3. *Claim:* The accessibility of a schema depends in part on the case type of the current case.

Evidence: Two identical patterns of relationships are processed differently if different labels are given to them. For example, a pattern of interpersonal relationships which is completely ordered (asymmetric, transitive, and complete) is much easier to learn if the relationships are labeled "influences" rather than "likes."[29] See also III, A, 1.

E. Modifying the Initial Partial Specification (Box 11)

1. *Claim:* The initial partial specification is modified in a manner which improves the fit between the partial specification and the selected schema.

Evidence:

a. An assimilation/contrast effect exists in which a subject tends to underestimate the distance between a stimulus and a standard of reference when the distance is small, and overestimate it when the distance is large.[30] The effect has been applied to attitude change,[31]

[18] Anderson, "Primacy Effects"; Zajonc, "Cognitive Theories"; and Rosenberg, "Mathematical Models."

[19] Clinton B. DeSoto and James L. Kuethe, "Subjective Probabilities of Interpersonal Relationships," *Journal of Abnormal and Social Psychology,* 59 (September, 1959), 290–294.

[20] Fred Attneave, "Multistability in Perception," *Scientific American* (December, 1971), pp. 63–71.

[21] This effect was found by William J. McGuire, "Cognitive Consistency and Attitude Change," *Journal of Abnormal and Social Psychology,* 60 (May, 1960), 345–353.

[22] Only weak indications of such an effect were found by R. C. Dillehay, C. A. Insko, and M. B. Smith, "Logical Consistency and Attitude Change," *Journal of Personality and Social Psychology,* 3 (June, 1966), 646–654.

[23] Frederic Bartlett, *A Study in Experimental and Social Psychology* (Cambridge: Cambridge University Press, 1969).

[24] Simon, *Models of Man.*

[25] James G. March and Herbert A. Simon, *Organizations* (New York: Wiley, 1958).

[26] Richard M. Cyert and James G. March, *A Behavioral Theory of the Firm* (Englewood Cliffs, N.J.: Prentice-Hall, 1963).

[27] James Kuethe, "Pervasive Influence of Social Schemata," *Journal of Abnormal and Social Psychology,* 68 (May, 1964), 248–254.

[28] James Kuethe and Herbert Weingartner, "Male-Female Schemata of Homosexual and Non-Homosexual Penitentiary Inmates," *Journal of Personality,* 32 (March, 1964), 23–31.

[29] Clinton B. DeSoto, "Learning a Social Structure," *Journal of Abnormal and Social Psychology,* 60 (May, 1960), 417–421.

[30] Muzafer Sherif and Carl I. Hovland, *Social Judgment: Assimilation and Contrast Effects in Communication and Attitude Change* (New Haven: Yale University Press, 1961); Carolyn W. Sherif, Muzafer Sherif, and R. E. Nebergall, *Attitude and Attitude Change* (Philadelphia: Saunders, 1965); and Carolyn W. Sherif and Muzafer, Sherif, eds., *Attitude, Ego-Involvement and Change* (New York: Wiley, 1967).

[31] Sherif and Hovland, *Social Judgment.*

personality functioning,[32] and social perception.[33]

b. A stereotyping effect exists in which a subject underestimates the relevant differences within certain groups and overestimates the differences between contrasting groups. Stereotyping occurs not only in the perception of social groups, but even of abstract stimuli such as lengths of variously classified lines[34] and stimuli classified by their positions in an array.[35]

c. Regularization of speech occurs in which children treat strong verbs as it they were weak verbs (e.g., by saying "comed" instead of "came" for the past tense of "come").[36]

d. A common error in recalling an experience is to recall the part that fits a schema and forget the part that does not fit.[37] In general, material is recalled in a manner which indicates that it has been selected, organized and interpreted.[38]

e. Stimuli which have separate names can be more accurately remembered than stimuli which do not (e.g., highly codable colors can be accurately selected from a collection of colors). This holds for the same colors between different languages[39] and for different colors within one language.[40] It may be due to covert verbalization.[41]

f. The extent to which actual friendship groups fit the schema of balance is overperceived.[42]

F. *Expansion of the Partial Specification (Box 11)*

1. *Claim:* The modified partial specification is extended in a manner which does not worsen the fit between the specification and the schema.

Evidence:

a. Guesses based on limited information provide the best possible fits to the appropriate schema (e.g., if "*A* likes *B*" then "*B* likes *A*" is guessed),[43] and in general missing information about friendship patterns is guessed to fit a balanced schema.[44]

b. Guesses in signal detection experiments are consistent with a model of a person as a receiver who is uncertain about the signal rather than as a receiver who has a variable response criterion or who has noise inherent in his sensory system.[45]

c. Errors in long-term recall of liking relationships contained in stories are more likely to be made in recalling imbalanced as balanced patterns than the other way around.[46]

d. The previously noted effect of overperception of balance in actual friendship groups[47] may be due to the extension of the partial specification beyond the information available.

[32] Leonard Berkowitz, "Judgmental Processes in Personality Functioning," *Psychological Review,* 67 (March, 1960), 130–142.

[33] Leonard Berkowitz and R. E. Goranson, "Motivational and Judgmental Determinants of Social Perception," *Journal of Abnormal and Social Psychology,* 69 (September, 1964), 296–302.

[34] Henri Tajfel and A. L. Wilkes, "Classification and Quantitative Judgement," *British Journal of Psychology,* 54 (May, 1963), 101–114.

[35] D. T. Campbell, "Enhancement of Contrast as Composite Habit," *Journal of Abnormal and Social Psychology,* 53 (November, 1956), 350–355.

[36] Susan Ervin, "Imitation and Structural Change in Children's Language," in *New Directions in the Study of Language,* ed. Eric H. Lenneberg (Cambridge: M.I.T. Press, 1964), pp. 163–190.

[37] R. S. Woodworth, *Experimental Psychology* (New York: Holt, 1938); George A. Miller, "Some Psychological Studies of Grammar," *American Psychologist,* 17 (November, 1962), 748–762.

[38] Bernard R. Berelson and Gary A. Steiner, *Human Behavior* (Burlingame: Harcourt, Brace and World, 1964).

[39] Eric H. Lenneberg and John M. Roberts, *The Language of Experience* (Baltimore: Waverly Press, 1956). Also appeared as *International Journal of American Linguistics,* 22, No. 2; and in Sol Saporta, ed., *Psycholinguistics* (New York: Holt, Rinehart and Winston, 1961).

[40] Roger Brown and Eric H. Lenneberg, "A Study in Language and Cognition," *Journal of Abnormal and Social Psychology,* 49 (July, 1954), 454–462.

[41] Murray Glanzer and William H. Clark, "Accuracy of Perceptual Recall: An Analysis of Organization,"

Journal of Verbal Learning and Verbal Behavior, 1 (January, 1963), 289–299.

[42] Nathan Kogan and Renato Tagiuri, "Interpersonal Preference and Cognitive Organization," *Journal of Abnormal and Social Psychology,* 56 (January, 1958), 113–116.

[43] Clinton E. DeSoto and James L. Kuethe, "Perception of Mathematical Properties of Interpersonal Relations," *Perceptual and Motor Skills,* 8 (December, 1958), 279–286; and DeSoto and Kuethe, "Subjective Probabilities." For a quantitative extension, see A. Rodney Wellens and Donald L. Thistlethwaite, "Comparison of Three Theories of Cognitive Balance," *Journal of Personality and Social Psychology,* 20 (October, 1971), 82–92.

[44] J. Morrissette, "An Experimental Study of the Theory of Structural Balance," *Human Relations,* 11 (August, 1958), 239–254; and Elizabeth G. Schrader and D. W. Lewit, "Structural Factors in Cognitive Balancing Behavior," *Human Relations,* 15 (August, 1962), 265–276.

[45] J. A. Swets, "Is There a Sensory Threshold?" *Science,* 134 (July 21, 1961), 168–177; and D. M. Green, "Psychoacoustics and Detection Theory," *Journal of the Acoustical Society of America,* 29 (1960), 1180–1203. For a review see Clyde H. Coombs, Robyn M. Dawes, and Amos Tversky, *Mathematical Psychology* (Englewood Cliffs, N.J.: Prentice-Hall, 1970).

[46] Harold B. Gerard and Linda Fleischer, "Recall and Pleasantness of Balanced and Unbalanced Structures," *Journal of Personality and Social Psychology,* 7 (November, 1967), 332–337.

[47] Kogan and Tagiuri, "Interpersonal Preference."

III. Predictions of System Performance

A. *Ease of Learning*

1. *Prediction:* Where the initial information provides a good fit to an accessible schema, learning to reproduce the information in a message accurately will be easy.

Evidence:

a. The greater the imbalance in a liking structure, the more errors in learning a semicycle in it.[48]

b. As previously noted, a hypothetical social structure is easiest to learn when it possesses the structural properties expected of it.[49]

c. As previously noted, errors tend to improve the fit between the recalled material and the selected schema (see Evidence for Claim II, E, 1 above).

2. *Prediction:* When an excellent fit is required, the less accessible the appropriate schema is, the more difficult the problem will be to solve.

Evidence:

a. The unfamiliar use of the familiar is a difficult solution to achieve.[50]

b. When a prior success is inapplicable, the problem is difficult to solve.[51]

3. *Prediction:* When the initial information provides a good fit to an accessible schema there will be little manifestation of surprise.

Evidence:

a. Messages which provide a good fit to a balanced liking schema are judged to be persuasive, accurate, and pleasant.[52]

b. Messages which are incongruous cause physiological arousal (e.g., as measured by galvanic skin response).[53]

B. *Attitude Change*

1. *Prediction:* Old beliefs are changed in accordance with the model, i.e., when information in a new message does not fit the old interpretation, a comparison of the source credibility of the new message with the confidence in the old interpretation can result in blaming the old interpretation.

Evidence:

a. Repeating the same argument is no help in attitude change.[54]

b. Internalization occurs in attitude change, which means that if the source of a persuasive message is forgotten, the changed attitude is still retained. Even if the source is known to switch his position, the attitude change remains.[55]

c. Over a wide range, the larger the advocated change, the greater the change in attitude, provided the source is regarded as credible.[56]

C. *Effect of Experience*

1. *Prediction:* A highly accessible schema will only be downgraded if reliable information is acquired which does not fit the schema (since no other schema will get priority in the search process).

Evidence: A dog taught to jump at regular intervals to avoid a shock continues to jump long after the shock mechanism is turned off. In order to unlearn the lesson, he has to be physically prevented from jumping.[57]

2. *Prediction:* When the interpretation of a sequence of cases repeatedly uses the same schema, the schema becomes more accessible.

[48] R. B. Zajonc and E. Burnstein, "Structural Balance, Reciprocity, and Positivity as Sources of Cognitive Bias," *Journal of Personality,* 33 (December, 1965), 570–583. For related results on the learning of liking structures, see R. B. Zajonc and E. Burnstein, "The Learning of Balanced and Unbalanced Social Structures," *Journal of Personality,* 33 (June, 1965), 153–163.

[49] DeSoto, "Learning a Social Structure." For more recent verification that learning a set of relationships is easier when they fit the expected structure, see Clinton B. DeSoto, Nancy M. Henley, and Marvin London, "Balance and the Grouping Schema," *Journal of Personality and Social Psychology,* 8 (July, 1968), 1–7; Nancy M. Henley, Robert B. Horsfall and Clinton B. DeSoto, "Goodness of Figure and Social Structure," *Psychological Review,* 76 (1969), 194–204; and Robert B. Horsfall and Nancy M. Henley, "Mixed Social Structures: Strain and Probability Ratings," *Psychonomic Science,* 15 (May, 1969), 186–187; Donald L. Mosher, "The Learning of Congruent and Noncongruent Social Structures," *Journal of Social Psychology,* 73 (December, 1967), 285–290.

[50] Berelson and Steiner, *Human Behavior,* p. 204.

[51] Berelson and Steiner, *Human Behavior,* p. 204.

[52] Milton J. Rosenberg and Robert P. Abelson, "An Analysis of Cognitive Balancing," in *Attitude Organiza-*

tion and Change, Milton J. Rosenberg, Carl I. Hovland, William J. McGuire, Robert P. Abelson and Jack W. Brehm (New Haven: Yale University Press, 1960), pp. 112–163.

[53] D. E. Berlyne, *Conflict, Arousal, and Curiosity* (New York: McGraw-Hill, 1960), and Evgenii N. Sokolov, *Perception and the Conditioned Reflex,* trans. Stephen W. Waydenfeld (Oxford and New York: Pergamon, 1963).

[54] McGuire, "The Nature of Attitudes and Attitude Change," p. 169.

[55] Sherif, "A Study of Some Social Factors in Perception."

[56] See McGuire, "The Nature of Attitudes and Attitude Change," p. 223, for a review.

[57] R. L. Solomon, L. J. Kamin, and L. C. Wynne, "Traumatic Avoidance Learning: The Outcomes of Several Extinction Procedures with Dogs," *Journal of Abnormal and Social Psychology,* 48 (April, 1953), 291–302.

Therefore, it will eventually be selected even when other less accessible schemata might provide better fits.

Evidence: As previously noted, children can learn to switch the order in which they test hypotheses.[58]

D. Resolution of Cognitive Inconsistencies

1. Prediction: When some information (whether old or new) fits none of the sufficiently accessible schemata precisely, employable tactics include the following: blame the source, use the other old and new information about the case to select a schema which gives a sufficiently good fit to all the available information, or exit without an interpretation.

Evidence: These modes are among the many which have been suggested (with varying degrees of empirical support) as ways of resolving cognitive inconsistencies.[59]

E. Measuring Accessibility of a Schema

The accessibility of a schema for a particular type of case is not directly observable. It can be measured indirectly using any one of the four methods described above: ease of learning, attitude change, effects of experience, and resolution of cognitive inconsistencies. When studying a new person or a new type of case, one method can be used to validate another method's results.

IV. Comparison with Other Theoretical Approaches

A. Computer Simulations

To my knowledge, no computer simulation of human perception or cognition treats the differential accessibility of alternative schemata, which is the heart of the present model.[60]

B. Gestalt School of Psychology

The Gestalt School[61] provides some of the fundamental ideas which the present information processing model tries to develop. The common criticism that the Gestalt approach has lacked precision is well founded.

C. Information Theory

Information theory[62] provides some useful mathematical tools, including a way to measure the size of a schema (for a few details see Part VI, A). The application of information theory to formal problems in statistical inference is by now quite well developed.[63]

D. Balance Theory

The predictions of balance theory[64] are consistent with the schema theory for those and only those situations in which the balanced schema is the one selected (see VI, B).[65]

1. Claim: Balance is a highly accessible schema in certain contexts, such as friendship relationships.[66]

Evidence (all previously cited):

a. Balanced messages are more acceptable than unbalanced messages.[67]

b. Incomplete specifications are extended with the use of a balanced schema.[68]

c. Balance is overestimated.[69]

d. A balanced message is easier to learn and to retain over time.[70]

[58] Miller and Dollard, Social Learning and Imitation.

[59] William J. McGuire, "The Current Status of Cognitive Consistency Theories," in Cognitive Consistency: Motivational Antecedents and Behavioral Consequents, ed. Shel Feldman (New York: Academic Press, 1966); Robert P. Abelson, "Psychological Implication," in Abelson et al., Theories of Cognitive Consistency, pp. 112–139; Abelson et al., Theories of Cognitive Consistency, chapters 64–71; and Percy H. Tannenbaum, Jacqueline R. Macaulay, and Eleanor L. Norris, "Principle of Congruity and Reduction of Persuasion," Journal of Personality and Social Psychology, 3 (February, 1966), 233–238.

[60] But for some interesting simulations of mental processes see Silvan Tomkins and Samuel Messick (eds.), Computer Simulation of Personality (New York: Wiley, 1963), Robert P. Abelson and J. Douglas Carroll, "Computer Simulation of Individual Belief Systems," American Behavioral Scientist, 8 (May, 1965), 24–30; John C. Loehlin, Computer Models of Personality (New York: Random House, 1968); U. Moser, I. S. von Zeppelen and W. Schneider, "Computer Simulation of a Model of Neurotic Defence Processes," Behavioral Science, 15

(March 1970), 194–202; and Allen Newell and Herbert Simon, "Simulation of Human Thought," in Computer Simulation of Human Behavior, ed. John M. Dutton and William Starbuck (New York: Wiley, 1971).

[61] Max Wertheimer, Productive Thinking (New York: Harper, 1945).

[62] Wendell R. Garner, Uncertainty and Structure as Psychological Concepts (New York: Wiley, 1962).

[63] Satosi Watanabe, Knowing and Guessing: A Quantitative Study of Inference and Information (New York: Wiley, 1969).

[64] Robert P. Abelson and Milton J. Rosenberg, "Symbolic Psychologic: A Model of Attitudinal Cognition," Behavioral Science, 3 (January, 1958), 1–13.

[65] For a basic introduction to balance theory, see Roger Brown, Social Psychology (Glencoe, Ill.: The Free Press, 1956); for a review of most of the experimental evidence see Zajonc, "Cognitive Theories"; for a fund of source material, see Abelson et al., Theories of Cognitive Consistency.

[66] In fact, much of the experimental work on schemata cited in this paper has been inspired more or less directly by the study of interpersonal relationships contained in Fritz Heider, The Psychology of Inter-personal Relations (New York: Wiley, 1958).

[67] Rosenberg and Abelson, "An Analysis of Cognitive Balancing."

[68] Morrissette, "An Experimental Study."

[69] Kogan and Tagiuri, "Interpersonal Preference."

[70] Clinton B. De Soto, Nancy M. Henley and Marvin London, "Balance and the Grouping Schema," Journal of Personality and Social Psychology, 8 (January, 1968),

e. Balanced messages are viewed as less likely to change than unbalanced messages.[71]

f. Balance is an accessible schema in perceived friendship relationships among a set of countries.[72]

g. Balanced situations are imagined more vividly, rapidly and elicit higher affective ratings than unbalanced situations.[73]

2. *Claim:* The limitations of balance theory can be understood in terms of the availability of schemata more accessible than the balance schema which can provide adequate fits to the information on a given case.

Evidence:

a. The schema of positivity (consisting of nothing but positive relationships) can explain some of balance theory's failures, such as

(1) positive links are easier to learn than negative links,[74]

(2) positive semicycles are easier to learn than negative semicycles,[75] and

(3) there is not a large negative correlation between the first two links of a triad when the third is negative.[76]

(4) subjects' willingness to change the relationships between themselves and a fictitious person is determined by positivity forces.[77]

b. If a subject likes chicken, and chickens like chicken feed, the subject is not expected to like chicken feed.[78]

c. If subjects are told that two boys like a girl, the subjects do not expect them to like each other as much as if they both like a third boy.[79]

d. If told that two people like *Newsweek* magazine, subjects do not mistakenly learn that they like each other, but this mistake is made when two people are said to like racial integration.[80]

3. *Claim:* A balanced schema is selected when appropriate, even outside of the context suggested by balance theory.

Evidence: The concepts used by decision makers in describing their images of external reality are balanced.[81] A balanced schema is applied in tasks of recall and attribution of responsibility.[82]

4. The schema theory is consistent with all of the following explanations for the tendency toward cognitive consistency: a motivational drive toward consistency, limited cognitive capacity resulting in the need for simplification of incoming information, and inadequacies in the incoming information which must therefore be processed in a manner that allows predictions to be made and later tested.

V. Development of Schema Theory

A. *General Principles of Schema Accessibility*

1. *Claim:* People seek logical consistency.

Evidence:

a. Arguments against the premise of a syllogism will affect the belief in the conclusion a week later.[83]

b. Attitude change by posthypnotic sug-

1–7. Nicolas B. Cottrell, Larry H. Ingraham and Franklin W. Monfort, "The Retention of Balanced and Unbalanced Cognitive Structures," *Journal of Personality*, 39 (March, 1971), 112–131.

[71] Eugene Burnstein, "Sources of Cognitive bias in the Representation of Simple Social Structures; Balance, Minimal Change, Positivity, Reciprocity, and the Respondent's Own Attitude," *Journal of Personality and Social Psychology*, 7 (September, 1967), 36–48. Harold Miller and Dennis Geller, "Structural Balance in Dyads, "*Journal of Personality and Social Psychology*, 21 (February, 1972), 135–138.

[72] Nicholas B. Johnson, "Some Models of Balance Applied to Children's Perceptions of International Relations," *European Journal of Social Psychology*, 2 (1972), 55–64.

[73] Edward B. Blanchard, Marilyn Vickers and Katina C. Price, "Balance Effects in Image Formation," *The Journal of Social Psychology*, 87 (June, 1972), 37–44.

[74] Zajonc and Burnstein, "The Learning of Balanced and Unbalanced Social Structures" and "Structural Balance."

[75] Zajonc and Burnstein, "Structural Balance."

[76] William M. Wiest, "A Quantitative Extension of Heider's Theory of Cognitive Balance Applied to Interpersonal Perception and Self-Esteem," *Psychological Monographs*, 79, No. 1 (Whole No. 607) (December, 1965).

[77] Aroldo Rodriguez, "Effects of Balance, Positivity and Agreement in Triadic Social Relations," *Journal of Personality and Social Psychology*, 5 (April, 1967), 472–476.

[78] R. B. Zajonc, "The Concepts of Balance, Congruity,

and Dissonance," *Public Opinion Quarterly*, 24 (Summer, 1960), 280–296.

[79] Robert B. Zajonc and Steven J. Sherman, "Structural Balance and the Induction of Relations," *Journal of Personality*, 35 (December, 1967), 635–650.

[80] Zajonc and Burnstein, "The Learning of Balanced and Unbalanced Social Structures." The authors explain this result by saying that one issue was less important than the other, but an alternative explanation is that the balance schema is not accessible for a case type involving readership of a general purpose magazine.

[81] Axelrod, "Psycho-Algebra."

[82] N. T. Feather, "Organization and Discrepancy in Cognitive Structures," *Psychological Review*, 78 (September, 1971), 355–379.

[83] William J. McGuire, "Cognitive Consistency and Attitude Change"; William J. McGuire, "A Syllogistic Analysis of Cognitive Relationships," in *Attitude Organization and Change*, Milton J. Rosenberg et al. (New Haven: Yale University Press, 1960), pp. 65–111; R. C. Dillehay, C. A. Insko, and M. B. Smith, "Logical Consistency and Attitude Change," *Journal of Personality and Social Psychology*, 3 (June, 1966), 646–654.

gestion causes cognitive reorganization for the maintenance of consistency.[84]

c. People with inconsistent associative structures are easier to change by reinforcement.[85]

d. Logical "mistakes" are often due to the use of different premises from the ones intended.[86]

e. As previously mentioned (II, D, 1, b), there may be a Socratic effect in which a person who is asked to state his opinions on related issues changes his opinions to achieve logical consistency.

2. *Claim:* There is a great deal of culturally stored information and knowledge (especially in the language of a society as Whorf emphasizes).[87] Even beyond this culturally stored information, the accessibilities of schemata are determined in part by factors other than direct observation or interpersonally transmitted experience.

Evidence:

a. Linguistic and other types of cognitive development proceed in relatively fixed stages, which suggests that some types of general rules are easier to learn than others.[88]

b. There seem to be some linguistic universals which are nonfunctional principles of grammar common to all languages. For example, grammatical operations apply in a cyclic fashion, first to the most deeply embedded structures, then to the structures that contain them, and so on.[89]

c. There seems to be a working model of three-dimensional space within the human nervous system which provides the capacity to interpret visual images.[90]

3. *Claim:* Schemata which are readily accessible for the interpretation of sets of relationships tend to have simple mathematical properties.

Evidence: There is empirical evidence for the accessibility of schemata with the following mathematical properties:

a. positive (see IV, D, 2, a above).[91]

b. symmetric.[92]

c. transitive.[93]

d. balanced (see IV, D, 1 and 3 above).

e. acyclic (no cycles, i.e., no set of relationships such that aRb, bRc, cRd, . . . , xRy, yRz, and zRa).[94]

f. linearly ordered (irreflexive, asymmetric, transitive, and complete).[95]

g. singly ordered (several dimensions collapsed into one linear order).[96]

4. *Claim:* A general feature of schemata is that a new case can be extended by using the parametric values of the specification of old relevant cases (which is a kind of generalization process).

Evidence:

a. Subjects systematically go beyond assuming attitudes which are sufficient to explain specific actions they observe, imputing to the actor attributes of trans-specific generality.[97]

[84] Milton J. Rosenberg and C. W. Gardner, "Case Report: Some Dynamic Aspects of Posthypnotic Compliance," *Journal of Abnormal and Social Psychology,* 57 (November, 1958), 351–366.

[85] W. A. Scott, "Cognitive Consistency, Response Reinforcement, and Attitude Change," *Sociometry,* 22 (September, 1959), 219–229.

[86] Mary Henle, "On Error in Deductive Reasoning," *Psychological Reports,* 7 (August, 1960), 80.

[87] Benjamin L. Whorf, *Language, Thought and Reality,* ed. J. B. Carroll (Cambridge, Mass.: M.I.T. Press, 1956).

[88] For a review of linguistic development in children see Roger Brown, *Social Psychology* (Glencoe, Illinois: The Free Press, 1956). For a review of Piaget's work on cognitive development see John H. Flavell, *The Developmental Psychology of Jean Piaget* (Princeton: Van Nostrand, 1963).

[89] A recent formulation of the claim for linguistic universals which uses this example is Noam Chomsky, *Problems of Knowledge and Freedom* (New York: Pantheon Books, 1971). For a review of psycholinguistic research see Miller and McNeill, "Psycholinguistics."

[90] Attneave, "Multistability in Perception."

[91] Concept formation experiments provide further indirect evidence. See, for example, Jerome S. Bruner, Jacqueline J. Goodnow and George A. Austin, *A Study of Thinking* (New York: Wiley, 1956).

[92] For example, DeSoto and Kuethe, "Perception of Mathematical Properties"; DeSoto and Kuethe, "Subjective Probabilities"; and DeSoto, "Learning a Social Structure."

[93] For example, DeSoto and Kuethe, "Perception of Mathematical Properties"; DeSoto and Kuethe, "Subjective Probabilities;" and DeSoto, "Learning a Social Structure."

[94] Henley, Horsfall and DeSoto, "Goodness of Figure," Axelrod, "Psycho-Algebra."

[95] Henley, Horsfall and DeSoto, "Goodness of 'Figure"; Clinton DeSoto and Frank Albrecht, "Conceptual Good Figures," in *Theories of Cognitive Consistency,* Abelson et al., pp. 504–511; and Clinton DeSoto and Frank Albrecht, "Cognition and Social Orderings," in *Theories of Cognitive Consistency,* Abelson et al., pp. 531–538; Jean Pierre Poitou and David Van Kreveld, "Is There a Position Bias in Learning of Influence Structures?" *European Journal of Social Psychology,* 2, No. 1 (1972), 75–85. For a related schema called proximity, see Edmund R. Peay, "Extensions of Clusterability to Quantitative Data with an Application to the Cognition of Political Attitudes" (Ph.D. diss., University of Michigan, 1970).

[96] Clinton B. DeSoto and John J. Bosley, "The Cognitive Structure of a Social Structure," *Journal of Abnormal and Social Psychology,* 64 (April, 1962), 303–307; DeSoto and Albrecht. "Conceptual Good Figure," and DeSoto and Albrecht, "Cognition and Social Orderings."

[97] C. Norman Alexander, Jr., and Joyce Epstein,

b. Subjects accept verbal generalizations even when they know of exceptions to them.[98]

B. Unanswered Questions

Among the questions which need to be answered in order to construct a more precise theory of schemata are the following:

1. How does one set the threshold for the level of goodness of fit which is regarded as providing a satisfactory interpretation of a case by a given schema? (See V, C, 1 below on the role of personality and VI, B below on the role of the reliability of the initial information.)

2. If an old interpretation of a case is canceled, is the old schema made less accessible?

3. When an old interpretation does not fit new information, is the blame ever divided between the two (see II, B, 4 above)?

4. Can goodness of fit be treated as a metric (distance function) on the abstract space of specifications of cases (see VI, B below), and if so what are the characteristics of this metric?

5. When and how does a person invent an entirely new schema?

C. Psychological Implications

Some psychological results which might be dealt with by an expanded version of the present model are the following:

1. Personality variables. Individual differences in cognitive complexity,[99] authoritarianism,[100] intolerance for ambiguity[101] and autism/realism[102] might be due to different thresholds of minimum goodness of fit. For example, authoritarians are likely to resist mildly derogatory information about a respected partner,[103] thereby maintaining an accessible interpretation at the cost of a good fit.

2. Cognitive dissonance. Dissonance effects

include the result that when a boring task is voluntarily chosen by a subject, the less the reward, the more the task is valued. This type of result might be attributable to the accessibility of a schema incorporating the consistency of self-behavior.[104]

3. Wishful thinking. The correlation of one's expectations with one's desires[105] might reflect an accurate generalization of past experience even when it seems inappropriate in an artificial setting.

VI. Applications in Normative Analysis

An information-processing model can be very helpful for suggesting new questions for further research as well as for integrating a variety of findings from experimental and social psychology. But from the viewpoint of political science, perhaps the greatest benefit from this type of model will come from its ability to provide a framework for the analysis of actual behavior in important arenas of human action. If we are able to identify the characteristics of optimal performance and if we are able to compare actual performance to optimal performance, then we can both improve our understanding of people's actual performance and perhaps offer some helpful advice to those who wish to improve their own performance.

The process of selecting a schema with which to interpret a case offers two opportunities for this type of analysis. The selection process within the model is a satisficing procedure which does not necessarily yield the best possible fit between the selected schema and the information available about the current case—nor should it necessarily, as will be shown. In addition to the information about the current case, the best use of the satisficing procedure requires at least two types of parameters. These are (1) the relative accessibilities of alternative schemata and (2) the magnitude of what constitutes a satisfactory fit. Analyzing how these two parameters should be set will help to identify the characteristics of optimal performance.

A. Optimal Accessibilities of Schemata

A particularly illuminating question for normative analysis using schema theory is how to

"Problems of Dispositional Inference in Person Perception Research," Sociometry, 32 (December, 1969), 381–395.

[98] Robert P. Abelson and David E. Kanouse, "Subjective Acceptance of Verbal Generalization," in Cognitive Consistency, ed. Shel Feldman (New York: Academic Press, 1966), pp. 171–197.

[99] James Bieri and Edward Blacker, "The Generality of Cognitive Complexity in the Perception of People and Inkblots," Journal of Abnormal and Social Psychology, 53 (July, 1956), 112–117.

[100] Brown, Social Psychology.

[101] Else Frenkel-Brunswik, "Intolerance of Ambiguity as an Emotional and Perceptual Personality Variable," Journal of Personality, 18 (September, 1949), 103–143.

[102] Theodore M. Newcomb, "Stabilities Underlying Changes in Interpersonal Attraction," Journal of Abnormal and Social Psychology, 66 (April, 1963), 376–386, esp. p. 385.

[103] Ivan D. Steiner and Homer H. Johnson, "Authoritarianism and 'Tolerance of Trait Inconsistency'," Journal of Abnormal and Social Psychology, 67 (October 1963), 388–391.

[104] Leon Festinger, A Theory of Cognitive Dissonance (Stanford: Stanford University Press, 1957); Jack W. Brehm and A. R. Cohen, Explorations in Cognitive Dissonance (New York: Wiley, 1962); and Zajonc, "Cognitive Theories in Social Psychology."

[105] Hadley Cantril, "The Prediction of Social Events," Journal of Abnormal and Social Psychology, 33 (1938), 364–389; D. McGreor, "The Major Determinants of the Prediction of Social Events," Journal of Abnormal and Social Psychology, 33 (1938), 179–204; and McGuire, "Cognitive Consistency and Attitude Change."

assign relative accessibilities to a given set of schemata. In other words, given a set of schemata, which one should be tested first against new information of a specific type of case, which second, and so on. The answer involves the tradeoff between two competing values which are both desirable in an accessible schema. These two valued characteristics of a schema are veridicality and smallness of size.[106]

The *veridicality* of a schema is the subjective probability that a case of a specific type is in fact an instance of that schema. Obviously, the person wants to interpret new information as fitting a highly veridical schema since such an interpretation would make it likely (at least in the sense of subjective probability) that his modification and extension of the initial partial specification of the case would be accurate rather than erroneous.

The second value desired in an accessible schema is smallness of size. The *size* of a schema is the number of different complete specifications which are instances of the schema. For example, the size of the balance schema is given by the number of different ways of dividing a group of people into two groups (such as friends and enemies). The smaller the size of a schema, the more can be deduced about a case which is interpreted in terms of that schema.

The veridicality of a schema depends on the type of case (see II, D, 3), but the size of the schema is solely a function of the nature of the schema itself. A useful measure of the smallness of a schema is given by the information theory concept of redundancy.[107] For present

purposes it is sufficient to note that interpreting a case in terms of a small schema has the advantage of allowing a greater amount of modification and extension of the original partial specification of the case.

A numerical illustration will help make these ideas clear. Consider a set of binary relationships between five objects (such as friendship relationships between five people). Any complete specification of such a case can be represented as a 5 by 5 matrix with 1 and -1 entries (although for convenience a -1 will be shown as a blank in Figure 3 below). For example, the entry in the second row and fourth column could represent whether or not the second person likes the fourth person.

Using this representation, a schema can be defined as the set of all matrices which satisfy certain specified properties. The number of different complete specifications for a schema can then be counted to give the exact size of that schema. Examples of specifications which fit different schemata are shown in Figure 3. The order of the rows and columns has been chosen to best display the defining characteristics of the different schemata.

The null schema is the one which includes all possibilities. There are 5^2 or 25 entries in the matrix, so there are a total of 2^{25} or about one hundred million possible specifications of the null schema. One of these is shown in Figure 3a.

The balance (or 2-cluster) schema has a size of 16, since there are $2^5/2$ ways of putting 5 people into one of no more than two groups, when the order of the groups does not matter. An example is shown in Figure 3b.

Figure 3c displays one of the specifications of the 3-cluster schema. There are 41 ways of putting 5 people into one of no more than three groups $(41 = (3^5 - 3)/3! + 1)$.

The positive schema has only one specifica-

[106] For a formal model with a similar tradeoff, see Shun-ichi Amari, "Theory of Learning Decision Systems," in *Unifying Study of Basic Problems in Engineering and Physical Sciences by Means of Geometry*, ed. Kazoo Kondo (Division 1), (Tokyo: Gakujutsu Bunken Fukyu-kai, 1969), pp. 33–42 (which is RAAG Memoirs, 4, [1969], 567–576).

[107] With the assumption that each instance of a schema has equal subjective probability, size determines redundancy. The assumption is based on the principle that if some instances have a higher subjective probability than others, they should be treated by the model as belonging to different schemata. For applications of redundancy to psychology see Garner, *Uncertainty and Struc-*

ture; and Wendell R. Garner and David E. Clement, "Goodness of Pattern and Pattern Uncertainty," *Journal of Verbal Learning and Verbal Behavior*, 2 (December, 1963), 446–452. For a recent critical review see D. W. J. Corcoran, *Pattern Recognition* (Harmondsworth, England: Penguin Books, 1971).

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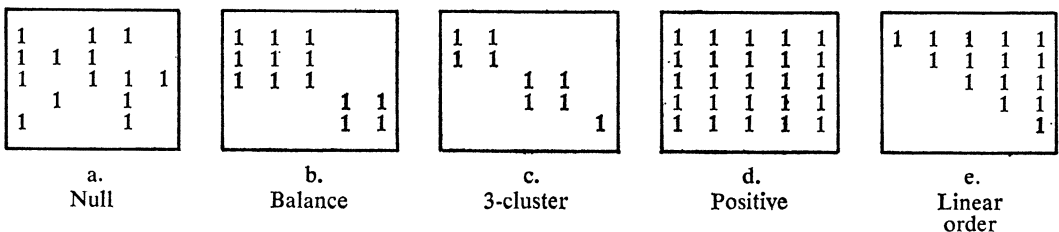</table>

Figure 3. Sample Specifications of Schemata of Relationships Between Five People.

tion (shown in Figure 3d), since there is only one way that everyone can like each other.

The schema of linear order has 5! or 120 specifications since there are that many ways of arranging 5 people in order without ties. Such a schema would be appropriate if the case were about relationships of height rather than friendship. Figure 3e illustrates this schema with the order of the rows and columns chosen to display best the pattern.[108]

The tradeoff between veridicality and smallness among schemata is illustrated in Figure 4 for a given type of case, namely friendship relationships. A highly accessible schema should be both veridical and small. The balance (or 2-cluster) schema is moderately small and has fairly good veridicality, since the person presumably knows that friendship groups do tend to be balanced.[109] The positive schema is very small indeed, but is not very veridical. The 3-cluster is assumed in this example to be more veridical than the postive schema and is certainly more veridical than the balance schema, but it is larger than either of them. The null schema is certain to be totally veridical, but it is no help in the modification and extension of a partial specification of a case, since it is so large as to include every possibility. The schema of linear order is of large size and is assumed to have low veridicality in this example since a linear order is asymmetric (if one individual has the relationship to a second, then the second can not have that relationship to the first), whereas actual liking relationships tend to be symmetric.

The dotted line of Figure 4 represents the frontier of knowledge about this type of case using these schemata. The growth of knowledge about a type of case could be reflected in the discovery of a schema which was above and to the right of this line and which thereby pushed out the frontier of knowledge.

Pushing out the frontier of knowledge may be one of the tasks of the social scientist, but the person who is actually trying to make sense out of a complex world is often more interested in just what he should do *today* when the frontier of knowledge is at a given place. The answer in terms of Figure 4 is that he should assign high accessibilities to schemata which are high and to the right in Figure 4, medium ac-

[108] For schemata of infinite size (e.g., with continuous rather than discrete parameters), the appropriate measure of size uses degrees of freedom. For example, a linear equation has two degrees of freedom (namely a and b in $y = ax + b$), and a quadratic equation has three degrees of freedom (namely a, b and c in $y = ax^2 + bx + c$).

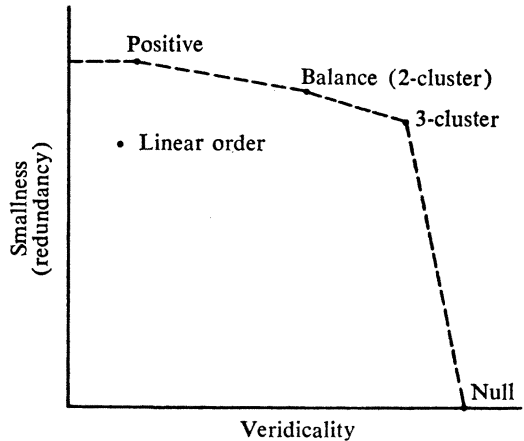[109] Kogan and Tagiuri, "Interpersonal Preference and Cognitive Organization."

Figure 4. Illustration of the Tradeoff Between Smallness and Veridicality of Different Schemata for Cases of Friendship Relationships.

cessibilities to schemata which are in the upper left or lower right, and low accessibilities to schemata in the lower left.[110]

B. *Optimal Threshold of an Acceptable Fit*

Setting the relative accessibilities of schemata determines the order in which they will be checked for their fit to the current case. Given this order of checking, one may ask what should constitute a satisfactory fit to bring a successful end to the satisficing checking process? In other words, what should be the threshold of how bad a schema's fit can be and still be acceptable as the interpretation of the present case?

To deal with this question a geometric analysis is helpful. To start with, a complete specification of a case can be represented as a single point in an abstract space, to be called a Q-space. In this space there is a distance function (or metric) which measures how similar two complete specifications are to each other. Thus if x and y are two points in the Q-space, then $d(x,y)$ is a real number indicating the degree to which these two complete specifications are similar or dissimilar to each other.[111]

[110] To carry the analysis further one could do the type of indifference curve analysis used in microeconomics. Negatively sloped indifference curves could be drawn in Figure 4 to represent the tradeoffs between smallness and veridicality. Then the schemata should be given accessibility in order of their intersection with the ordered set of indifference curves. If there are enough alternative schemata to allow for a continuous approximation of the frontier of knowledge, then the schema which should be given the highest accessibility is represented by the point at which one of the indifference curves is tangent to the frontier of knowledge.

[111] A metric function has the following properties:

The distance function can be applied to pairs of sets in Q by taking the minimum distance between members of the two sets. For example, let X be a partial specification of a case (i.e., a subset of Q consisting of all complete specifications which are consistent with the information in the partial specification), and let S be a schema (so that S is also a subset of Q by definition). Then define $d(X,S) = \min d(x,y)$ for x in X and y in S. Less formally, the distance between a partial specification and a schema is how close they come together.[112]

There are four immediate uses to which the distance function can be put. First, goodness of fit can be defined as the distance between an initial partial specification and a schema, namely $d(X,S)$. Second, a satisfactory fit can be defined by the condition that this distance is less than or equal to k for some fixed k. Third, the selected schema is the first schema such that $d(X,S_i)$ is less than or equal to k, where S_1 is the most accessible schema, S_2 is the second most accessible schema and so on. Fourth, the modification and extension of a partial specification is a set of points, X', defined in the following manner. X' is the set of all x' in the selected schema, S', such that $d(X,\{x'\}) = d(X,S')$. In other words, the modified and extended specification of a case is the set of all points in the selected schema which are at minimal distance from the initial partial specification. The idea is that the initial specification is altered as little as possible in order to make it fit the selected schema.

An abstract illustration of these ideas is provided by Figure 5. In this figure there are three schemata labeled in order of their accessibility, S_1, S_2 and S_3. There is also a partial specification of a case, X. Shown near the bottom is a scale of the distance, k, which is the maximum allowable for a satisfactory fit. (For convenience here, the metric in Figure 5 can be thought of as a normal Euclidean distance, but other metrics are certainly possible.)

Some of the key operations of the information-processing model can be illustrated with the help of this geometric example. The satisficing routine proceeds as follows. S_1 is not selected because all of its points are too far from any of the points in X. S_2 is selected as the interpretation of the case because some of the points in X are within a distance of k from some of the points in S_2. S_3 is never even checked by the satisficing subroutine and there-

$d(x,y) = d(y,x); d(x,y) \geq 0; d(x,y) = 0$ if and only if $x = y$, and $d(x,y) + d(y,z) \geq d(x,z)$.

[112] Although the distance between points is a metric function as defined in the previous footnote, the distance between sets is not.
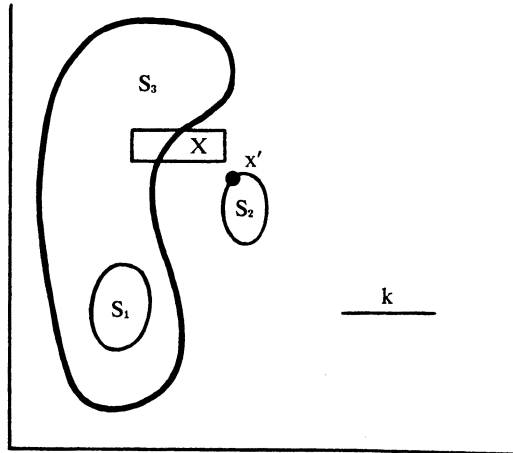

Figure 5. Illustration of the Q Space.

X is the initial partial specification of the case
S_1, S_2 and S_3 are schemata
k is the maximum distance of a satisfactory fit
x' is the final specification of the case using the selected schema, S_2

fore cannot be selected even though S_3 provides the best fit in this example. The specification routine proceeds by picking the points in the selected schema, S_2, which are closest to X. In this example, there is a unique such point, x', and thus the specification process results in a complete specification of the case as well as an interpretation of the case as belonging to the S_2 schema.

The familiar case type of friendship relationships helps demonstrate some of the properties a Q-space can have. For simplicity consider a set of friendship relationships among three people which take on one of only two values (i.e., like and dislike). Assume for a moment that the relationships are reflexive (everyone likes himself) and symmetric (everyone's feelings are reciprocated). Then the Q-space is three-dimensional, with the dimensions representing the three relationships between A and B, B and C, and A and C. This space has exactly 2^3 or 8 points. The schema of balance is a set of exactly four points in this space, namely $(1,1,1)$, $(1,-1,-1)$, $(-1,-1,1)$ and $(-1,1,-1)$.

This particular type of Q-space can be applied to the line hypothesis of Abelson and Rosenberg, which forms the basis of what is known as the theory of cognitive balance.[113] Their line hypothesis can be regarded as simply a special case of the specification routine of the present model for the situation in which the selected schema is balance and the distance func-

[113] Abelson and Rosenberg, "Symbolic Psycho-logic."

tion is the so-called city block metric (in which the distance between two points is the arithmetic sum of the separate distances separating them on each dimension of the Q-space).

As another example, suppose that the relationships are still reflexive and symmetric but are now continuous (to allow degrees of liking and disliking). The Q-space is still three-dimensional, but now has an infinite number of points. The schema of balance is now the set of points of the pyramid that has for its four corners the four balanced points listed above.[114]

With this geometric background, it is easy to see the implication of changing the size of the maximum distance of a satisfactory fit, k. The smaller the maximum distance for a satisfactory fit, the greater the chance that the more accessible schemata will be rejected and a less accessible (or no) schema will be selected.

In a domain which has precise measurement (such as one of the natural sciences), it is best to set k relatively low. The reason is that if a highly accessible schema gives a mediocre fit in such a situation, it is best to keep searching for a better fit since it is unlikely that random error alone would be responsible for the discrepancy.[115]

Conversely, in a domain which has imprecise information (such as is common in politics) it is best to set k relatively high so that an accessible schema is not rejected when the observed discrepancy could easily have been due to random error.[116]

[114] Wiest, "A Quantitative Extension."

[115] Signal detectability theory treats the situation in which there is only one accessible schema. See Coombs, Dawes, and Tversky, *Mathematical Psychology*.

[116] Geometric analysis of this section can be extended to yield a number of suggestive theorems about some of the more subtle consequences of the present information processing model. Here are four such results.

(1) *Potential Completeness.* If Q is a continuous space, then under a weak set of assumptions the modified and extended specification of a case will be a complete specification of the case. This corresponds to the situation in which the person can make an estimate about every feature of the case (e.g., every friendship relationship). For example, in Figure 5 the set of points in S_2 which are minimally distant from X is a single point, x', and is therefore a complete specification.

(2) *Potential Enlargement.* Under certain circumstances the modified and extended specification can actually be larger than the initial partial specification. This occurs when there are few points in the partial specification, but more points in the selected schema which are at the minimum distance from the initial partial specification than there were in the initial partial specification itself. In such a situation the person has a schema which he can use to interpret the case, but he does not end up with a single unique specification of the case (even if he started with one). He believes something is wrong with the initial information, but he can not pin down what it is, even though he has selected a schema with which to interpret the case.

VII. Illustrative Applications to Politics

Now for a few illustrations to show that the model of how people make sense out of their complex worlds can be directly relevant to political phenomena. These examples are illustrative only, since the range of the potential political applications seems almost to coincide with the range of political science. Because my own interests are primarily in international relations and foreign policy formation, most of the examples are taken from that domain. The reader is invited to see if his favorite political actors try to make sense out of their own complex worlds, and if so whether it makes any difference how they try to do it, and how they might do it better.

Before turning to the illustrations, several points should be made about the operationalization of the schema theory. As a model of what happens in a controlled setting, the schema theory has already been operationalized by the same operations which have been used in the various experiments upon which the theory is based. For example, all of the standard ways of eliciting a subject's beliefs can be used to measure the details of the person's modified and extended specification of a case. As a model of what happens in a political arena, somewhat different measurement techniques are needed. For example, the problems of measuring the beliefs of a political actor are certainly difficult, but hardly unique to this model. Once again, there are a set of standard techniques which can be used to measure beliefs, this time involving the analysis of interviews, questionnaires, documents produced by the actor, and the actor's actual decisions. For the parameters of the model which are not "directly observable," the system level characteristics of the model itself provide alternative indicators that can be used as cross-validating measurement

(3) *Cancellation Effect.* Under a wide range of conditions, an initial partial specification with continuous parameters will be modified to achieve a fit to the selected schema by leaving most of the parameters unchanged and by giving the rest neutral values. This can be called the cancellation effect since the only changes in the modification are neutralizations. The cancellation effect is a consequence of the principle that the modification is made in such a way as to move the least distance to the selected schema.

(4) *Seriatim Effect.* Under a wide range of circumstances, the sequential presentation of the same information can reduce the amount of attitude change compared to a simultaneous presentation. The seriatim effect is due to the principle that a message is first evaluated for how well it fits into a previous interpretation of the case. Presenting discrepant information a little at a time can result in each message being blamed as it is received, whereas if the discrepant information were presented all at once, the blame might be affixed to the old interpretation.

techniques. A good example of the potential for cross-validation is schema accessibility which can be indirectly measured with any of four methods (see III, E).

While waiting for independent evaluations of the model in different political arenas, one can hopefully expect that the literature on perception (and perhaps cognition) will generalize quite well to field studies. People may bargain and exercise power differently in a laboratory than they do in a "real life" situation, but they probably use the same thought processes no matter where they are. This is another way of saying that perception and cognition may be more fundamental psychological processes than bargaining and the exercise of power. Because they may be more fundamental, they probably generalize better from one context to another. But even before the schema theory is empirically evaluated in political contexts, it can serve well heuristically by suggesting new ways of looking at some old political problems. In this spirit the illustrative examples are offered.

A. Conceptual "Models" of One's Adversaries

The first example is a direct application of the normative analysis of schema accessibilities (VI, A). As Allison points out, most foreign policy analysts explain and predict the behavior of national governments in terms of a rational policy "model."[117] He also points out that more sophisticated "models," such as an organizational process "model" and a bureaucratic bargaining "model," can be formulated.

If these alternative "models" are treated as schemata which include some possibilities and exclude others, then the present information-processing model can be applied. In particular, the question of which schema should be given highest accessibility can be analyzed. As has been discussed in Part VI, A, there is a tradeoff between improved veridicality of a schema and smallness of size. The improvement of the conditions of the tradeoff comes from improved knowledge of the environment (e.g., by discovering a schema which is both small and veridical, a process that is similar to discovering a theory which is both parsimonious and accurate).

In the meantime (at any given level of knowledge about the environment) the conditions of the tradeoff have this implication: it may be better for the analyst to give higher accessibility to a small but "simple minded" schema (such as one based on the rational pol-

icy "model") rather than to a more sophisticated but larger schema.

B. Individual Belief Systems

The second example deals with individual belief systems. Like all political actors, a foreign policy maker has his own characteristic belief system which helps shape his perceptions and therefore his decisions. His belief systems can be studied through an analysis of speeches, documents, and interviews. For example, John Foster Dulles followed his usual mode of analysis when he interpreted a large cut in the size of the Russian Army as being due to Russian economic weakness, as possibly leading to an increased production of atomic weapons, and as not lessening world tensions.[118] Thus even a large cut in the Russian Army did not disconfirm Dulles's interpretation of Soviet policy.

Perhaps this is no more than an unusually blatant example of a rather common problem. I conjecture that the schemata people use are often larger than they think, and therefore less easy to disconfirm. When they are actually larger than they think, people are more confident in their own interpretations of past cases and in their prediction of future events than they have a right to be.

C. Learning Lessons from History

People often interpret a current case as being analogous to a previous case which was in some ways similar. For example, President Johnson argued that the policy problem of Vietnam was similar to the policy problem of Munich. Historical analogies seem to be drawn by selecting the single previous case which provides the satisficing fit to the present case. This process is therefore a special case of the present model.

The more important to the person a previous case was, the more accessible it will be as an analogy for a future case.[119] Thus "Munich" is a highly accessible analogy, since it is associated with the origins of World War II. This dependence of the accessibility of a prior case on its importance is helpful to the decision maker if (but only if) there is actually a correlation between the importance of a case and the likelihood that it will be a useful guide to future decisions.

D. The Intelligence Game

The intelligence/deception interaction is one of the most fascinating aspects of international

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[117] Graham T. Allison, "Conceptual Models and the Cuban Missile Crisis," *American Political Science Review*, 63 (September, 1969), 689–718.

[118] Ole R. Holsti, "The Belief System and National Images: A Case Study," *Journal of Conflict Resolution*, 6 (September, 1962), 244–252.
[119] Axelrod, *Framework for a General Theory of Cognition and Choice*.

relations. In terms of the model of how people make sense out of a complex world, three factors make it relatively easy for an intelligent actor (A) to be deceived by another intelligent actor (B) about B's future decisions. First, knowledge and information about the internal decision-making process of B is not well-known to A, and therefore no schema can be both small and veridical. Thus extensions of specifications are not likely to be reliable. Second, actor B can deliberately behave so as to make predictions even harder for A. For example, he can build up a record of consistent behavior and then break the pattern at a crucial moment (which is exactly what the British did to the Germans in the D-Day deception by building up the reliability of double agents under British control.) [120] Third, if actor B knows about the relative accessibility of A's schemata, and if B knows about the type of information available to A on each case, then B can adjust his behavior to increase the likelihood that his behavior will be interpreted by A as fitting a particular schema.

Actor A in trying to predict a future decision by actor B can adopt special tactics to deal with these problems. He can try to avoid being deceived by relying on information which B does not control or which is costly for B to manipulate. Which information has these characteristics, however, is also a matter for A's interpretation, and is therefore subject to the countermeasures by B discussed above. For example, in World War II the Germans trusted the spies they sent to Britain when in fact the British soon controlled every one of them.[121]

E. *The Slow Growth of Knowledge in the Policy Sciences*

In a policy domain each interpretation and decision is important to the actors involved. Be-

cause of this, the application of a policy science may develop a set of doctrines. In some cases, such as medicine in traditional societies, these doctrines provide a widely accepted interpretation (diagnosis) and decision in each possible type of case.[122] Such a set of doctrines has three functions. It guarantees that each and every case will get the best interpretation and decision given the current state of the shared knowledge. It promotes confidence on the part of the practitioner and trust on the part of the client, and this confidence and trust can be important in securing results in a policy domain. Finally, the set of doctrines protects the practitioner from charges that he has made a mistake if a particular decision turns out badly.

On the other hand, if the set of doctrines is followed in *every* instance there will be no experimentation and therefore little gathering of information on cases which might disconfirm current theories. For example, in a disease which often has spontaneous remission (such as peptic ulcer), false beliefs about cures can easily arise and be maintained. This is like the dog (mentioned in III, C, 1, a above) who got so good at jumping to avoid a shock that he could not discover when the shock mechanism was turned off.[123]

An exclusive focus on getting the best outcome in each case can therefore retard the growth of discovery of smaller, more veridical schemata. By retarding the growth of knowledge, an exclusive focus on getting the best result in each case can prove a poor tactic in the long run. Therefore, practitioners of policy sciences (such as international relations) should value deliberate experimentation in suitable circumstances. Their clients (such as electorates in democracies) should be willing to tolerate a lower average success in the short run in order to attain a higher level in the long run.

[120] J. C. Masterman, *The Double-Cross System in the War of 1939 to 1945* (New Haven and London: Yale University Press, 1972).

[121] Masterman, *The Double-Cross System.*

[122] Joseph Ben-David, *The Scientist's Role in Society* (Englewood Cliffs, New Jersey: Prentice-Hall, 1971), pp. 25f.

[123] Solomon, Kamin and Wynne, "Traumatic Avoidance Learning."