CHAPTER ONE

Communication and Organization—an Essay

> *And the Lord said, "Behold the people is one, and they have all one language; and this they begin to do: and now nothing will be restrained from them, which they have imagined to do. Go to, let us go down and there confound their language, that they may not understand one another's speech." So the Lord scattered them abroad from thence upon the face of all the earth: and they left off to build the city. Therefore is the name of it called Babel . . . .*
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> *Genesis*, Ch. 11.

Leibnitz, it has sometime been said, was the last man to know everything. Though this is most certainly a gross exaggeration, it is an epigram with considerable point. For it is true that up to the last years of the eighteenth century our greatest mentors were able not only to compass the whole science of their day, perhaps together with mastery of several languages, but to absorb a broad culture as well. But as the fruits of scientific labor have increasingly been applied to our material betterment, fields of specialized interest have come to be cultivated and the activities of an ever-increasing body of scientific workers have diverged. Today we are most of us content to carry out an intense cultivation of our own little scientific gardens (to continue the metaphor), deriving occasional pleasure from a chat with our neighbors over the fence, while with them we discuss, criticize, and exhibit our produce.

Too many of us today are scientifically lonely; we tire of talking continually to ourselves, and seek companionship. We attend Symposia and Congresses, perhaps too many! From time to time since the growth of specialization, broad movements have arisen in reaction to this trend, seeking unity and attempting integration. Some have lived and prospered; others were stillborn.

There are signs of such a movement today; an awareness of a certain unity of a group of studies is growing, originally diverse and disconnected, but all related to our *communicative* activities. The movement is rapidly becoming "popular," so great is the desire for unification, and this popularity carries with it a certain danger. By all means let us encourage any tendency toward unity, any attempts to make common ground, but we must continually be critical. The concept of "communication" certainly arises in a number of disciplines; in sociology, linguistics, psychology, economics; in physiology of the nervous system, in the theory of signs, in communication engineering. Awareness of the universal nature of "communication" has existed for a very long time, in a somewhat vague and empirical way, but recently the mathematical developments which come under the heading of the "Theory of Communication" have brought matters to a head, and many there are who regard this work as a panacea. True, it has very considerable relevance to these different disciplines, which we shall try to explain in these pages; but it is not a cure-all. Perhaps, since we shall be discussing this relevance, we had better state a point of view right at the start, and write it in italics: *At the time of writing, the various aspects of communication, as they are studied under the different disciplines, by no means form a unified study; there is a certain common ground which shows promise of fertility, nothing more.* In this little book, as our subtitle claims, we shall attempt a review, a survey, and a criticism of the study as it is being developed. The level will necessarily be elementary. There is a wide sea of literature which we shall try to chart for the novice, and there are a few classic islands where we shall land and explore in some detail. And in this little ship, our book, we shall be taking no experts amongst the passengers. It is a cruise for novices only, but they will be introduced to the professional crew.

1. THE SCHEME OF THIS BOOK

It should be emphasized at the outset that this book is in no sense an exposition of the mathematical theory of communication, though we shall be making some reference to this subject, and Chapter 5 attempts a survey of its principal concepts and theorems. This book is intended to take its place as one of a series of texts on communication, to be prepared by

different authors, the others of the series being more specific and detailed studies.* This one is introductory—no more.

The various chapters are written, so far as possible, as self-contained essays, and the chapter headings should give some guide. None of the chapters is written for the experts. Thus, linguists are asked to be lenient in reading Chapter 3, and psychologists may regard Chapter 7 as superficial to the extreme. Again, if any mathematicians or logicians come to Chapters 5 and 6—pass on, they are not for you! No; the book is written for that curious person, the "general reader." But you experts, if you read my little volume, please do comment, criticize, and correct. For that is the only way to progress.

One of the great difficulties of discussing a subject that lies in the borderland of a number of well-established fields of study is the choice of language and definitions. It may be true that concepts can be validly relevant in different fields, yet their expression in forms acceptable to students in these various specialities may not prove easy. In each field there may already be sets of definitions, and students may be loth to change, modify, or extend their customary definitions, framed for their specific purposes, to suit the interest of others. But a certain compromise is necessary if we are to find a common language of discussion; so in the Appendix a list of terms is given, together with explanations which in some cases may be dignified by the name of definition. This, it is hoped, forms a self-consistent terminology, and though the definitions given have no official backing, some have a degree of common usage among students of communication theory. The various chapters do not pretend to be expositions or even summaries (with the doubtful exception of Chapter 5) of different sciences—linguistics, phonetics, communication theory, semantics, psychology. Had this been the intention, the author would have been guilty of supreme conceit. Rather we are seeking to extract from these various sciences the common related concepts and ideas concerning communication, in such a way as to show the historical development and growth of this subject. At the same time we hope to stress in particular some of those snares and pitfalls which, though well known to the specialist, catch the unwary who chance to stray in from other fields.

2. WHAT IS "COMMUNICATION"?

Communication is essentially a social affair. Man has evolved a host of different systems of communication which render his social life possible—social life not in the sense of living in packs for hunting or for making war,

* For a complete list of the Series "Studies in Communication," published by The M.I.T. Press, see page facing title page.

but in a sense unknown to animals. Most prominent among all these systems of communication is, of course, human speech and language. Human language is not to be equated with the sign systems of animals, for man is not restricted to calling his young, or suggesting mating, or shouting cries of danger; he can with his remarkable faculties of speech give utterance to almost any thought. Like animals, we too have our inborn instinctive cries of alarm, pain, et cetera: we say *Oh!*, *Ah!*; we have smiles, groans, and tears; we blush, shiver, yawn, and frown.* A hen can set her chicks scurrying up to her, by clucking—communication established by a releaser mechanism—*but human language is vastly more than a complicated system of clucking.*

The development of language reflects back upon thought; for with language thoughts may become organized, new thoughts evolved.[465] Self-awareness and the sense of social responsibility have arisen as a result of organized thoughts. Systems of ethics and law have been built up. Man has become self-conscious, responsible, a *changeable* creature.

Inasmuch as the words we use disclose the true nature of things, as truth is to each one of us, the various words relating to personal communication are most revealing.† The very word "communicate" means "share," and inasmuch as you and I are communicating at this moment, we are one. Not so much a union as a unity. Inasmuch as we agree, we say that we *are of one mind*, or, again, that we understand *one another.* This one another is the unity. A group of people, a society, a culture, I would define as "people in communication." They may be thought of as "sharing rules" of language, custom, of habit; but who wrote these rules? These have evolved out of those people themselves—rules of conformity. Inasmuch as that conformity is the greater or the less, so is the unity. The degree of communication, the sharing, the conformity, is a measure of one-mindedness. After all, what we share, we can not each have as our own possession, and no single person in this world has ever been born and bred in utter isolation. "No man is an island, entire of itself."‡

Speech and writing are by no means our only systems of communication. Social intercourse is greatly strengthened by habits of gesture—little movements of the hands and face. With nods, smiles, frowns, handshakes, kisses, fist shakes, and other gestures we can convey most subtle understanding.§ We also have economic systems for trafficking not in ideas but in material goods and services; the tokens of communication are coins,

* But such reflexes do not form part of true human language; like the cries of animals they cannot be said to be *right* or *wrong* though, as signs, they can be interpreted by our fellows into the emotions they express. Chapter 8, Section 5 continues this discussion.

† See Sec. 6.1 for further comments.

‡ John Donne, the Sixteenth Devotion.

§ See reference 399 (Reusch and Kees) for many illustrations and examples of pictures, icons, motifs, gestures, manners, etc.

bonds, letters of credit, and so on. We have conventions of dress, rules of the road, social formalities, and good manners; we have rules of membership and function in businesses, institutions, and families. But life in the modern world is coming to depend more and more upon "technical" means of communication, telephone and telegraph, radio and printing. Without such technical aids the modern city-state could not exist one week, for it is only by means of them that trade and business can proceed; that goods and services can be distributed where needed; that railways can run on a schedule; that law and order are maintained; that education is possible. Communication renders true social life practicable, for communication means organization. Communications have enabled the social unit to grow, from the village to the town, to the modern city-state, until today we see organized systems of mutual dependence grown to cover whole hemispheres.[230.]* Communication engineers have altered the size and shape of the world.

The development of human language was a tremendous step in evolution; its power for organizing thoughts, and the resulting growth of social organizations of all kinds, has given man, wars or no wars, street accidents or no street accidents, vastly increased potential for survival.

As a start, let us now take a few of the concepts and notions to do with communication, and discuss them briefly, not in any formal scientific sense, but in the language of the market place. A few dictionary definitions may serve as a starting point for our discursive approach here; later we shall see that such definitions are not at variance with those more restricted definitions used in scientific analysis (Appendix). The following have been drawn from the *Concise Oxford English Dictionary*:†

Communication, n. Act of imparting (esp. news); information given; intercourse; . . . (Military, Pl.) connexion between base and front.

Message, n. Oral or written communication sent by one person to another.

Information, n. Informing, telling; thing told, knowledge, items of knowledge, news, (on, about); . . . .

Signal, n., v.t. & i. Preconcerted or intelligible sign conveying information . . . at a distance. . . .

Intelligence, n. . . . understanding, sagacity . . . information, news.

News, n. pl. Tidings, new information. . . .

Knowledge, n. . . . familiarity gained by experience, person's range of information. . . .

Belief, n. Trust or confidence (*in*); . . . acceptance as true or existing (of any fact, statement, etc.; . . .). . . .

Organism, n. Organised body with connected interdependent parts sharing common life, . . .; whole with interdependent parts compared to living being.

System, n. Complex whole, set of connected things or parts, organised body of material or immaterial things . . .; method, organisation, considered principles of procedure, (principle of) classification; . . . .

* These numbers refer to the references at the end of the book.

† With kind permission of the Clarendon Press, Oxford.

Such dictionary definitions are the "common usages" of words; scientific usage frequently needs to be more restricted but should not violate common sense—an accusation often mistakenly leveled against scientific words by the layman.

The most frequent use of the words listed above is in connection with *human* communication, as the dictionary suggests. The word "communication" calls to mind most readily the sending or receipt of a letter, or a conversation between two friends; some may think of newspapers issued daily from a central office to thousands of subscribers, or of radio broadcasting; others may think of telephones, linking one speaker and one listener. There are systems too which come to mind only to specialists; for instance, ornithologists and entomologists may think of flocking and swarming, or of the incredible precision with which flight maneuvers are made by certain birds, or the homing of pigeons—problems which have been extensively studied, yet are still so imperfectly understood. Again, physiologists may consider the communicative function of the nervous system, co-ordinating the actions of all the parts of an integrated animal. At the other end of the scale, the anthropologist and sociologist are greatly interested in the communication within large groups of people, societies and races, by virtue of their cultures, their economic and religious systems, their laws, languages, and ethical codes. Examples of "communication systems" are endless and varied.

When "members" or "elements" are in communication with one another, they are associating, co-operating, forming an "organization," or sometimes an "organism." Communication is a social function. That old cliché, "a whole is more than the sum of the parts," expresses a truth; the whole, the organization or organism, possesses a structure which is describable as a set of *rules*, and this structure, the rules, may remain unchanged as the individual members or elements are changed. By the possession of this structure the whole organization may be better adapted or better fitted for some goal-seeking activity. Communication means a *sharing* of elements of behavior, or modes of life, by the existence of sets of rules of sign usage.

It should be emphasized at this point that we shall make no attempt in this book to unify the host of different systems of communication which we see around us, and a few of which we have just instanced. We shall be discussing certain common aspects, nothing more. At the same time we hope to convince the reader of the extremely complex and difficult nature of certain concepts, which superficially seem so easy. And, in particular, we shall make reference to the mathematical theory of communication, but with no intention of applying this as a "unifying" theory. It has a right and proper place in the study of communication, which its originators

thoroughly understood, and attempts to extend it outside the technical field in which it first arose will be fraught with pitfalls. Application of this theory to biological systems has scarcely begun, though some preliminary ground clearing has been done.

Perhaps we may be permitted to comment upon a definition of communication, as given by a leading psychologist:[313] "*Communication is the discriminatory response of an organism to a stimulus.*"* The same writer emphasizes that a definition broad enough to embrace all that the word "communication" means to different people may risk finding itself dissipated in generalities. We would agree; such definitions or descriptions serve as little more than foci for discussion. But there are two points we wish to make concerning this psychologist's definition. First, as we shall view it in our present context, communication is not the response itself but is essentially the *relationship* set up by the transmission of stimuli and the evocation of responses. Second, it will be well to expand somewhat upon the notion of a stimulus; we shall need to distinguish between human language and the communicative signs of animals, between languages, codes, and logical sign systems, at least.

The study of the signs used in communication, and of the rules operating upon them and upon their users, forms the core of the study of communication. There is no communication without a system of signs—but there are many kinds of "signs." Let us refer again to the *Oxford English Dictionary*:

> *Sign*, n. . . . written mark conventionally used for word or phrase, symbol, thing used as representation of something . . . presumptive evidence or indication or suggestion or symptom *of* or *that*, distinctive mark, token, guarantee, password . . . portent . . .; natural or conventional motion or gesture used instead of words to convey information. . . .
>
> *Language*, n. A vocabulary and way of using it. . . .
>
> *Code*, n., and v.t. Systematic collection of statutes, body of laws so arranged as to avoid inconsistency and overlapping; . . . set of rules on any subject; prevalent morality of a society or class . . .; system of mil. or nav. signals. . . .
>
> *Symbol*, n. . . . Thing regarded by general consent as naturally typifying or representing or recalling something by possession of analogous qualities or by association in fact or thought. . . .

In this book we shall use the word *sign* for any physical event used in communication—human, animal, or machine—avoiding the term *symbol*, which is best reserved for the Crown, the Cross, Uncle Sam, the olive branch, the Devil, Father Time, and others "naturally typifying or representing or recalling . . . by association in fact or thought," religious and cultural symbols interpretable only in specified historical contexts. The term *language* will be used in the sense of human language, "a

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vocabulary [of signs] and way of using it"; as a set of signs and rules such as we use in everyday speech and conversation, in a highly flexible and mostly illogical way. On the other hand, we shall refer to the strictly formalized systems of signs and rules, such as those of mathematics and logic, as *language systems* or *sign systems*.

The term *code* has a strictly technical usage which we shall adopt here. Messages can be coded *after* they are already expressed by means of signs (e.g., letters of the English alphabet); then a code is an agreed transformation, usually one to one and reversible, by which messages may be converted from one set of signs to another. Morse code, semaphore, and the deaf-and-dumb code represent typical examples. In our terminology then, we distinguish sharply between *language*, which is developed organically over long periods of time, and *codes*, which are invented for some specific purpose and follow explicit rules that have been *invented*.

Apart from our natural languages (English, French, Italian, etc.), we have many examples of *systems* of signs and rules, which are mostly of a very inflexible kind. A pack of playing cards represents a set of signs, and the rules of the game ensure communication and patterned behavior among the players. Every motorist in Britain is given a book of rules of the road called the *Highway Code*, and adherence to these signs and rules is supposed to produce concerted, patterned behavior on British roads. There are endless examples of such simple sign systems. A society has a structure, definite sets of relationships between individuals, which is not formless and haphazard but organized. Hierarchies may exist and be recognized, in a family, a business, an institution, a factory, or an army—functional relationships which decide to a great extent the patterned flow of communication. The communication and the structure are subject to sets of rules, rules of conduct, authoritarian dictates, systems of law; and the structures may be highly complex and varied in form. A "code" of ethics is more like a language, having developed organically; it is a set of guiding rules concerning "ought-situations," generally accepted, whereby people in a society associate together and have social coherence. Such codes are different in the various societies of the world, though there is an overlap of varying degrees. When the overlap is small a gulf of misunderstanding may open up. Across such a gulf communication may fail; if it does, offence is caused and the organization breaks down.

The whole broad study of language and sign systems has been called, by Charles Morris, the theory of signs,[243,244] and owes much to the earlier philosophy of Charles Peirce.* Morris distinguishes three types of rule

* Locke used the word "semeiotic" to denote the "doctrine of signs." See reference 207. For an appreciation and survey of Peirce's relevant work in digestible form, see reference 129. For his collected works see reference 258. See also references 447 and 466.

operating upon signs, (*a*) *syntactic* rules (rules of syntax; relations between signs); (*b*) *semantic* rules (relations between signs and the things, actions, relationships, qualities—*designata*); (*c*) *pragmatic* rules (relations between signs and their users). We shall be making considerable reference later to the ideas of Peirce and Morris in Chapter 6.

3. WHAT IS IT THAT WE COMMUNICATE?

The dictionary definition of "communication," which was quoted before, includes the communication of goods and supplies. Certainly the transport of coal, oil, food, and people by the railways, or of parcels by the Post Office, or of raw materials from mine to factory, forms an essential social function; without such transport our society would collapse. But transport of goods is not communication in the sense we are adopting here, and does not raise the same subtle and difficult questions. What "goods" do we exchange when we send messages to one another?

Physically, we transmit signals or signs—audible, visual, tactual. They may be spoken or written words, or numbers, or pictures, or many other forms of physical expression that are said to be *meaningful* or *significant.* Again, we do not *send* signs; we *share* them, for if I tell you something, I have still got that something in my head. We now both have it—shared. Whereas goods are sent or exchanged, messages are always *shared.**

The theory of communication is partly concerned with the measurement of *information content* of signals, as their essential property in the establishment of communication links. But the information content of signals is not to be regarded as a commodity; it is more a property or potential of the signals, and as a concept it is closely related to the idea of selection, or discrimination. This mathematical theory first arose in telegraphy and telephony, being developed for the purpose of measuring the information content of telecommunication signals. It concerned only the signals themselves, as transmitted along wires, or broadcast through the aether, and is quite abstracted from all questions of "meaning." Nor does it concern the importance, the value, or truth to any particular person. As a theory, it lies at the syntactic level of sign theory and is abstracted from the semantic and pragmatic levels. We shall outline this theory of "selective" information in Chapter 5 and shall argue there and in Chapter 6 that, though the theory does not directly involve biological elements, it is nevertheless quite basic to the study of human communication —basic but insufficient.

It may be helpful if, in this introductory essay, we first approach our problem descriptively, if only to illuminate some of its great difficulties

* See final paragraph of this chapter, p. 30.

before we enter into scientific discussion and become concerned with *measurement.*

It is always important to distinguish between a physical property (attribute, quality) and a measure, unit, or magnitude of that property. When talking of measurement, any statements we make should be scientific statements, but we may discuss properties, attributes, and qualities in a variety of ways. For example, "color" may be considered artistically, poetically, even musically—but we could not discuss it so in ångstrom units. Again, it is possible to discuss "length" emotionally ("There's a long, long trail a-winding . . ."), though we should not refer to 1000 meters with emotion. So with many other physical concepts, including communication, signals, information. Human communication can be discussed in the language of aesthetics, or of philology or history, for example, as well as in that of physical science. For physical science is not the only system of thinking; it is one particular way.

A complete group, society, or organism, as a preliminary study, or hors d'oeuvre, is too indigestible. It is quite sufficient to take an elementary link, say two people in conversation, to illustrate some of the difficult questions. A conversation is one of the commonest phenomena we encounter, yet it is one which raises very great scientific problems, many still unsolved. It is so often our commonest experiences, which we take for granted, that are most elusive of explanation and description.

Suppose we take an example of two friends, George and Harry, conversing. George wants to instill some idea into Harry—say the idea of drinking a scotch and soda. What does he do? He might, for instance, show him a glass, or go through the motions of drinking; that is, he might imitate the desired situation as closely as possible. But conversations limited by such means would be very meager! He does nothing of the kind, of course, but makes the sounds of speech, which we can represent in writing by the sentence: "Come and have a scotch, Harry, I'm thirsty" —and off they go to the nearest pub.

The suggestion that words are symbols for things, actions, qualities, relationships, et cetera, is naive, a gross simplification. Words are slippery customers. The full meaning of a word does not appear until it is placed in its context, and the context may serve an extremely subtle function—as with puns, or *double entendre.* And even then the "meaning" will depend upon the listener, upon the speaker, upon their entire experience of the language, upon their knowledge of one another, and upon the whole situation. Words do not "mean things" in a one-to-one relation like a code. Words, too, are empirical signs, not copies or models of anything; truly, onomatopoeia and gestures frequently seem to possess resemblance, but this resemblance does not bear too close examination.[254] A cockerel

may seem to say *cook-a-doodle-do* to an Englishman, but a German thinks it says *kikeriki*, and a Japanese *kokke-kokkō*. Each can paint only with the phonetic sound of his own language.

Before George spoke, he had certain notions, ideas, or "desires" in his mind, a wish to set up some change in the situation. These ideas represented a selection from his whole range, constituting some message he desired to communicate, and this message he framed into the sounds of speech, as an *utterance*. The particular utterance he made depended largely upon his environment, and upon his previous experiences of communicating with Harry. He did not necessarily "think out" exactly what words to speak, and how to order them according to rules in a way calculated to achieve his desired ends. His utterance was a stream of speech which the entire situation evoked. How do our ideas, our desired messages, set up utterances in such an effective goal-seeking way, as they do in real life?*

A further difficulty comes from the fact that we cannot say that George spoke "words." He did not; he made a physical utterance, noises made with his vocal organs. If the same words are spoken by a number of different people, their physical characteristics will be different, for no two people speak exactly alike. George's utterance was peculiar to George and, furthermore, *peculiar and unique to that one occasion*. An utterance is an event; a word is a class or universal, and it is essential to distinguish between *word-events* or *word-tokens* (utterances) and *word-types* ("words" as they are listed in dictionaries, a linguistic concept). Linguists are not commonly concerned with the utterances of any *one* particular speaker, but rather with description of the general characteristics, attributes, or invariants of large groups—those things which are broadly in common. They classify and are continually dividing groups into subgroups, as they wish to make finer and finer comparisons. Thus George might be classed as "Southern English speaking," or more precisely "South London"; perhaps Professor Higgins in *Pygmalion* might have tied him down to one street!

The utterance which George made falls upon the ears of Harry and sets him into response. He might reply: "O.K. George, let's go"; and off they go. A goal has been achieved. Before his friend spoke, Harry may have formed a number of hypotheses concerning George's "desired message," and the receipt of the utterance has placed weight upon one in particular. The utterance acts as no more than "evidence" which is weighed, in the light of the whole environment and past experience of the

* In animal communication too, the signs (movements, displays, calls, etc.) made by one may stimulate the other into activity which serves as a respondent sign, so that a "goal-seeking" behavior results (e.g., leading to mating). See references 209, 324.

hearer, though we must not regard such "weighing of evidence" and "making of decisions" as necessarily involving Harry in any logical deductions. He does not hear the utterances, identify the words, piece them together according to rules of grammar and semantics, and then calculate the relative likelihood of his various hypotheses being true. Far from it. He hears the utterance and responds immediately by replying; he may do little conscious "thinking out" at all. But we can perhaps describe what he appears to do in such terms, *for it is important to distinguish between the phenomenon itself* (the conversation on which we are eavesdropping) *and a description of that phenomenon.* To clarify this distinction, we shall refer to the observed conversation as being in *object-language* and the observer's description as being expressed in *meta-language.*

This very rough account of "a conversation" may illustrate a few of the uncertainties which surround any communicative event. We have first the physical, acoustic uncertainties of accent and articulation; then we have language uncertainty, of grammatical construction; for the "desired message" could be framed into an utterance in many varied ways. For example:

(1) "I'm tired out Harry—let's go and have a drink."
(2) "I've got a thirst I wouldn't sell—let's find a couple of scotches."
(3) "What about a drink, Harry—I'm thirsty?"

. . . and so on, with infinite variations on a theme. George and Harry have had different past communicative experiences, and there exists an uncertainty of communication for that very reason. Their languages are not identical; their habits of speech and habits of response differ. Further, there is a great range of uncertainty of theme, for George might have been going to speak about anything—the weather, the cricket results, his lumbago, anything—and Harry's "initial hypotheses" might also have had a similar spread. But in practice this is not so, because his range of expectation will be determined to a major degree by the earlier conversation; there is a "thread of discourse," or line directed toward a goal. An utterance stimulates the hearer into response with another utterance, back and forth. And the whole of this proceeds amid what we may call "environmental uncertainties"—street noises, other people's chatter, dogs barking. It is remarkable that human communication works at all, for so much seems to be against it; yet it does. The fact that it does depends principally upon the vast store of habits which we each one of us possess, the imprints of all our past experiences. With this, we can hear snatches of speech, see vague gestures and grimaces, and from such thin shreds of evidence we are able to make a continual series of inferences, guesses, with extraordinary effectiveness.

Let us return to an earlier point and look again at the essential property of signals which forges and maintains a communication link. We referred earlier to the "information content" of signals, and to the way in which this is measured in statistical communication theory (about which more is to be said in Chapter 5). "Information content" is not a commodity but rather a potential of the signals. To take a rough analogy, it is rather like the economist's concept of "labor." Labor is not a commodity, not a stuff—yet it is bought and sold; we cannot see it, but only its results. Labor is not the particular men performing it (the signals in our analogy), though its quantity depends upon the men and their trades or skills. A labor force represents a potential to produce goods; by analogy, signals possess a potential to communicate, and the information communicated will depend upon the choice of signals in any particular channel of communication with relation to the receiver's expectancies.

To continue in this descriptive, non-mathematical way—you and I are forming a communication link at this moment. I have put my thoughts, or "desired messages," into carefully selected words and these are printed in the book you are holding. How could this link be broken?

Suppose I had packed this chapter full of lies; would you continue to read it? You most probably would, perhaps to see how many errors you could detect, or for many reasons. Again, this chapter might be stuffed with utter nonsense (and I trust it is not), yet you might continue reading, in the hope that it will improve later, or to see just how bad it does become. After all, some very fascinating nonsense verse has been written and is widely read. So neither truth nor common sense seems strictly essential to the link.

If you had been told, beforehand, that this book was "utterly devoid of meaning," you might decide not to read it; the link would be broken. But how can all meaning be destroyed? What is "absolute nonsense"? It is questionable whether it is possible to write "absolutely meaninglessly," *so long as any of the rules whatever of the language are retained*, rules shared by both writer and reader. We might invent words not in the dictionary and string them haphazardly into texts—yet each one will play upon our experiences and call up images of some kind or other. They cannot be entirely void.[15] Lewis Carroll's nonsense verse comes close to this, yet is delightful reading.

> 'Twas brillig and the slithy toves
> Did gyre and gimble in the wabe. . . .

No; in writing, and in speaking, we may break some of the rules some of the time, but we cannot break them all. And to destroy communication completely, there must be no rules in common between transmitter and receiver —neither of alphabet nor of syntax. If from this point on I had written

this book in Syriac, the chances are, dear reader, that you and I would part!

Even now, we are not quite out of the wood. For given time and patience you might be able to start deciphering, like a cryptographer; from assumptions about subject matter, and from your knowledge of other languages and cultures, you might make a series of prudent guesses and follow them up. Lost languages have been deciphered from the slightest of clues. You might, again, be attracted by the sheer beauty of calligraphy, and we might communicate aesthetically. Signs make a powerful social cement.

There is one particular way of weakening the bond, perhaps breaking it completely. Suppose that by a bookbinder's error all the pages of this book were identical, as a casual glance at the page numbers would tell you; then you might read the first page and no more. The book would form a cyclic or periodic signal, one cycle would communicate with you, the others you would know for *certain* beforehand. To set up communication, the signals must have at least some surprise value, some degree of unexpectedness, or it is a waste of time to transmit them.

Turning back to the list of dictionary definitions (page 5), perhaps the term "news" stands out, after our recent discussion. For news is "new information"; news suggests novelty. Can novelty be measured? Indeed it can, if the novelty of a signal is regarded as depending upon the relative number of times it has been received before, compared to all the possible alternatives. For this, the mathematical idea of probability as a *relative frequency* (or percentage) is applicable. The statistical theory of communication adopts this view, but with certain important restrictions, for it is not concerned with personal man-to-man conversations such as that between our George and Harry, but rather with the properties of telephones, telegraphs, and the like—with communication channels used by many people. The letters of the alphabet, or range of alternative signs (words, speech sounds, and so on), are initially specified and their relative frequencies assessed. It is not their probabilities as "appearing" to some one person that are considered, but their frequencies of use by a certain population, such as are observed in "newspaper English," "prose," "telephone speech," et cetera—the *average* or statistical properties of a *source*. And for this reason in particular, this mathematical work should be interpreted with the greatest care, in situations involving real people. In this mathematical sense, information is measured in terms of the *statistical rarity* of signs.*

* Of course, there are many examples of *value* assessments according to improbability, or rarity. Bernoulli assessed the value of money as proportional to the logarithm of the quantity you possess; Adam Smith observed that the "wages of labour in different employments vary according to the probability or improbability of success in them."

At our present descriptive level we may say that it is the most infrequent words, phrases, gestures, and other signs which arrest our attention; it is these that give strength to the links. The others we can predict very readily. The great majority of our everyday surroundings, the sights and sounds of home and street, we largely ignore from familiarity.

In Aesop's fable, the boy cried "Wolf!" too often.

4. SOME DIFFICULTIES OF DESCRIPTION OF HUMAN COMMUNICATION

In our introductory apologia to the description of a conversation between George and Harry, a distinction was drawn between qualitative and quantitative statements. This example—a conversation—was chosen partly to illustrate some of the difficulties which beset attempts to make quantitative, scientific description of a situation involving human individuals, and especially to warn the beginner against rushing in and "applying" the mathematical theory of communication.

There is first a difficulty in providing a *selective* basis to quantitative measurement of information conveyed by the signs, because the vocabularies used by the two individuals, George and Harry, are virtually impossible to define. What total range of sounds or words, or gestures, or phrases does each use? Added to this there is a further difficulty in defining sets of signs to be called their "vocabularies." In natural languages, spoken or written, the "signs" may be defined in many ways, depending upon the particular structural aspects of interest. Linguists break up languages into many different types of element. We are all so familiar with print and with dictionaries that we tend to accept the "word" as a kind of natural unit. But there are languages where the concept is far less evident. Again, it would be possible to compile, say, an English dictionary as a list, not of words but of syllables, though it might be inconvenient to use.[235]

Secondly, since no two individuals speak exactly alike, there are the great difficulties of defining, standardizing, and specifying utterances—the whole difficult field of phonetics and of signal analysis.

There is next the possibility of confusion between objective and subjective aspects of communication; between the personal sense impressions of an individual, private to him, and his overt behavior, which is observable and describable by an external observer. But a too rigid adherence to the strictly behavioral point of view can be cramping and may obscure many things of considerable interest. We shall be making particular reference to objective tests upon subjective phenomena later.

Man has remarkable powers of learning. Every communication, every perception, adds to his accumulation of experiences; he is continually becoming a different person, for his every experience is part of a continuing process. In a communication experiment he will show reactions to stimuli which may change as the experiment proceeds. These changes, of course, may be the phenomenon of interest, if his learning abilities are being studied; but in many experiments learning may provide a difficulty, and tests must be carefully designed to minimize or eliminate the consequences. In tests upon hearing or aural perception, for example, the listener may at first be unfamiliar with a speaker's accent but gradually improve his score as the tests proceed. In certain extreme cases, it may be impossible to use the same man twice for an experiment, because the second time he will know what is expected of him. Learning continually disturbs the *status quo* and may render the results of tests inconsistent or unreproducible.

Among the very simplest creatures, the absence of learning, or its restriction to elementary types, ensures fixed and common behavior patterns under similar conditions. Experiments are repeatable, and the results may to a great extent be generalized from one creature to his brothers. But as we proceed higher up the evolutionary scale, and learning faculties improve, behavior becomes far less regular and predictable. If a man is subjected to some experiment involving his responses to, say, spoken or visual signals, he may react in varied ways according to his personal experiences and habits, or his prejudices and anxieties—or he may deliberately cheat. His responses may even depend upon anticipation (of the consequences, or future test conditions, for example). But well-designed experiments may guard against such variables.

In conclusion, the human body is not to be thought of as a unit possessing a number of receptor organs, into which separate signals are received, like the wires entering a telephone exchange. A man is an organism, and the various stimuli bring into action physiological functions which set the whole organism into adjustment. Response to a stimulus of one organ may be influenced by the states of others and by the whole environment.

5. CO-OPERATIVE AND NON-CO-OPERATIVE LINKS

In the preceding discussion we have rather presumed that a whole social field of communication may be broken down into simple links, as illustrated by a conversation between two friends. Such an isolation may be more or less valid. A telephone conversation, for example, represents a fairly close communication between two people, only loosely affected

by external sources; yet the spoken language they use is a consequence of many different past contacts. A language grows from countless communications within a social group, and from mutual influence among different groups. In studies of crowd behavior we have another extreme, with individual links not forming a prominent characteristic.

A conversation forms a two-way communication link; there is a measure of symmetry between the parties, and messages pass to and fro. There is a continual stimulus-response, cyclic action; remarks call up other remarks, and the behavior of the two individuals becomes concerted, co-operative, and directed toward some goal. This is true communication.

The reading of a newspaper represents a one-way, non-co-operative link (except that the reader can write letters to the editor!). The relation of a speaker in a broadcasting studio, speaking into a microphone, to his individual unseen listeners in the privacy of their homes is one-way, whereas a speaker on a platform can see and hear the effects of his words upon the crowd; their facial expressions, their laughs and claps, and other signs reciprocate upon the speaker and affect the course of his speech. One-way communication is not strictly true communication.

An archaeologist deciphering a stone inscription forms a one-way communication link with his forebears. He receives no further help from them than the signs carved on the stone; he can make guesses and follow up to conclusions, but the dead cannot help or correct him.

The possibility of communication with a distant planet provides a currently popular example of communication that is initially one way. What can be assumed to exist in common between Earth and the planet that can serve as signs and rules, for a start, to build up a common language?[385,156] We have no knowledge, if living creatures exist there, of their intelligence level, their sense organs, their basic concepts. For the concepts we each of us possess, and for which we have signs, depend upon our individual experiences. The concepts held by people of one culture may differ from those of another culture, depending upon chance of history or geography. The system of description of nature we call "physics" has a certain form, constructed of concepts and laws, which has grown in a certain way from the accidents of our own history. Had history been different or had we different sense organs, physics might have become constructed otherwise. I see no reason to suppose, for example, that physics would be the same on Mars; nor need Martian mathematics have evolved along the same path. Perhaps the Martians share with us the concepts of day and night alternation, or of number, or of male and female, or of geometric figures—which we could represent not with empirical signs but with icon signs. Interesting, perhaps, to speculate about but rather a waste of time.

Our life is a continuity of experience. It does not remain static but benefits from previous happenings; it advances now here, now there, and steadily grows in social scale. By contrast, animal life is relatively static, a here-now world, the animal living each moment as it comes. The very simplest creatures show little or no power of learning and benefiting from past experience. They do not have continued thoughts and do not readily form abstract concepts. They have no language in the sense that we have, and no system of organized thoughts, but use sign systems which are comparatively rigid and incapable of development.

Suzanne Langer has written,* "Between the clearest animal call of love or warning or anger and a man's least trivial word there lies a whole day of creation—or in modern phrase a whole chapter of evolution." She was referring specifically to our possession of language. With our language we share, we have relations, and we are involved. We are not animals in a herd nor insects in a swarm, for we can change these relations; we can have purpose and motives; we believe and adopt attitudes. We communicate in societies and we commune with ourselves. Our language canalizes our thoughts and permits us our particular way of looking at the world, not "as it is," but as we see it to be. A great bulk of our thoughts are word-thoughts, deep ruts of habit. Our own language is so structured as to set up in our minds the idea of the ever-flowing stream of time, that metaphysical background of our experience. There is only one "now," but we have created past, present, and future—the lesser creatures have not. It is as though these creatures use signs signifying immediacy; as though, to be anthropomorphic, they said "go," "friend," "come hither," "boss," and so on, leading to future action, not referring to the past.

One of the most fascinating animal sign systems which has been studied is that of the bees, and this pioneer work of Karl von Frisch[118] illustrates the fixed nature of such systems compared to human language. You and I can have endless conversation about all sorts of subjects, but the bees mostly discuss one thing only—food and where to find it.† The bees make signs by peculiar forms of movement, a kind of "dancing" on the vertical combs in their hive. There are two distinct forms of dance. In the first, which is used to indicate that a source of food exists within a very short distance of the hive, the bee, carrying nectar and pollen from the flowers it has found, runs around in a small circle—one way and then the other—attracting the attention of the other bees, who smell and taste the pollen and nectar. The second dance is used to indicate food at greater distances, and is even more remarkable; in this, the bee walks in a figure

* See page 103 of reference 393.

† This may be too narrow, for they have other social behavior; they may change their hive to another place, for example, which may involve sign-usage.

eight, wagging its abdomen at a speed which depends upon the distance to the food. Further than this, the center line of the figure lies in such a direction on the comb, relative to the vertical, that it indicates direction of the food relative to the sun.

Now this system of signs may seem to be "ingenious," though we would rather say it is simple but efficient, because we should not credit each bee with thinking out how to express its desires. It follows these habits which remain unchanging through countless generations; its system of signs is not at all like human language, for it is not developable, flexible, and universal. To catch the attention of its fellows, a bee can do nothing but continue its dance, repeating it over and over again. J. B. S. Haldane has insisted that such signs are not to be considered as constituting a report, by the bee, of her recent excursion, but rather that they constitute *intention movements* which set other bees into imitative behavior until a major united action is achieved. Very much the same is yawning, in humans; yawns are very infectious. Many animal signs have similar consequences, setting up imitative behavior and leading to flocking and swarming.[209,324,*] Animal signs can relate only to the *future*, but never, like human language, refer to the past.[139] A man may change his method of expression, invoke new ideas; he can shift his line of argument, refer to past occasions, and hold out promise for the future. He can co-operate with his companions by changing his language to suit their reactions, and so achieve his goal more readily.

Simple repetition of a signal is the most elementary way of introducing *redundancy*, an idea we shall discuss in Chapter 3. Briefly, redundancy is a property of languages, codes, and sign systems which arises from a superfluity of rules, and which facilitates communication in spite of all the factors of uncertainty acting against it. Human languages have grown to have an excess of rules, so that some can be broken without serious harm. The rules we call grammar and syntax are not inviolate, but the more we break them, the lower are our chances of successful communication. The various rules supplement and duplicate one another, providing a great factor of safety. We can break some of the rules, but we cannot break them all if we wish to remain within the social community. In the Country of the Blind the one-eyed man is *not* a king—he is a gibbering idiot.

6. COMMUNICATION AND SOCIAL PATTERN

The title of this essay is "Communication and Organization." So far we have confined our attention to communication; let us examine now something of the nature of organization in the sense of "social pattern."

* Much human social behavior is imitative, too (e.g., see reference 240).

6.1. Analysis and synthesis

During the mid-nineteenth century, the early theories of society as an institution set up by individuals, the better to serve and satisfy their needs and desires, became radically changed, to be replaced by the concept of social evolution—a process of natural selection leading not to a better serving of the individual's interests but to higher social efficiency and consequent survival of the society itself. This introduction of evolutionary concepts led to analogies and comparisons between the aggregate of individuals forming society and the living animal body; Herbert Spencer was perhaps the chief proponent of these analogies and discussed them in some detail: the veins and arteries compared to systems of transport; the brain as the seat of government, et cetera; all the specialized *functioning* of the various mutually dependent organs compared to the division of labor and the essential institutions of the State.[307]

But such comparisons are little more than metaphors. For analogies to serve a useful purpose in science, to be a genuine part of scientific method, they should at least suggest some form of analysis or type of experiment capable of being carried over from one scientific field to another. Mere superficial similarity carries nowhere.

In modern times, A. N. Whitehead has treated the concept of *organism* in a much broader and more purposeful sense, not for setting up analogies but as a doctrine, a guiding principle, in reaction to the predominance of analysis and abstraction in science which has existed since the time of Galileo. "The concrete enduring entities of the world are complete organisms, so that the structure of the whole influences the character of the parts."[346] He has argued that analysis has formed the greater part of natural science in the past, and that analysis essentially involves abstraction, with its consequent ignoring of the rest of nature and of experience. But "the synthetic method of approach to reality may be as valid as the analytic." Such reasons have led Whitehead to insist that a further stage of provisional realism is required, in which "the scientific scheme is recast and founded upon the ultimate concept of organism."[76,28] Today we see an increasing concern with the synthetic, as opposed to the analytic view; such a movement has arisen not as an alternative but as a vital supplement to analysis in physics, in physiology, in psychology, and in sociology; and indeed our whole attitude toward history has been affected (e.g., Toynbee's concepts[326]). The analysis and breaking down of social groups into individuals, or into elementary communication units, may leave untouched the main problems of sociology, which concern not the properties of the individual parts but their complex relationships, just as breaking down a man into atoms and electrons loses sight of the man. An army, a

nation, an institution is not a mere crowd, not an amorphous collection of people, for all the members have certain dominant purposes; such "organisms" have continuity of existence and of form.[230] We recognize in them certain characteristics of their integrated structure, "*esprit de corps*," "national self-consciousness," "popular will." Again, although such characteristics suggest, by the terms used, extrapolations from the characters of individuals, comparison between the collective life of social groups and the life of an individual can so often become odious. Toynbee warns us that there is no historical justification for analogies between nations and individuals;[326] we cannot carry over analogy to "birth and death of nations" or invoke "obscure principles of senility or decadence."[230]

This is not to say, however, that the mathematics and methods of biology have no application to social studies; they certainly have, of course, especially the statistical methods. Biological evolution and social evolution have certain aspects in common; both represent a growth from simple beginnings, proceeding by trial and error to more complex structures, retaining advantageous changes and rejecting failures. But the two evolutionary processes need not be assumed to follow identical or analogous laws. Since man has evolved language and systems of organized thoughts, the evolution of social organizations can no longer be said to proceed by chance. Today we see planned experiments; the social organizations we call businesses, industries, government, economics, and all the great interdependent systems which form our modern world have become so complex and costly, and their failure would represent disaster on such a scale, that planning, control, and social design are becoming ever more prominent. This trend shows up as *logistics*, *operational research*,[245,299] *time and motion study*[298] and planned production in industry, *census* and *social survey* bureaus,[188,322] *planned economics* for full employment. It is the political ideal of the Welfare State—group responsibility for the basic human standards of the individual person; it leads to a whole intensity of awareness of the urgent need for better understanding of social organizations of all kinds. And for gaining this understanding, there has been a great search by sociologists for methods, a search which has led to the taking over of systems of analysis from other fields—not only physics, engineering, and chemistry, but also mathematical biology.

It is only too easy, in a discussion of this kind, to lapse into vague generalities; to use terms like *element*, *system*, *relationship*, *structure*, *pattern*, with which we can write so much and say so little. It is precision, above all, that is desired in social studies; we need to know relationships as mathematical and statistical laws, yet heaven knows how easy it is to say this, and how appallingly difficult and laborious it is to gather the necessary data and to formulate social laws! The sociologist is, unhappily, not often

in the position to control and experiment upon his material, as is the physicist; he so often must wait for wars, strikes, trade depressions, and other calamities to do it for him.

6.2. Social fields and networks

It is not unnatural that in the technology of telecommunication many aspects of this subject have received clear mathematical treatment; there are three specific developments which undoubtedly are filtering through into social studies:[84] (*a*) the theory of networks, (*b*) statistical communication theory, and (*c*) the theory of feedback (sometimes called cybernetics). The latter has been adequately dealt with in literature,[349] and we shall here refer mainly to *networks*.

In telecommunication, the notion of an isolated discrete link is exceptionally pertinent; such links take the form of telephone and telegraph lines, for example, forming patterns of connections between pairs of transmitting and receiving points (*nodes*). In such systems, messages are essentially canalized. The flow of signals along the lines of communication which enmesh the globe—the telephone lines, submarine cables, radio links, postal services—has a profound effect upon our social organization and patterning. The increase in sheer scale of social organization is one of the most significant trends of our times, a growth possible only by modern telecommunication technology.[422] And it is concerning such networks that a great deal of mathematical theory has been constructed.

This notion of canalized messages may be of far less value, on the other hand, in studies of crowd behavior; the microscopic point of view may reveal nothing of the character and patterning of large and closely knit congregations, which may perhaps more effectively be treated as "fields." Students of crowd behavior[259] have been concerned with the manner of propagation of ideas or "potential reaction patterns"—starting perhaps from a single individual, spreading as a "wave" over the whole crowd, growing and decaying—and with the dynamic spread of popular crazes (e.g., diabolo and other games and puzzles), new slang, rumor,[4] fashions, panics, and fervors. Such "wavelike" rise and fall has been compared, in some detail, with the epidemiology of infectious diseases.[259]*

J. B. S. Haldane's most interesting remarks about animal *ritual* behavior, to which we have referred in Section 5, suggest that such study may cast light upon human crowd behavior. The intention movement of an animal (insect, bird) is not to be considered "purposive," but it may set up imitative action, eventually becoming concerted, until a flock or swarm

* A modern remarkable instance of news spread, afforded by television, is the occasion of President Kennedy's assassination. The news was learned by 68% of population in the U.S.A. within half an hour.

is formed.[159] Perhaps human crowds attending football matches or watching processions or other displays are remnants of our own animal behavior; the whole crowd may be described as having purpose, but each member merely imitates.

We have mentioned two extremes of social structure, the true network and the "field." How far can the concepts and methods of network analysis be extended toward more general structures? To take a rough analogy, the relation between electrical networks and electromagnetic fields is known precisely; but we have no such exact relation in the case of the social phenomena. Still, in the next section (section 6.3) we shall comment upon one brave attempt to extend the theory of networks to social structures in which messages are not canalized so precisely from one individual to another.

Business, industries, and armies are not mobs, or crowds. They have defined purpose, they have formal structure—a skeleton of rules relating one part to another, and relating one individual member to others, which determine on the whole how messages (orders, instructions, etc.) shall flow and communication unite the parts into a whole, purposeful, goal-seeking "organism."[256] Such highly organized units possess a *constitution* (a set of rules, usually imposed, though they may be modified by experience) which defines a "network" in which messages have been intended to flow. But the fact that messages are frequently found to flow in other paths, short-circuiting or by-passing "the usual channels," is itself quite revealing. In this connection there are two recent developments in social studies, at which we shall glance later (Section 6.3), that represent the *observation* and *experimentation* approaches. The first involves prolonged observation of some particular business, office or factory, to find out the principal paths of internal communication:[303] the flow of orders, instructions, chasings, requests for advice, et cetera; the frequency, nature, and cause of blockages; who consults who and for what purpose; and other aspects of the *true* communication network, to be compared with the assumed formal one. For the formal rules, as laid down "by authority," may not necessarily be the most practical and efficient; the social organism may itself determine another set for achieving its purpose. Such a study is analytical, but a second is synthetic. This concerns *group networks*, an experimental study of the self-organizing potentialities of very small social groups, when set to solve specific tasks. At present, such studies are highly abstracted from real-life organizations, but in such a way that the mathematical theory of networks has direct relevance. We shall return to this later.

In point of fact, when a young man enters a large business or industry, filled with zeal, he imagines that above him there is an Ordered World;

but as he climbs the ladder and reaches the giddy heights of Administration, only then does he slowly come to realize that the "machinery" may be very nebulous—an affair jerked along by clash of personalities and given momentum by ambitions.

6.3. On mechanical analogies to social structures

Popular parlance uses many analogous mechanical terms in reference to social matters; we commonly speak of: "swing of the pendulum" (of public opinion), "government machinery," "forces of reaction." Mechanical analogy forms a basis for a great deal of our thinking. In the social field, "forces" are not the forces of mechanics, nor are social groups to be compared with machines in the Newtonian sense. For in simple mechanics, time can be reversed; but we cannot reverse the course of history.

It is true that certain social and biological studies have concerned the interactions of abstracted quantities, often represented mathematically by differential or integral equations, and such representation may suggest a "machine" analogy (for example, the growth of populations and the interaction of populations). In such mathematical work, the important quantities singled out are macroscopic, average quantities and rates; in biology we may be dealing with numbers of males and females, average birth and death rates, et cetera. But the solution of such equations does not give the life history of any one individual. Again, economics is concerned with abstracted quantities like average incomes, investment rates, scales of taxation, prices and their interactions. But such calculations are concerned with averages and aggregates, and do not describe precisely the budgeting systems which are yours and mine. In all such calculations the related quantities, the parts of the "machine," must be regarded as subject to variations, frequently random, coming from an immense variety of causes which have been ignored in detail by the conditions of analysis, that is, by the necessary abstraction of the interacting quantities.[84]

In view of the necessary abstraction, and of the great residue of uncertainties facing us in analysis of material so varied and so numerous as human populations, it would seem that statistical mechanics[325] may be more relevant and applicable than ordinary (determinate) mechanics; this suggestion has occasionally been put forward.[120] Ordinary mechanics deals with simple rigid bodies like levers, wheels, frameworks, and with their motions and the various forces in equilibrium which act upon them, where *forces* is a clearly defined mathematical term having nothing whatever in common with the "forces" that control our destinies. On the other hand, statistical mechanics deals with the properties of *systems* consisting of such enormous assemblages of component elements (such as a volume of gas)

that exact determinate calculations become impossible. It abstracts certain macroscopic properties and ignores other data entirely, so that the life history of the system cannot be specified precisely, but only statistically —on an *average*. The founders of statistical mechanics seem to have been aware of the wide interpretation of their concepts and results, though they were expressly interested in certain well-defined physical problems. Today the principal concepts are finding application in many fields where vast assemblages or "systems" are studied.[349]

Nevertheless, this attractive proposition possesses many difficulties. For one thing, statistical mechanics deals adequately only with truly enormous assemblages, whereas most social groups are only moderately numerous. A second difficulty, which may eventually prove not insurmountable, is that statistical mechanics has mostly been applied to systems of particles having zero or very weak interactions, whereas the people composing a social group exert a great deal of influence upon one another. However, recent study of the theory of liquids and solids has considered particles which "co-operate" or exert strong interactions one upon another —as in, say, metals and crystals. Fürth suggests that the theory of such "co-operative" phenomena may assist in the understanding of certain social behavior problems.[120] A third trouble is that a human population does not normally form what a statistician would call a "stationary" system; that is, statistics gathered at one period of time may be quite inapplicable at a later period, for the major controlling conditions may be altered by plagues, windfalls, new regulations, currency devaluation, political reversals, international treaties, or wars. Social organisms are rarely in true "equilibrium," for evolution continues.

It should be understood that physical models and analogies are of no use if they merely "liken" people to atoms, molecules, and particles but lead to no further inferences. Such blind-end comparison would carry us no further than have the analogies of Herbert Spencer.[307] The laws which determine true forces between atoms or particles, and the various physical properties of gases, solids, or liquids, have nothing to do with the "forces" or natural influences exerted upon human beings—and the great difficulty lies just there, to discover by observation and experiment what are the important parameters, and the laws relating them, in social fields. It is the mathematical methods *per se* of statistical mechanics which may eventually prove of some value in the study of social and other systems, rather than the (extensional) semantic relations of the method to the problems of physics. The mathematical methods exist in their own right.

If the methods of physics are considered in relation to social problems, two further points should be borne in mind. In the first place, society may require not one model but many, depending upon what attributes

are to be portrayed. Then again, and more delusive, the concepts of time and space in physics are highly abstracted and universal, whereas *time and space in sociology mean history and geography.* We cannot take a model of some social phenomenon and transplant it to another epoch, or another part of the world.

To many laymen the notion appears strange that material so varied and willful as human beings is subject to any laws; but we should remember that at the time of Newton the idea may have seemed laughable to many, that the complex motions of solid bodies of all different shapes, sizes, and weights could be given mathematical expression. Although human beings are individual personalities, they are all subject to certain appetites, needs, and desires; and we are simply *not* free to do what we like; to say, to spend, to beget, in complete independence of the actions of our fellows. A man who breaks *all* the rules is not a member of the social group—he is a lunatic or an anarchist.

Governments spend enormous sums on gathering census data, the better to predict and cater for future social needs; there are other sources of data too—public opinion polls, market research, radio listener research, and various social surveys. As computing machine techniques improve, so more and more facts may be extracted from this mass of material, concerning economic matters, population trends, opinions, habits, and preferences, and their various relationships. But we sadly lack techniques of similar power for analysis of the psycho-social or communication problems which so concern our social health—the acceptance and spread of slogans, the propagation of rumors,[4] the building up of national attitudes out of the daily blast and counterblast of accusations in press and radio. How is it that a crowd can listen to and applaud with enthusiasm, a string of clichés and platitudes which no one member would waste a thought upon in the privacy of his own home.* Why are mobs violent? What distinguishes news from propaganda? What is the difference between competition and conflict? Why does society continually split into two, like the two opposing teams in a game: capital and labor, the two parties of stable democracies, the two sides in war, believers and infidels? Within each side there is sense of cohesion, loyalty, and rectitude. Our side is wholly good, the other wholly evil. Is such dualism inherent in the way we think?

7. GROUP NETWORKS

Who does not remember seeing, in his school history books, diagrams with arrows, dots, and little shaded rectangles representing armies arrayed

* Television is a far more critical medium for political personalities than any we have had before.

against each other in battle? All the vast mêlée, the terrors and agonies of the day, reduced to the neatness of geometry.

Such diagrams represent a simplified, abstracted pattern of relationships, a formalized skeleton. Equally familiar must be the organizational charts stuck on the walls of offices and factories: little blocks labelled "President," "Sales Manager," "Chief Engineer," with connecting lines showing their functional relationships—the rules of the institution. Family trees form another example. Again, flow charts are commonly used by engineers, to illustrate the functional relations between the various functions of complicated machines.

This type of representation, and the mathematical system which goes with it, is called *graph theory* (an aspect of combinatorial topology), and it has received elaborate application and interpretation in the theory of electrical networks. Recently, "social networks" have also been studied by the methods of graph theory from two aspects, theoretical and experimental (work which has perhaps received some inspiration from Kurt Lewin's use of topological concepts for expressing psychological situations).

Although it has been concentrated upon very simple social structures, this work is nevertheless interesting, especially since it represents a genuine attempt at *synthesis*, breaking away from the long tradition of analysis in social studies.[17,18,65,111,211,213]

Roughly speaking, a *topological graph* is the mathematical name given to a set of lines connected together into any kind of network. We may imagine a number of wires, having hooks at each end, which can be hooked together into different network patterns; the hooks, or ends of the wires where they are united, are called *nodes*. The distinction between networks and true geometrical figures is that the former consist of lines which have no specified shapes or lengths but are merely connected together by their ends; magnitudes are not involved, but only number and connection. A fishing net is a topological graph; so are the various flow charts or *sociograms* to which we have referred. One of the best illustrations of the distinction between a geometric figure and a topological graph is provided by the two kinds of railroad maps we use; one is the normal survey map, using correct scales of distance and compass bearings, and the other is the stylized map showing only the *connections* between the stations, such as is sometimes used for a subway or the Underground.

In a sociogram the nodes may represent people, and the connecting lines channels of communication—the passage of messages, instructions, orders, and so on.[211] Such connections may be unidirectional (e.g., the passage of orders) shown by arrows on the lines; the network is then called a *directed graph*. As a representation of a social group this is of course highly idealized, but any application of mathematics to physical problems

is idealized to some degree; the question is always: How much idealized, and what factors does the idealization conceal or eliminate?

Such networks are admirably suited to analysis by the use of matrix algebra. If the various connections, or channels of communication between the nodes, can have only one of two *states* (a message is or is not sent; a relationship or its opposite exists, etc.), then the problem becomes one of two-valued logic. The connections are either made, or not made (*yes* or *no*), and the matrix representing the properties of the network consists of an array of two distinct numbers, for example, 1 (*yes*) and 0 (*no*).[211] The whole network and the social situation it idealistically represents become closely analogous to an electrical network consisting of interconnected switches which are *open* or *closed*. Experience with electrical network analysis, using similar mathematical methods, suggests that general, overall properties of large social networks may possibly be found, provided the communication between nodes (people) is restricted to well-defined types of message. Such properties are not restricted to networks of specified size or complexity; and it may be possible to set up a system of *classification* of sociograms. But, of course, the whole success of such an approach will depend upon the precision with which messages can be controlled and objectively defined. Such theoretical work cannot stand alone, based entirely on conjecture and mathematical deduction; it must be paralleled by experimental findings.

On the experimental plane, work has been carried out on comparatively small social groups, under such controlled conditions that the idealized nature of the network representation is thrown into relief. In typical experiments,[17,65,150] a number of people sit alone in small adjacent cubicles and communicate with one another by passing written messages through slots in the walls between the cubicles; the slots can be arranged so that any required network of connections may be set up, ad initium. Such a pattern of communication, regarded as a "social group," is of course highly artificial; the very mechanics of the method which has had to be employed to canalize the flow of messages into a true network emphasizes this. Such networks do not represent real-life social situations, but invented or set-up systems with formalized rules; we shall later be referring to the analogous case in language study, where invented or set-up "language systems," having formalized syntax rules, are developed in the same spirit of synthesis. The analogy in methodology here is very close, arising from similarity of difficulty. Both language and social pattern are evolved systems, not imposed from outside or designed on any logical basis. In both cases, the synthesis of artificial but "logical" structures may eventually help understanding of the natural phenomena, partly by throwing into relief the very failures of the synthetic systems;

just what can these systems *not* do that the natural systems perform very efficiently?

There are numerous examples of social working groups set up to perform specific tasks, for which Authority has planned and imposed what it thinks to be the best internal patterns of communication. Frequently, these patterns are of a comparatively rigid type, not readily changed by the individual group members themselves: army units, business offices, factories, and so on. Yet working groups may show a tendency to depart from the formal imposed pattern of communication: "One may take the view that this departure is due to the tendency of groups to adjust towards that class of communication patterns which will permit the easiest and most satisfying flow of ideas, information, decisions, etc."[17]

In group-network experiments, the tasks to be performed frequently require the group members to obtain data from one another. Externally imposed communication patterns are set up by the arrangement of slots through which written questions or answers may be passed: star patterns, rings, chains, et cetera. What is subsequently observed throws light upon the emergence of a "leader" and his position in the group pattern, the relative times taken to complete tasks, and the degree of satisfaction or irritation (questions of "morale") experienced by members at different positions in the network. In other experiments, message exchange is left completely free, and the preferred patterns of communication are observed as they develop when tasks of various types are set for the groups to tackle.

Popular speech suggests that definite skeleton structures are recognizable in large social organisms. For example, we use words such as "dictatorship" to imply a strong central authority with branches radiating to all its servants (a star pattern); or "commercial ring" to imply that the members use one set of rules among themselves and quite another for their attitude toward the public; again "bureaucracy," implying "pass to you, please" (a chain pattern). Popular fancy clings to such simple imagery. It would be extremely dangerous to generalize from network experiments upon small groups, especially since such studies are in a very early stage. Nevertheless, armies, factories, banks, ministries, and many of our most important organizations possess highly formalized networks of communication which, although much more complex than those used in the experiments, may eventually benefit from this work.

Rather than think of real-life organizations as single "networks," it may be more realistic to regard them as a number of networks superimposed. For example, in an army the pattern of relationships is clearly laid down, but this pattern is not a simple network. There is a network for *supplying* the army in the field; there is a patterning of flow or orders and directives, relating to the *movement* of troops; another may represent

the flow of *intelligence* signals. Each network would represent the flow of messages of a particular class: messages concerning materials, quantities, messages representing orders on troop disposition, messages representing secret information. Such patternings are not necessarily independent parts or subsections of the entire system but have rather the nature of projections; they exist simultaneously and are superimposed.

It has become a cliché to refer to man as "the communicating animal." Of all his functions, that of building up systems of communication of infinite variety and purpose is one of the most characteristic. Of all living creatures he has the most complex and adaptable systems of language; he is the most widely observant of his physical environment and the most responsive in his adjustment to it. He has organized ethical, political, and economic systems of varied kinds; he has the greatest subtlety of expressing his feelings and emotions, sympathy, awe, humor, hate—all the thousand facets of his personality. He is self-conscious and responsible; he has evolved spiritual, aesthetic, and moral sensibilities.

A man is not an isolated being in a void; he is essentially integrated into society. The various aspects of man's behavior—his means of livelihood, his language and all forms of self-expression, his systems of economics and law, his religious ritual, all of which involve him in acts of communication—are not discrete and independent but are inherently related, as sociologists have continually stressed from the time of Adam Smith.

8. COMMUNICATION IS AN ACT OF SHARING

The word *communication* comes from the Latin, *communico*, meaning *to share*. We do not "send" messages; we always share them. Messages then are not goods or commodities, which can be exchanged or sent from one person to another. Thus, if I tell you something, I have not lost it—we now both have it whereas we cannot both possess the same article or commodity. Furthermore, you could tell it to somebody else, and so on. In principle, the same message could be passed on and shared throughout the human race, and something infinitely shareable has no rarity value (as all goods have). However, artificial constraints are frequently introduced to restrict the sharing and give the messages rarity value—such constraints, for example, as secrecy or security law, copyright, privacy, and censorship. *We can communicate with one another in this world (or outside it) only inasmuch as we can share sign-usage.*