THE MEASUREMENT OF MORALE BY THE MATHEMATICAL THEORY OF COMMUNICATION

By

RAYMOND CURTIS STOKES

Bachelor of Science

Oklahoma Agricultural and Mechanical College

Stillwater, Oklahoma

1950

Submitted to the faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
August, 1953

THE MEASUREMENT OF MORALE BY THE MATHEMATICAL

THEORY OF COMMUNICATION

Thesis Approved:

Harry K. Brobst
Thesis Adviser

L. L. Reed.

Dale M. Entach
Dean of the Graduate School

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

Organizational Morale

Morale is usually thought of as a phenomena of organizations. All organizations that exist for any extended period of time have some level of unity, solidarity or esprit de corps. Leaders of all times have recognized the importance of this phenomena and have attempted to build high morale.

A scientific definition of morale is difficult if not impossible. People who become members of an organization do so because they have needs which they expect to be satisfied as a result of their association with the organization. A high level of morale depends upon the organizational members having strong needs and expectations and also upon the satisfaction of these needs and expectations without having to contribute an excessive amount of activity to the organization. Since morale is, to a large extent, determined by needs and expectations it may be made up of a lot of little things. McNemar[1] believes that morale is not an entity, but that there are many "morales." It seems reasonable to McNemar that these little things are not, however, entirely independent, either statistically or functionally. Certain of them tend to go together or form clusters that may be independent of each other. Therefore, morale is defined as the sum total of the satisfactions which the individual experiences because of his membership in and association with an organization.

---

[1]Quinn McNemar, "Opinion-Attitude Methodology," Psychological Bulletin, Vol. 34, No. 4 (July 1946), p. 365.

Barnard,[2] in his development of the theory of organization, states: "It is clear that willingness of persons to contribute efforts to the cooperative system in indispensable. The degree or level of willingness to cooperate is the expression of the net satisfactions or dissatisfactions experienced or anticipated by each individual in comparison with those experienced or anticipated through alternative opportunities." Thus, from the viewpoint of the individual, willingness to cooperate is the joint effect of personal desires and reluctances; from the viewpoint of organization, it is the joint effect of objective inducements offered and burdens imposed. This willingness to serve is, of course, determined by the individual level of morale which is entirely personal and subjective. Hence, the very existence of organization depends upon the inducements or incentives that satisfy them. Thus, the effectiveness and existence of organization depends upon the maintenance of a relatively high level of morale.

It is for this reason that leaders of all organizations are interested in the needs, motives and expectations of the members. It is obvious that before the needs can be satisfied by the proper rewards, the needs must be known. In small organizations where the leader personally knows each member, the process of determining individual needs and how well they are being satisfied is relatively simple, but in huge complex organizations this is a difficult and sometimes seemingly impossible task. During the last two decades techniques of surveying morale have been developed which are being used to gather this information for leaders of organizations.

---

[2]Chester I. Barnard, The Functions of the Executive (Cambridge, Massachusetts, 1950), pp. 83-85.

The Measurement of Morale

A scientific study of morale is impossible without the use of some type of measuring instrument. In fact, practical evaluation of morale in complex organizations is impossible without having some measuring device. The measurement of morale is similar to the measurement of many other psychological and sociological phenomena. It is similar in that morale is intangible, that is, one cannot see it, touch it, or smell it. This does not necessarily mean that morale cannot be measured, because anything that exists, exists in some amount and anything that exists in some amount can be measured even though the measurement must be indirect.

Indirect measurements are not uncommon in the physical sciences. Altitude is measured by detecting changes in the density of air. This measurement is possible because it is known that the higher one goes above sea level the less dense the air becomes. Altitude and air density are inversely related. Other examples are the measurement of temperature by changes in the volume of mercury and the measurement of electricity by the electro-magnetic field it produces. In a similar manner morale has been measured indirectly by inferences drawn from behavior. This is possible because it is assumed that the degree to which an individual's needs and motives are satisfied will influence his behavior. These inferences can be drawn either from overt behavior or from verbal symbolic behavior. Presumably observations of overt behavior would be more accurate but the necessary data can be obtained much more economically from symbolic behavior.

Most measures of morale are made from verbal behavior. The principle techniques used for measurement are those of opinion polling and attitude scaling. However, morale is sometimes measured by overt be-

havior using such indicators as turnover, absenteeism, production, lack of strikes, and grievances. These indicators are frequently so confounded with other variables that they are usually considered to have low validity as measures of morale.

The management of complex organizations have sometimes depended upon the rumored attitudes of employees as an indication of morale. These rumors have so frequently been the extreme attitudes of malcontents that this method has practically no validity. Management also depends upon reports by supervisory personnel. This casual haphazard method has also resulted in management being inadequately informed about the organizational morale. Another method that has had some appeal is employee interviews. This method has a number of advantages that make it superior in many ways to other methods, but because of the cost in time and money it has not been widely used.

Opinion polling techniques are the most common techniques used to evaluate employee morale. The poll questionnaire is designed to obtain a choice made by the respondent to one of a set of alternative answers. The two principle forms are check lists and multiple choice questions. These alternatives are designed to gather the information that is believed to be needed by management.

The opinion polling type questionnaire has been rather popular because it has face validity, i.e. it looks like it measures what it is supposed to measure, and it is, therefore, easy to sell to management. The questionnaire can be constructed comparatively quickly and easily. It can be administered to a large number of employees in a short period of time. The tabulation and analysis of the results are simple and can be done quickly and cheaply. The results are usually given in the per-

centage of employees who have a favorable opinion and the percentage who have an unfavorable opinion about each of the areas covered by the questionnaire. Comparisons are also usually made between various sub-populations in each of these areas.

The opinion polling technique has been critized because it is probably impossible to determine bias when only one question is asked in an area. It is impossible to determine whether or not only one dimension is involved. This is a severe criticism because if two dimensions are being measured then separating the population into pro and con or favorable and unfavorable has no meaning. If this should be the case, what are employees for and what are they against? The technique is also weak in that it cannot determine how favorable or unfavorable the opinions are but only that certain percentages of the population are favorable and unfavorable.

A number of techniques called attitude scales have been developed that are designed to overcome some of the weaknesses of opinion polling. The most important of these techniques are the Thurstone, Likert and Guttman techniques. Each of these techniques will be discussed briefly in the following paragraphs.

Thurstone[3] developed a method of attitude scale construction that has been widely used. The construction of a Thurstone scale involves the following steps: (1) A collection of a large number of simple statements about the attitude area in question; (2) the judging of each statement by a sizeable group of experts as to the position on a continuum from extremely favorable to extremely unfavorable and the rejection of

---

[3] L. L. Thurstone, "Theory of Attitude Measurement," Psychological Bulletin, Vol. 36 (1929), pp. 222-241.

those items for which there is insufficient agreement among the judges as to the proper location on the continuum; (3) the assignment of a scale score to each remaining item, computed as the median scale position for that item given by the group of judges; (4) the selection of a group of statements that spread approximately evenly along the scale from one extreme to the other.

The original statements may be collected from any source. They should be phrased in simple, unambiguous terms and they should refer rather directly to the attitude area in question.

The group of judges must be large, usually more than one hundred. The personal attitudes and opinions of the judges themselves do not affect the validity of the scale. Each judge is asked to place each statement in one of eleven piles which appear to be about equally spaced from one extreme of the continuum to the other. There is, of course, never perfect agreement among the judges on the location of the statements. The items having the highest amount of agreement are selected for further consideration.

The median position assigned to a statement by the judges is assigned as the scale value of that statement. The scale is usually made up of about twenty statements that are selected to have scale values that spread over all parts of the continuum.

The individuals who take the test are instructed to check those items with which he agrees. His morale score is computed as the median of the scale values of the items he checks.

Likert[4] has developed a somewhat different approach to the scaling

---

[4]Rensis Likert, "A Technique For the Measurement of Attitudes," Arch. Psychol., (1932), No. 140.

of attitudes. The Likert technique involves the following steps: (1) The collection of a large number of statements which directly refer to the attitude area in question; (2) securing a response of strongly agree, approve, undecided, disapprove, or strongly disapprove from a group of subjects to each of the statements; (3) the assignment of the value of 5, 4, 3, 2, and 1, respectively to each of the above categories and the summation of the responses made by each individual; (4) the determination of the amount of correlation between each item and the total score; (5) the elimination of statements that do not correlate with the total score.

Guttman[5] recently developed a new technique for the scaling of attitudes. The primary advantage of this technique over others is that it determines whether or not the attitude is scalable. An attitude is scalable if only one dimension is being measured and if the attitude is structured in the given population at the time of testing. The scalability of the attitude is determined by the coefficient of reproducibility which is determined by the following formula:

$$\text{Coefficient of Reproducibility} = 1 - \frac{\text{number of errors}}{\text{number of questions x number of respondents}}$$

This coefficient must be about .90 before the attitude is considered scalable. This means that if an individual's scale score is known, it would be possible to guess the exact items which the respondent endorsed and did not endorse about 90 times out of 100.

If the attitude is scalable, it is possible by this technique to

---

[5] Samuel A. Stouffer, Louis Guttman, Edward A. Suchman, Paul F. Lazarsfeld, Shirley A. Star, and John A. Clausen, Measurement and Prediction (Princeton, 1950), Vol. IV, pp. 60-91.

place respondents along a continuum ranging from extremely favorable to extremely unfavorable, just as the Thurstone and Likert techniques do. If the attitude is not scalable, the measurement is considered to be invalid.

This technique also has provisions for an intensity scale along with the attitude scale. Intensity of feeling is conceived to be strongest at both ends of the scale and to decrease in the middle. The scale position with lowest intensity of feeling is the cutting point which divides the population into two groups, one positive and the other negative.

Applications of the Guttman technique indicates that morale is not a scalable attitude. Presumably this is because morale is not unidimensional. This is compatible with McNemar's belief that morale is not an entity but is made up of many little attitudes. This would make the Guttman scale difficult to use as a morale measuring instrument. Its use would necessitate the development of a scale for each dimension of morale. This problem is more formidable than it might first appear because the dimensions of morale could be expected to vary from organization to organization and from time to time within the same organization.

A New Approach to Morale Measurement

It has been shown that because morale is intangible it must be measured indirectly. This measurement is usually based upon overt behavior or symbolic verbal behavior. The opinion polling and scale analysis measurements are inferred from qualitative variations in verbal behavior. This means that the level of morale is inferred from "what

is said." The content or semantic meanings of the statements endorsed by the respondents is the basis of measurement. If one employee endorses the statement "My supervisor is a swell guy" and another endorses the statement "My supervisor is unfair," the content would indicate that the first employee has the more favorable attitude toward supervision. Because this difference in verbal behavior is a difference in quality of behavior rather than a difference in quantity of behavior, it is extremely difficult to establish a standard unit of measure to such an instrument.

Since the measurement of morale is indirect any variable that is related to morale can be used as the basis of measurement. Verbal behavior seems to be the most convenient variable to use as a basis of measurement, however verbal behavior can vary both qualitatively and quantitatively which means that verbal behavior can vary both in what is said and also in how much is said. A new approach to the measurement of morale will be developed on the assumption that the quantity or amount of verbal behavior can be used as the basis of morale measurement. This basis of measurement may be just as valid or perhaps more valid than the qualitative variable if the amount of verbal behavior is related to morale. It is believed that this may be true if respondents are allowed to freely express any and all of those attitudes toward their work life which they feel are important to their own morale.

The amount of symbolic behavior has never been used as a basis of morale or attitude measurement. The reason for this is that until recently no accurate method was available for measuring the amount of information transmitted during symbolic behavior. New developments in the theory of communication not only furnish a means of measuring information,

but also offer a realistic model for considering morale surveys and their purpose in the functioning of an organization.

This new method of measuring morale will be applied to data gathered by the General Motors Corporation. This application of the method is used primarily for illustrative purposes and is not intended to prove or disprove the validity of the technique. However, it is hoped that this application, together with the theoretical development of the method, will give some indication of its possibilities.

CHAPTER II

COMMUNICATION THEORY AND MORALE

Cybernetics as an Organizational Communication Model

Recently Wiener[1] presented a remarkable synthesis of material from a number of disciplines, the most important of which were electronic engineering, pure mathematics, neurophysiology and statistics. This field was not only a synthesis of material but also a development of a comprehensive model of communication and control within organisms, both animal and machine.

The operation of the living animal and the operation of most electronic machines are believed to be parallel. They both have sensory receptors or a special apparatus for gathering information from the external environment. This information is used to determine future behavior or action performed on the outer world. The performed action on external environment, and not merely the intended action is reported back to a central regulatory apparatus. This process of reporting back is called feedback.

It is well known that animals have a kinaesthetic sense, by which they keep a record of the position and tensions of their muscles. In order for any animal or machine subject to a varied external environment to act effectively, it is necessary that information concerning the results of its own behavior be furnished to it as a part of the information on which it must continue to act. Feedback is the process of transmitting information about behavior back to the "brain." The success or

---

[1]Norbert Wiener, Cybernetics (New York, 1948).

failure of this behavior modifies future behavior.[2]

The human organism in performing any simple task such as picking up a pencil, not only sends nervous impulses from the brain to the muscles, tendons and joints of the arm, hand, and fingers, but also nervous impulses from the nerve endings in the muscles, tendons and joints are sent back to the proper center in the brain informing it of the actual action taken. Both of the functions are absolutely essential before any simple task can be successfully executed. It is, of course, obvious that the muscles in the arm and hand could not perform any action unless directed to do so by impulses from the brain. It has also been conclusively shown that the task cannot be accomplished unless the feedback function is also carried out. Certain neural disorders result in a malfunction of the feedback function. People suffering from ataxia, even though their muscles are strong and healthy, and they are able to send nervous impulses to them, are unable to perform simple tasks. One form of ataxia is known as tabes dorsalis. This condition exists when part of the spinal cord has been damaged by the late sequelae of syphilis. Impulses from the lower limbs are blunted or completely blocked. Another type of injury is known as purpose tremor. In this case the damage is believed to be in the cerebellum.

Principles of feedback have long been used by electronic engineers in the design of electrical communication equipment. One of the first applications of electronic feedback was the automatic volume control on the ordinary house radio receiving set. Before AVC was built into receiving sets, it was necessary for listeners to make frequent manual adjustments of the volume. The reason for this was that the radio fre-

---

[2]Wiener, The Human Use of Human Beings (Boston, 1950), pp. 10-15.

quency signal picked up by the antenna is not constant in volume. The variation may be caused by changes in weather conditions or changes in the volume of the radio transmitter signal. If the radio set does not have AVC, the slight variations in the radio frequency volume will be amplified and cause wide variations in the audio frequency volume in the speaker.

Listeners of modern radio sets do not adjust the manual volume control very often. The volume of the radio frequency signals picked up by the antenna is still varying, but the AVC makes the necessary adjustments automatically. A simplified schematic drawing of a radio receiving set is shown in Figure 1. If the volume of the radio frequency signal picked up by the antenna is high, the volume in the last amplifier will be high. The feedback circuit bleeds off about ten per cent of the voltage and feeds it back to the first amplifier in such a manner that the amount of amplification is cut down. If the radio frequency

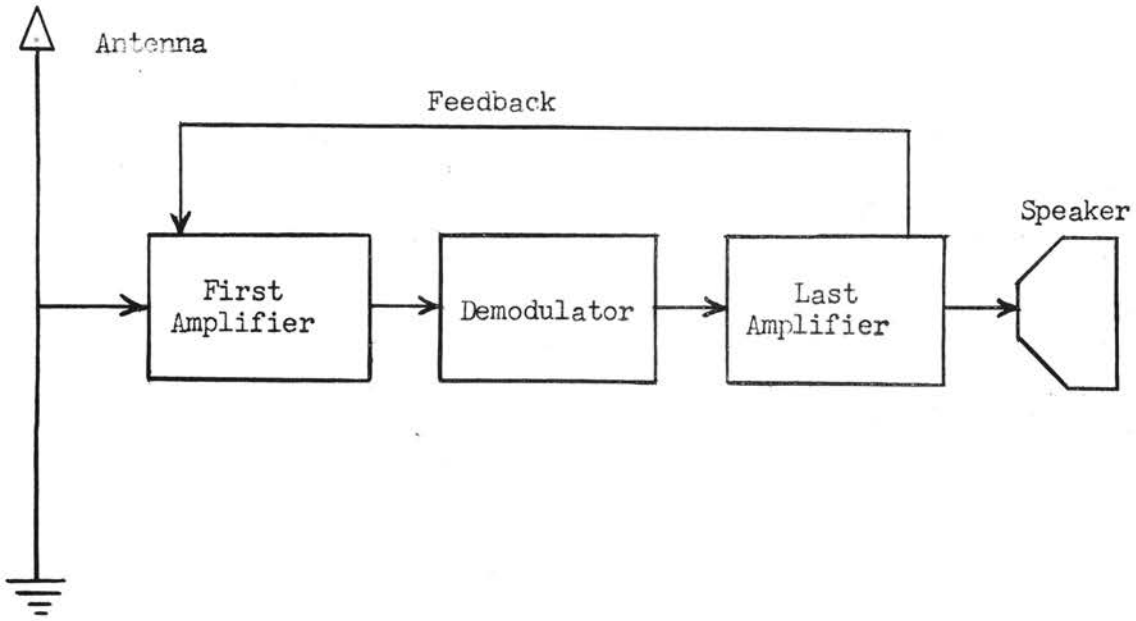

Figure 1

Feedback in a Radio Receiver

signal decreases, the volume in the last amplifier will become small which will in turn decrease the amount of feedback. The decreased amount of feedback will allow the first amplifier to increase its amplification. In this way the volume is automatically stabilized regardless of the volume of the signal picked up by the antenna.

It is believed that the principles of cybernetics or communication and control can be applied as a model in analyzing organized group activity. Deutsch[3] has proposed the use of these principles as a realistic and fruitful model for analyzing a number of aspects of organization.

The processes of communication and control are the decisive processes in organizations. The system of communication is the nerve tissue and connective fiber of an organization. Organizations could not exist without a system of communication. It is, of course, through the channels of communication that directives and orders are sent out from management to the workers. There are also channels of communication transmitting information from workers to management that tell management of the action taken. Both of these functions are believed to be just as essential in an organization as they are in the animal or machine. It is through these processes of communication that management is able to control or guide the organizations' activities toward a goal in a changing external environment. There are, of course, several channels of communication in a complex organization for transmitting information from management to workers and workers to management. Until recent years, however, most of the information has been transmitted by the supervisory hierarchy, known as "the line." It is becoming increasingly apparent that

---

[3]Karl W. Deutsch, "On Communication Models in the Social Sciences," Public Opinion Quarterly (Fall, 1952), pp. 356-380.

the line organization does not furnish management with all the information that is needed to guide the organization in a rapidly changing environment. The recognition of this need has brought about the establishment of a number of specialized communication channels which gather information about the action taken and the internal state of the organization. Some of these channels are cost accounting systems, suggestion box systems, merit rating plans and morale surveys.

These communication channels in an organization that transmit information from the extremities of the organization back to management (the "brain") are in this model seen to be feedback mechanisms. They serve the purpose of allowing management to initiate corrective action through orders and policies that will tend to stabilize or guide the organization toward its objectives.

Morale Surveys as Feedback Communication Channels

Morale surveys are seen to be channels of communication that transmit information from the employees to management. Because of this and the fact that this information is used by management in deciding upon what action should be taken to increase employee satisfaction, morale surveys serve as feedback mechanisms. If the actual state of employee morale is transmitted to management and management initiates action that tends to increase morale, the channel is thus serving the purpose of stabilizing and guiding the organization just as feedback channels tend to stabilize the activity of animals and machines.

The information that is transmitted from the nerve endings in the hand back to the brain during the performance of a simple task is in no way controlled by the brain. The impulses inform the brain of the

actual state of the muscles, tendons and joints and not necessarily the expected state. The source of information that transmits feedback information is independent of the destination in that the destination cannot dictate what the information shall be. This must be the situation in order for a channel to serve as a stabilizing and guiding mechanism.

In order for morale surveys to be effective feedback mechanisms, the employees should have complete control of the channel. Ordinarily this is not completely true. The communication procedure that is usually followed is shown in Figure 2. The survey is almost always done by an

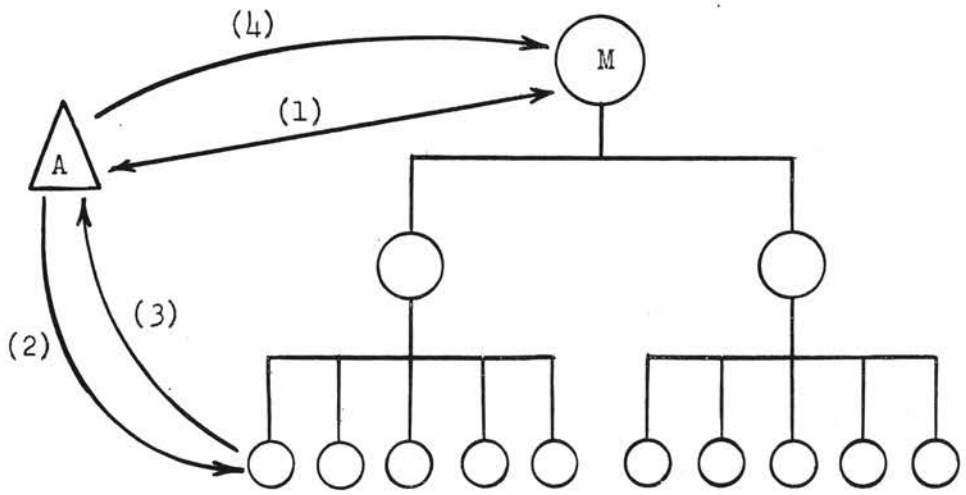

Figure 2

Typical Morale Survey Communication Procedure

outside agency (A). There is a discussion between the agency and management (M) about the information that is needed (1). On the basis of this discussion, the agency (A) constructs some type of questionnaire which is given to the employees (2). The questionnaire is completed and sent back to the agency (3). The agency analyses the information and converts it into some meaningful form and writes a report to management (4). In this situation it is difficult, if not

impossible, to keep management from partially controlling the content of the information that is received.

The communication procedure as shown in Figure 3 would serve much better as a feedback mechanism. In this case an outside agency (A) is hired to receive and analyze the employee statements. Management notifies all employees that this communication channel has been established for their use and will be in operation for a certain period of time. Each employee is urged to inform the agency of any aspects of their job life that they themselves feel to be important to their own morale and whether or not they are satisfied with these job aspects (1). This information is received, analyzed and converted into a meaningful form and sent to management (2). In this case, the employees are in complete control of the channel. This channel may, therefore, serve more effectively as a feedback mechanism.

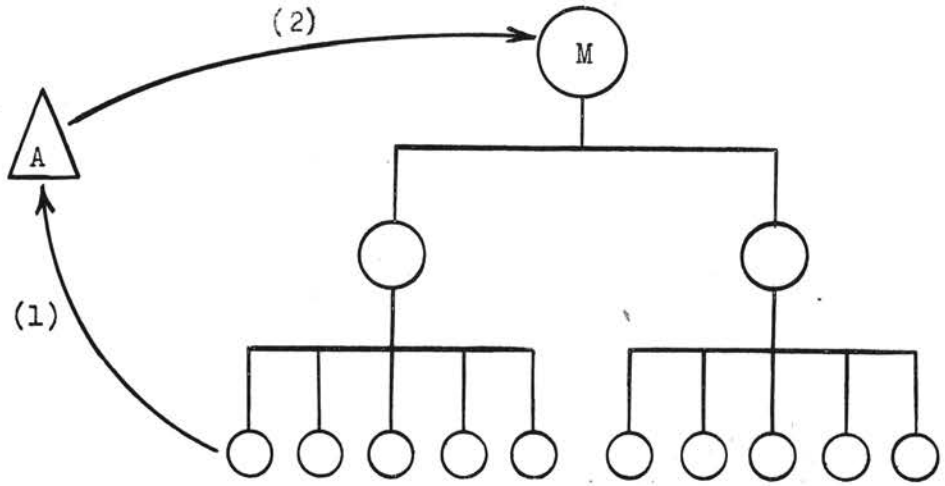

Figure 3

Morale Survey Communication Procedure

in a True Feedback Channel

The burden of interpretation has also been shifted from the employee in the first case to management in the second. When the questionnaire is used, the employee must interpret each question and decide just what information management wants. This in itself violates the feedback principle. In the second case, management interprets the meaning of the information transmitted by the employees.

The Measurement of Information by the Mathematical Theory of Communication

Shannon,[4] of the Bell Telephone Laboratories, has developed a mathematical theory of communication in which a method for measuring the amount of information is presented. The concept of information is used in this theory in a special sense which must not be confused with ordinary usage of the word. It cannot be emphasized too strongly that information must not be confused with meaning. Only the amount of information is measured. The quantitative measurement of the amount of information in a communication situation does not in any way specify the content, truthfulness, value, history, purpose, exclusiveness, correctness, or that the information has any meaning at all for any particular individual or group.

Information may be defined as the occurrence of one of a set of alternative discriminative stimuli.[5] A discriminative stimulus is a stimulus that is arbitrarily, symbolically, associated with some thing (or state, or event, or property) and that enables the stimulated or-

---

[4]Claude E. Shannon and Warren Weaver, The Mathematical Theory of Communication (Urbana 1949), pp. 99-106.

[5]George A. Miller, Language and Communication (New York 1951), p. 41.

ganism to discriminate this thing from other things. The content of the information concerns the particular discriminative stimulus that does occur. The amount of information concerns the range of possible alternatives that could occur.

The amount of information is related not so much to what is said, as to what could have been said. The amount of information conveyed by a symbol cannot be determined by an examination of that symbol alone, but from an examination of the range of symbols that could have occurred instead but did not. Information, in this sense, is a measure of one's freedom of choice when one selects a message. If only two alternative messages could be selected, e.g., the "dit" or "dah" of telegraphic code, the selection of one or the other, can convey relatively little information. If there are thousands of alternatives possible, e.g., the words in any language, the selection of one symbol out of this large range of alternatives carries a relatively large amount of information.

In the simplest cases, the amount of information is defined as the logarithm of the number of alternatives. It is most convenient to use logarithms[6] to the base 2 rather than to the base 10. A two choice situation conveys unit information since $\text{Log}_2 2 = 1$. This unit of information is called a "bit," which is a condensation of "binary digit." Numbers are represented in the binary system by the two digits 0 and 1. In this system zero and one may be used to represent any two choices. Other units of measurement could have been used but the "bit" has been arbitrarily selected because it seems to be the most convenient.

It may seem strange that the amount of information is defined as the logarithm of the range of alternatives. However, it may be shown

---

[6]When $M^x = y$, then x is said to be the logarithm of y to the base M.

that the logarithmic measurement is the logical and natural one to use. If a relay with two positions, off and on or 0 and 1, can handle one bit or unit information, how much information can be handled by three relays? It seems logical that three relays could handle three times as much as one relay or three bits of information. Three relays are able to respond in eight combinations or alternatives. If 0 indicates a closed contact and 1 indicates an open contact, then three relays could respond as follows: 000, 001, 011, 010, 100, 110, 101, 111. Since the range of alternatives is eight, the amount of information in this situation is defined as $\text{Log}_2 8$ which equals 3 bits since $2^3 = 8$. So the logarithmic measure assigns three units of information to this situation just as one would wish.

So far the simple case of equal choice among the available alternatives has been considered. For example, in the case of a two choice situation, it has been assumed that one is completely free to choose between the two alternatives. In this case one would say that each alternative is equally probable or that $p_1 = p_2 = 1/2$. Suppose, however, that one is not completely free to choose between the available alternatives, or in other words, the probability of the occurrence of the various symbols are not equal. The amount of information in this situation may be determined by the following formula:[7]

$$H = -\left[p_1 \text{Log}_2 p_1 + p_2 \text{Log}_2 p_2 + \ldots + p_n \text{Log}_2 p_n\right]$$

$$\text{or} \quad H = -\sum p_i \text{Log}_2 p_i \ .$$

The occurrence of the various symbols from this set are independent, i.e., the occurrence of one symbol does not alter the probabilities of

---

[7] Shannon and Weaver, p. 105.

of the occurrence of any other symbol in the set.

The amount of information that can be conveyed by a fixed range of alternative symbols is a maximum when the probabilities of the occurrence of the symbols are equal. That is when $p_1 = p_2 = p_3 = p_n$. Thus H is largest when one is completely free and unbiased in his choice from a set of alternatives and the amount of information is reduced to zero when one's freedom of choice is gone. If it is known that one and only one symbol can occur then the occurrence of that symbol can give no knowledge that is not already known. Before information can be conveyed by an occurrence of an event, there must be some uncertainty about which event will occur out of a range of possible events. The greater the uncertainty of just which event will occur, the greater will be the amount of information conveyed when one of the events does occur. It may be seen that information is that which reduces uncertainty or ignorance.

Up to this point the occurrence of the various events out of a range of events have been considered to occur independently. The case of interdependence between events will now be considered. Obviously, if there is a perfect dependence between two events such as x always occurring when y occurs and y always occurring when x occurs, the occurrence of either of the events conveys all the information that they can convey jointly since there is no reduction of uncertainty when the other event occurs. It will be recalled that the maximum amount of information is conveyed when the events are independent and the probabilities of occurrence are equal. If the events are not completely independent something less than the maximum amount of information can be conveyed by the range of alternatives.

Suppose there are two events, x and y, that are not completely independent or completely dependent. In order for the amount of information

to be calculated in this situation the probability of x alone occurring must be known, the probability of y alone occurring must be known, and the probability of the joint occurrence of x and y must be known. The amount of information conveyed by the occurrence of x alone is calculated by the formula:

$$H_{(x)} = - p_x \, Log_2 p_x$$

The amount of information conveyed by the occurrence of y alone is calculated by the formula:

$$H_{(y)} = - p_y \, Log_2 p_y$$

The amount of information conveyed by the joint occurrence of x and y is calculated by the formula:

$$H_{(x,y)} = - p_{x,y} \, Log_2 p_{x,y}$$

$H_{(x)} + H_{(y)}$ will equal $H_{(x,y)}$ if x and y are completely independent. If x and y are not independent $H_{(x)} + H_{(y)}$ will be larger than $H_{(x,y)}$ and become increasingly greater as the correlation increases.

If the events x and y are correlated, it may be seen that if x has occurred a smaller amount of information will be conveyed by y if it occurs than if x had not occurred. Likewise, if y has occurred a smaller amount of information will be conveyed by x if it occurs than if y had not occurred. If the amount of information conveyed by the occurrence of y when x is known is symbolized as $H_x(y)$, this amount of information may be calculated by the formula:

$$H_x(y) = H_{(x,y)} - H_{(x)}$$

Likewise $H_y(x)$ is calculated by the formula:

$$H_y(x) = H_{(x,y)} - H_{(y)}$$

This situation is represented schematically in Figure 4.[8] The area of the left circle called $H_{(x)}$ represents the amount of information conveyed by the occurrence of x alone. The right circle called $H_{(y)}$ represents the amount of information conveyed by the occurrence of y alone. The area of these two circles minus the area that is common to both represents the amount of information conveyed by the joint occurrence of x and y. The larger the correlation between x and y, the larger will be the area represented by C. Thus, the total amount of information in the joint occurrence of x and y decreases as the correlation increases. This may be represented mathematically as follows:

$$H(x,y) = H(x) + H_{(y)} - C$$

$H_{x(y)}$ and $H_{y(x)}$ also decrease as the correlation increases as can be seen in Figure 4.

There are three ways in which the amount of information that is transmitted in a communication situation may be increased. They are as follows:

1. The amount of information per event is increased if the range of alternative events that can occur is increased.
2. The amount of information per event will be at a maximum for any fixed range of alternative events if the probability of the occurrence of the various events is equal.
3. Then, of course, the amount of information transmitted may always be increased by increasing the number of events that do actually occur. If the range of alternative events

---

[8]George A. Miller, "What Is Information Measurement," The American Psychologist Vol. 8, No. 1 (January 1953), pp. 5-6.

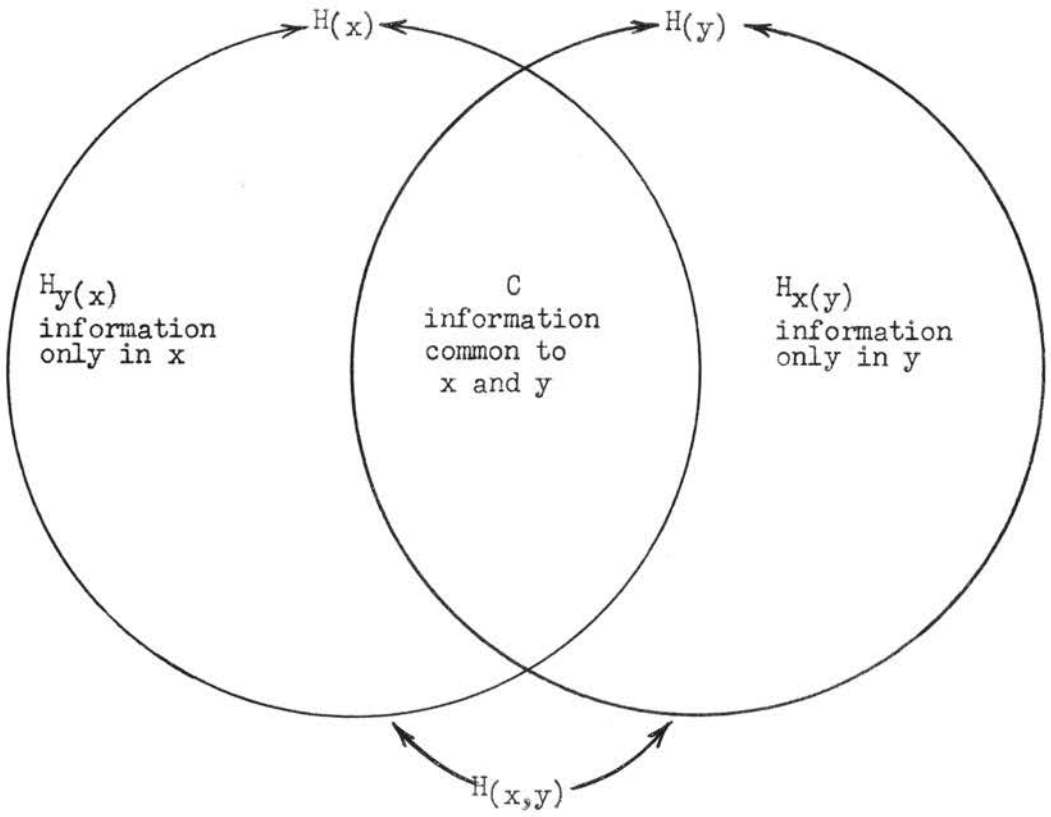

Figure 4

A Schematic Representation of the Amount of

Information in Dependent Events

is fixed and the probability of the occurrence of each event is fixed, the actual occurrence of an event will convey some information - then if another event occurs more information will be conveyed. The amount of information will be increased by the occurrence of each additional event even when an event is repeated.

The Amount of Information as a Measure of Morale

Since morale surveys are considered to be communication channels, it seems logical to use the mathematical theory of communication as a method of analyzing the information transmitted by these channels. It has been shown that it is mathematically feasible to measure the amount of information transmitted in any communication situation if the probabilities of the occurrence of the communicative units are known. It is possible to calculate the probability of the occurrence of each employee statement category in all types of morale surveys. This may be done by simply dividing the number of times each statement category occurs by the total number of statements in all categories. There can be no doubt that the amount of information transmitted by the media of morale surveys can be measured. The quantity of symbolic behavior can be measured.

It is the central thesis of this paper that the amount of information transmitted by the proper type of morale survey under appropriate conditions is in fact a measure of morale. In order for the amount of information to be a measure of morale, the amount of information transmitted must be directly related to the level of morale. It is believed that a group of employees with relatively high morale will transmit more information expressing favorable attitudes and opinions and less information expressing unfavorable attitudes and opinions than will a group of employees with relatively low morale if each employee is free to express any and all possible attitudes and opinions about any aspect of his work life. If this is true, a measure of the amount of information transmitted would be a measure of morale. The survey technique used as the communication medium would have to allow the partici-

pating employees complete freedom of expression.

If the proper technique were used in gathering information from two employee groups, one with extremely high morale and the other with extremely low morale, it would seem safe to make the following assumptions:

1. The group of employees with high morale would like more different things about their job life than would the group of employees with low morale. If each were perfectly free to express these attitudes, the high morale group would express a wider range of favorable attitudes than the low morale group. The converse would be true regarding unfavorable attitudes.
2. In addition to a wider range of favorable attitudes, on the average, the individual employees of the high morale group would express a larger number of favorable attitudes than would be expressed, on the average, by employees of the low morale group. The converse would be true regarding unfavorable attitudes.
3. Since the individual employee in the high morale group tends to express a larger number of favorable attitudes from the available range of attitudes, the probability of the occurrence of the various attitudes from the available range would tend to become equalized. If each employee expressed every attitude of the range of attitudes, the probabilities would be equal. Since the individual employee in the low morale group tends to express few favorable attitudes from the available range of attitudes, the probability of the occur-

rence of the various attitudes would tend to be increasingly unequal as the number of attitudes expressed decreased. If each employee expressed only one favorable attitude, it would be expected that the probability of the occurrence of a few attitudes would be relatively high and the others in the range would be relatively low or zero. The converse would be true regarding unfavorable attitudes.

In the development of the mathematical theory of information measurement it was shown that the amount of information transmitted in a communication situation may be increased by: (1) Increasing the range of alternative events that can occur; (2) Choosing an increasing number of events from this range; (3) Choosing the events from the range of alternatives equally often, i.e., tending to have maximum uncertainty about just which event will occur. These three means of increasing the amount of information as measured by the mathematical theory of communication are the same ways in which employees would be expected to respond as their morale increased if they were free to do so. Therefore, if an increasing level of employee morale causes employees to: (1) Express more different favorable attitudes toward their work life; (2) Express a larger number of favorable attitudes from this range; (3) Tend to express the various attitudes equally often, a mathematical measure of the amount of information transmitted is a measure of morale.

CHAPTER III

AN APPLICATION OF INFORMATION THEORY

The General Motors My Job Contest[1]

In 1947 the Employee Research Section of the General Motors Corporation conducted a letter-writing contest which was called My Job Contest (MJC). Each participating employee wrote a letter entitled "My Job and Why I Like It." An extensive promotional campaign was carried out and 174,854 employees participated. This was 58.8 per cent of all eligible employees. The entries were judged and five thousand individual prizes were awarded. The prizes ranged from a Cadillac convertible to automobile accesory kits.

This contest was carried out with the general purpose of improving the communication between employees and management. It, however, was only part of a long-range communication program.

The contest had four major specific objectives. These were:

1. To encourage more constructive attitudes in the minds of employees by directing their attention to the positive aspects of their jobs.
2. To place certain educational bulletins in the hands of employees that would indicate some of the benefits derived from employment with General Motors.
3. To collect material for the enlightenment and education of supervisory and management groups.

---

[1]Chester E. Evans and Lavern N. Laseau, "My Job Contest," Personnel Psychology, Vol. 2 (1949), pp. 1-17, 185-227, 311-367, 461-490.

4. To obtain a body of data for the analysis of employee attitudes.[2]

The first two of the objectives were completed during the contest. A satisfactory accomplishment of the last two objectives depended upon the proper analysis and use of the tremendous body of material collected during the contest. This material had to be analyzed in such a manner as to make it meaningful to supervisory and management groups; also the data had to be analyzed so that cross-comparisons of morale could be made between various sub-populations. The large mass of data made this a formidable research undertaking.

The General Motors Analysis of MJC Data

The analysis of the data was begun with the assumption that it would be possible to analyze the human and personal documents to produce a significant reflection of employee thinking. It was felt that "A human and personal document, such as the employees submitted in MJC, was a record of a person's thoughts, when his mind was at liberty to discuss subject matter of interest or importance to himself."[3]

This is the most important unique feature of MJC. This technique is similar to non-directive counseling and psycho-analysis in which a person is free to express anything without control by another person. It should also be noted that this free expression of employee opinion which is not controlled by management is, in fact, a feedback communication channel. As such, the information transmitted by this channel can serve the true purpose of a feedback mechanism, i.e., to guide

---

[2] Ibid., p. 6

[3] Ibid., p. 186.

and stabilize the organization toward its goals.

The first task facing the research group was that of a content analysis system that would allow a quantification of the huge mass of narrative material. A system of 77 theme categories was devised that was meaningful and had high reliability. The reliability was determined by obtaining correlations between independent coding readers. A group of coding readers were trained and the coding of each entry was punched on oversize IBM cards.

This process of content analysis destroyed the uniqueness of the respondents original phrasing and patterning of the letters. It should be obvious, however, that this is inevitable any time a mass of qualitative data is converted into quantifiable units for tabulating purposes. As such, any content analysis structure is by necessity a superficial representation of the original material.

After all of the entries had been coded and punched on IBM cards, frequency counts were made of the 77 items. Frequency distributions were determined for the GM total population and also for each Division of GM.

The following working hypothesis was formulated:

> "Any outstanding differences that exist between any Division and the distribution of themes within GM as a whole, must be due to something within that Division. This would follow, irrespective of any external influences that were uniform for all Divisions. Such external influences would be apparent in the general patterning of themes purely on the basis of number of mentions."[4]

---

[4] Ibid., p. 214.

Subsequent analysis of the percentage distributions indicated that 19 of the 77 themes were not sensitive enough for meaningful results. These 19 themes were either discarded or combined with themes of similar content. For example, less than one per cent of the employees mentioned the union. This theme was discarded. An example of combining themes was that of parties and picnics. Separately the percentages were too small but they appeared to be stronger in combination.

Percentage calculations were made of the frequency distributions of the remaining 58 themes for the GM total population and each Division. A study of the rank order of the differences between the Divisions and the GM total population indicated that the results did not seem to agree with the few local conditions on which the researchers had information. Because the working hypothesis stated that differences in theme distribution would be caused by something within the Divisions and since the percentage differences did not seem to reflect known conditions within the Divisions, it was decided to find a more meaningful method of analyzing the data instead of rejecting the working hypothesis.

The method of analysis that was used was the chi-square test of goodness of fit between two distributions of data. This test cumulates the deviations between two distributions and produces a single index figure which gives the total amount of deviation between the two distributions. The deviation between the all Division distribution and each Division distribution was determined by first obtaining a chi-square index of significant differences between each distribution and the theoretical normal distribution. This index was determined by the formula $X^2 = \frac{(f_o - f_e)^2}{f_e}$, where f_o is the observed frequency and f_e

is the theoretically expected frequency. The difference between the obtained chi-square indices gave the total amount of deviation between two distributions. This variation of the chi-square test made it possible to get an index of significant deviation at each of the 58 points on the distribution. Differences in the magnitude of the deviation index made possible the ranking of themes in descending order for each Division as compared to all of GM. Even though the chi-square method does not have a plus or minus sign, this variation carried a sign so that it could be determined if the number of themes mentioned in a Division was above or below the total GM distribution.

A number of statisticians examined this application of the chi-square test and could find no serious objection to its use in the analysis of MJC data.

The themes for each Division were ranked in descending order after the computation of the indices of significant difference. The Divisions were also ranked in descending order on each theme.

Tests of validity were made on objectively verifiable themes such as cafeteria services, suggestion plans and medical facilities. For example: "The rank order of the Divisions medical facilities was submitted to the Medical Consultant for General Motors, with a query as to how he felt this ranking tallied with the comparative position of the Divisions on medical facilities. After studying the ranking, he stated that he believed it would be difficult to produce a better or more accurate ranking of Division performance on medical facilities."[5]

This and similar checks was apparently enough to convince members

---

[5] Ibid., p. 224.

of the Employee Research Section that validity was high. Most staff personnel were "amazed" at the correspondence between the MJC ranking and their own knowledge of relative Division performance. Nevertheless, the question still remains: How high is high validity? Also, how much correspondence does it take to "amaze" a GM staff personnel man?

It seemingly would have been more convincing if the staff personnel would have ranked the Divisions from their own knowledge of conditions existing within the Divisions independent of any knowledge of MJC reslts. Then correlation coefficients could have been obtained between these rankings and the MJC rankings. These correlation coefficients would have been one indication of how "high" the validity was.

It is usually not recognized that there are two distinct types of validity. One is called internal and the other external.[6]

Internal validity is a problem of definition. Does the content of a particular statement belong in the universe? Only a judgment of the content can answer this question. In the construction of questionnaires this judgment is made by management. This question was answered by the participating employees in MJC because it was assumed that the statements made by the employees were those that the employees felt to be important to their own morale.

External validity is a problem of prediction. Thus any universe may have many external validities because it may be used for many different predictive purposes. This is one reason why the external validity of morale surveys is difficult to determine. Any particular survey may have high validity in the prediction of one thing but low validity

---

[6]Stauffer and others, pp. 57-59.

in the prediction of another. A morale survey has a number of validities not just validity.

These validity tests indicated that the chi-square test was superior to simple percentages in detecting the conditions within the Division. The analysis of employee attitudes as were reflected in the letters was then complete.

Published data is available on the theme distributions of the total GM population and Division No. 48.[7] These percentage distributions are given in Table 1.

The chi-square indices of significant differences between Division No. 48 and all Divisions[8] is shown in Table 2.

The MJC data seemed to have served rather effectively as a feedback mechanism. The MJC results were given to all Divisions. Each Division then was able to evaluate its internal conditions as compared with all Divisions. On the basis of the evaluation of the results of the MJC each Division was able to locate those areas in which they were doing an outstanding job and those areas in which they were not doing so well. This information enabled management to make much better decisions in formulating policy and initiating action in the proper areas than could have possibly been made without this information.

---

[7] Evans and Laseau, p. 220-221.

[8] Ibid., p. 226.

TABLE 1

The Percentage Distribution of 58 Themes in All Divisions and in Division 48

Theme Category	All Divisions Percent Mention	Division 48 Percent Mention
Supervision	47.9	44.9
Associates	41.2	39.7
Wages	40.9	35.6
Work Type	33.7	35.3
Pride in Company	32.2	34.7
Management	31.3	27.7
Insurance	28.7	25.5
Pride in Project	25.6	22.6
Benefit from Wages	23.7	20.9
Pride in Stability of Co.	22.8	21.8
Safety	22.8	15.8
Security	21.5	24.3
Training, Education, Exp.	21.5	26.9
Opportunity for Advancement	21.5	25.8
Medical Facilities	20.2	11.2
Teamwork	18.6	19.4
Tools, Methods and Equip.	16.6	14.7
Paid Vacation	16.3	14.3
Cleanliness	15.7	10.3
Pride in Important Job	15.1	17.9
Hospitalization Plan	14.3	9.6
Fair Treatment	14.0	14.5
Non-discrimination	11.5	13.3
Steady Work	11.1	14.7
Cafeteria	10.5	5.2
Suggestion Plan	10.1	10.3
Job Description	9.4	10.2
Recreation	8.9	11.6
Saving Plan	8.7	6.8
Working Hours	8.5	7.9
Free Enterprise	8.0	7.3
Comparison with Other Cos.	7.9	9.9
Company and America	7.5	8.1
Air and Temperature	7.2	5.6
Pride in Years Service	7.1	5.7
Personal History	6.6	6.3
Lighting	6.2	4.6
Personnel Policies	6.0	4.7
Plant Location and Transp.	5.9	3.1
Wash Rooms	5.8	2.6
Comparison with Other Jobs	5.4	6.5
Suitable Placement	5.4	5.6
Employee Relations	4.6	5.0
Personnel Department	3.5	3.0

TABLE 1 (CONTINUED)

Theme Category	All Divisions Percent Mention	Division 48 Percent Mention
Pride in Commu. Rela.	3.5	2.0
Modern Plant	3.4	3.4
Locker Rooms	3.2	.9
Parking Facilities	3.2	1.7
Paid Holidays	3.1	1.9
Information Services	2.6	2.5
Pension Plans	2.5	4.1
Seniority	2.4	1.6
Success Theme	1.8	2.4
Parties and Picnics	1.8	5.7
Rest Periods	1.3	.4
Leaves of Absence	1.1	1.7
Pride in Bldg. Good Pro.	.8	1.7
Open House	.3	.04

TABLE 2

Indices of Significant Difference Between All Divisions and Division 48

Theme Category	Index
Supervision	0
Associates	1
Wages	-13
Work Type	20
Pride in Company	32
Management	-12
Insurance	-5
Pride in Product	-5
Benefit from Wages	-5
Pride in Stability of Company	0
Safety	-82
Security	41
Training, Education, Experience	116
Opportunity for Advancement	85
Medical Facilities	-175
Teamwork	11
Tools, Methods and Equipment	-3
Paid Vacation	-4
Cleanliness	-74
Pride in Important Job	15
Hospitalization Plan	-60
Fair Treatment	7

TABLE 2 (CONTINUED)

Theme Category	Index
Non-discrimination	31
Steady Work	89
Cafeteria	-119
Suggestion Plan	3
Job Description	11
Recreation	69
Saving Plan	-12
Working Hours	0
Free Enterprise	0
Comparison with Other Companies	41
Company and America	8
Air and Temperature	-12
Pride in Years Service	-7
Personal History	0
Lighting	-14
Personnel Policies	-8
Plant Location and Transportation	-60
Wash Rooms	-79
Comparison with Other Jobs	18
Suitable Placement	3
Employee Relations	5
Personnel Department	-2
Pride in Community Relations	-25
Modern Plant	1
Locker Rooms	-81
Parking Facilities	-30
Paid Holidays	-17
Information Services	0
Pension Plans	70
Seniority	-10
Success Theme	14
Parties and Picnics	503
Rest Periods	-34
Leaves of Absence	25
Pride in Building Good Product	71
Open House	-11

The Analysis of MJC Data by Information Theory

It has been shown in CHAPTER III that the amount of information transmitted by a communication channel can be measured if the probabilities of the occurrence of each discrete communicative event is known. If the events are independent and the probabilities of occurrence are $p_1, p_2 \cdots p_n$, then the formula for the total amount of information is as follows:[9]

$$H = - K \left[p_1 \text{Log}_2 p_1 + p_2 \text{Log}_2 p_2 \cdots p_n \text{Log}_2 p_n \right]$$

$$\text{or} \quad H = - K \sum p_i \text{Log}_2 p_i$$

If the events are not independent, the above formula is not applicable for calculating the total amount of information. In the case of interdependence of the events the inter-correlations must be known. Even though the events are not independent, the amount of information transmitted by the occurrence of one of the events may be determined by the formula $p_i \text{Log}_2 p_i$.

The published data of MJC will be analyzed by the mathematical theory of communication. The results obtained by this method of analysis will be compared with the results obtained by the chi-square test. If a high correlation is obtained between the results of the two methods, it could be assumed that both methods yield the same results. If the correlation is low, it will be assumed that the two methods do not yield the same results. Unfortunately, it will be impossible to compare the validity of the two methods since no external criterion data are available.

---

[9] Shannon and Weaver, p. 105.

Therefore, if it should be shown that the two methods do not yield identical results, this within itself will in no way indicate that either method is superior to the other. A determination of the comparative validities must await further research.

It will be shown that the information theory method of analysis has certain advantages over the chi-square method in that it will yield a number of overall measures of morale that cannot be obtained by the chi-square method.

The percentage mention of each of the 58 categories was given in Table 1 for all Divisions and Division 48. From this percentage Table it is possible to calculate the probabilities of the occurrence of each of the 58 categories. The probabilities of the occurrence of the 58 categories for all Divisions is shown in Table 3.

The probabilities are calculated in the following manner:

First the total number of times that each theme was mentioned is calculated. This is done by multiplying the percentage mention by the total number of employees that participated, which was 174,859. For example, 47.9 per cent of the participating employees mentioned supervision as one of the things they liked about their job. To obtain the total number of times supervision was mentioned, it is necessary to multiply 174,859 by .479 which is 83,757. The number of times that each theme was mentioned is calculated in the same way.

Next, it is necessary to determine the total number of times that all themes were mentioned. This is done by adding up the number of times that each theme occurred. This sum is 1,298,927.

It is now possible to calculate the probabilities of the occurrence of each of the categories as a GM employee starts to write a theme. This is done by dividing the number of times that each theme occurred by the number of times that all themes occurred. For example, to obtain the probability that a GM employee will write about supervision, 83,757 is divided by 1,298,927 which gives .0645.

It is now possible to calculate the amount of information transmitted each time any one of the 58 themes was mentioned. This may be done by substituting in the formula $H_o = p_i \text{Log}_2 p_i$. This process has been simplified considerably by reference to the Information Table given in the Appendix. In this Table the amount of information has been calculated for all probabilities from .001 to .999. For example, the amount of information transmitted when the probability is .0645 is found in the Table to be .2563 bit. The amount of information is determined for each theme in the same manner and listed in Table 3 under Column H_o.

Now that the amount of information transmitted by the occurrence of one of each of the 58 theme categories has been determined, it is possible to calculate the total amount of information transmitted within each theme category. This is done by multiplying H_o by the total number of times the particular theme was mentioned. For example, each time supervision was mentioned, .2563 bit was transmitted. Since supervision was mentioned 83,757 times, there was .2563 multiplied by 83,757 or 21,467 bits of information transmitted about supervision. This procedure is repeated for each theme category and the results are

listed under Column H_t of Table 3. The same procedure is followed in the analysis of the data obtained from Division 48. The results are presented in Table 4.

TABLE 3

The Amount of Information Transmitted by Employees in All Divisions

Theme Category	Total Mention	Probability of Mention	H_o	H_t
Supervision	83,757	.0645	.2563	21,467
Associates	72,042	.0555	.2329	16,779
Wages	71,517	.0551	.2301	16,456
Work Type	58,927	.0454	.2013	11,862
Pride in Company	56,305	.0433	.1952	10,991
Management	54,731	.0421	.1921	10,465
Insurance	50,185	.0386	.1825	9,159
Pride in Product	44,763	.0345	.1693	7,578
Benefit from Wages	41,442	.0319	.1589	6,585
Pride in Stab. of Co.	39,868	.0307	.1554	6,195
Safety	39,868	.0307	.1554	6,195
Security	37,595	.0289	.1481	5,568
Training, Educ. & Exp.	37,595	.0289	.1481	5,568
Opportunity for Adv.	37,595	.0289	.1481	5,568
Medical Facilities	35,322	.0272	.1407	4,970
Teamwork	32,524	.0250	.1330	4,326
Tools, Methods & Equip.	29,027	.0223	.1211	3,515
Paid Vacation	28,502	.0219	.1211	3,452
Cleanliness	27,453	.0212	.1170	3,212
Pride in Impor. Job.	26,404	.0203	.1129	2,981
Hospitalization Plan	25,005	.0193	.1086	2,716
Fair Treatment	24,480	.0188	.1043	2,553
Non-discrimination	20,109	.0155	.0955	1,920
Steady Work	19,404	.0149	.0909	1,764
Cafeteria	18,360	.0141	.0862	1,583
Suggestion Plan	17,661	.0136	.0862	1,522
Job Description	16,437	.0127	.0814	1,338
Recreation	15,562	.0120	.0766	1,192
Saving Plan	15,213	.0117	.0766	1,165
Working Hours	14,863	.0114	.0716	1,064
Free Enterprise	13,989	.0108	.0716	1,002
Comp. with Other Cos.	13,813	.0106	.0716	989
Company and America	13,114	.0101	.0664	871
Air and Temperature	12,590	.0097	.0664	836
Pride in Years Service	12,415	.0096	.0664	824
Personal History	11,541	.0089	.0612	706
Lighting	10,841	.0083	.0557	604

TABLE 3 (CONTINUED)

Theme Category	Total Mention	Probability of Mention	H_o	H_t
Personnel Policies	10,492	.0081	.0557	584
Plant Loca. & Transp.	10,317	.0079	.0557	575
Wash Rooms	10,142	.0078	.0557	565
Comp. with Other Jobs	9,442	.0073	.0501	473
Suitable Placement	9,442	.0073	.0501	473
Employee Relations	8,044	.0062	.0443	356
Personnel Department	6,120	.0047	.0382	234
Pride in Commu. Rela.	6,120	.0047	.0382	234
Modern Plant	5,945	.0046	.0382	227
Locker Rooms	5,595	.0043	.0319	178
Parking Facilities	5,595	.0043	.0319	178
Paid Holidays	5,421	.0042	.0319	173
Information Serv.	4,546	.0035	.0319	145
Pension Plans	4,371	.0034	.0251	110
Seniority	4,197	.0032	.0251	105
Success Theme	3,147	.0024	.0179	56
Parties & Picnics	3,147	.0024	.0179	56
Rest Periods	2,273	.0017	.0179	41
Leaves of Absence	1,923	.0015	.0179	34
Pride in Bldg. Good Pro.	1,399	.0011	.0100	14
Open House	525	.0004	.0000	0
Total	1,289,927			

TABLE 4

The Amount of Information Transmitted by Employees in Division 48

Theme Category	Total Mention	Probability of Mention	H_o	H_t
Supervision	2,805	.0649	.2563	719
Associates	2,480	.0537	.2356	584
Wages	2,224	.0515	.2218	493
Work Type	2,205	.0510	.2190	483
Pride in Company	2,168	.0502	.2161	469
Management	1,731	.0400	.1858	325
Insurance	1,593	.0369	.1760	280
Pride in Product	1,412	.0326	.1624	229
Benefit from Wages	1,306	.0302	.1518	198
Pride in Stab. of Co.	1,362	.0315	.1589	216
Safety	987	.0228	.1252	112
Security	1,518	.0351	.1693	257
Training, Educ. & Exp.	1,681	.0388	.1825	307
Opportunity for Adv.	1,612	.0373	.1760	284

TABLE 4 (CONTINUED)

Theme Category	Total Mention	Probability of Mention	H_o	H_t
Medical Facilities	670	.0155	.0955	64
Teamwork	1,212	.0280	.1170	175
Tools, Methods & Equip.	918	.0212	.1170	107
Paid Vacation	893	.0207	.1170	105
Cleanliness	644	.0149	.0909	58.5
Pride in Impor. Job.	1,118	.0259	.1369	153
Hospitalization Plan	600	.0139	.0862	51.7
Fair Treatment	906	.0210	.1170	106
Non-discrimination	831	.0197	.1129	93.8
Steady Work	918	.0212	.1170	107
Cafeteria	325	.0075	.0557	18.1
Suggestion Plan	644	.0149	.0909	58.5
Job Description	637	.0147	.0909	57.9
Recreation	725	.0168	.0999	72.4
Saving Plan	425	.0098	.0664	28.2
Working Hours	494	.0114	.0716	35.4
Free Enterprise	456	.0105	.0716	32.6
Comp. with Other Cos.	619	.0143	.0862	53.4
Company and America	506	.0117	.0766	38.8
Air and Temperature	350	.0081	.0557	19.5
Pride in Years Service	356	.0082	.0557	19.8
Personal History	394	.0091	.0612	24.1
Lighting	287	.0066	.0501	14.4
Personnel Policies	294	.0068	.0501	14.7
Plant Loca. & Transp.	194	.0045	.0382	7.4
Wash Rooms	162	.0037	.0319	5.2
Comp. with Other Jobs	406	.0094	.0612	24.8
Suitable Placement	350	.0081	.0557	19.5
Employee Relations	312	.0072	.0501	15.6
Personnel Department	187	.0043	.0319	6.0
Pride in Commu. Rela.	125	.0029	.0251	3.1
Modern Plant	212	.0049	.0382	8.1
Locker Rooms	56	.0013	.0100	0.6
Parking Facilities	106	.0025	.0251	2.7
Paid Holidays	119	.0028	.0251	3.0
Information Serv.	156	.0036	.0319	5.0
Pension Plans	256	.0059	.0443	11.3
Seniority	100	.0023	.0179	1.8
Success Theme	150	.0035	.0319	4.8
Parties & Picnics	356	.0083	.0557	19.8
Rest Periods	25	.0006	.0100	0.3
Leaves of Absence	106	.0025	.0251	2.7
Pride in Bldg. Good Pro.	106	.0025	.0251	2.7
Open House	0	.0000	.0000	0.0
Total	43,226			

In making cross-comparisons between all Divisions and Division 48, the total amount of information transmitted in each theme category cannot be compared directly because of the large difference in the number of employees concerned. A meaningful comparison can be made if the total amount of information is divided by the number of participating employees to obtain the average amount of information per employee. This data is presented in Table 5.

TABLE 5

The Average Amount of Information Transmitted by Employees in All Divisions and Division 48

Theme Category	All Divisions Average H	Division 48 Average H	Difference Times 10,000
Supervision	.1229	.1151	-78
Associates	.0959	.0935	-24
Wages	.0941	.0789	-152
Work Type	.0678	.0773	95
Pride in Company	.0629	.0751	122
Management	.0598	.0520	-78
Insurance	.0524	.0448	-76
Pride in Product	.0433	.0367	-66
Benefit from Wages	.0377	.0317	-60
Pride in Stability of Co.	.0354	.0346	-8
Safety	.0354	.0179	-195
Security	.0318	.0411	93
Training, Education, Exp.	.0318	.0495	177
Opportunity for Advancement	.0318	.0455	137
Medical Facilities	.0284	.0102	-182
Teamwork	.0247	.0280	33
Tools, Method and Equipment	.0201	.0171	-30
Paid Vacation	.0197	.0168	-29
Cleanliness	.0184	.0094	-90
Pride in Important Job	.0170	.0245	75
Hospitalization Plan	.0155	.0083	-72
Fair Treatment	.0146	.0170	24
Non-discrimination	.0110	.0150	40
Steady Work	.0101	.0171	70
Cafeteria	.0091	.0029	-62
Suggestion Plan	.0087	.0094	7
Job Description	.0077	.0093	16
Recreation	.0068	.0116	46

TABLE 5 (CONTINUED)

Theme Category	All Divisions Average H	Division 48 Average H	Difference Times 10,000
Saving Plan	.0067	.0045	-22
Working Hours	.0061	.0057	-4
Free Enterprise	.0057	.0052	-5
Comparison With Other Cos.	.0057	.0086	29
Company and America	.0050	.0062	12
Air and Temperature	.0048	.0031	-17
Pride in Years Service	.0047	.0032	-15
Personal History	.0040	.0039	-1
Lighting	.0035	.0023	-12
Personnel Policies	.0033	.0024	-9
Plant Loca. and Transp.	.00328	.0012	-20.8
Wash Rooms	.00323	.00083	-24.3
Comparison with Other Jobs	.0027	.0040	13
Suitable Placement	.0027	.0031	4
Employee Relations	.00202	.0025	4.7
Personnel Department	.00133	.00096	-13.7
Pride in Commu. Rela.	.00133	.0005	-8.3
Modern Plant	.0013	.0013	0.0
Locker Rooms	.00102	.0001	-92.4
Parking Facilities	.00102	.00043	-5.9
Paid Holidays	.00099	.00048	-5.1
Information Services	.00083	.0008	-0.3
Pension Plans	.00063	.0018	11.7
Seniority	.00060	.00029	-3.1
Success Theme	.00032	.00077	4.5
Parties and Picnics	.00032	.0032	28.8
Rest Periods	.00023	.00005	-1.8
Leaves of Absence	.00019	.00043	2.4
Pride in Building Good Pro.	.00008	.00043	3.5
Open House	.00000	.00000	0.0
TOTAL	1.0882	1.0585	-297.0

A Comparison of the Two Methods

The first comparison that will be made between the results obtained by the two methods of analysis will be that of rank order of the theme categories. Table 6 lists the theme categories ranked by the magnitude of the index of significant difference between Division 48 and all Divisions as determined by the chi-square test. Table 6 also lists the rank order of the theme categories as determined by the difference

in the average amount of information transmitted by Division 48 and all Divisions.

TABLE 6

Rank Order of Theme Categories As Determined By Chi-square Test and Information Theory

Theme Category	Chi-square Test	Information Theory	Difference	Difference Squared
Supervision	30	51	21	441
Associates	24	42	18	324
Wages	45	55	10	100
Work Type	14	4	10	100
Pride in Company	11	3	8	64
Management	43	52	9	81
Insurance	35	50	15	225
Pride in Product	37	48	11	121
Benefit from Wages	36	46	10	100
Pride in Stab. of Co.	26	33	7	49
Safety	56	57	1	1
Security	10	5	5	25
Training, Educ. and Exp.	2	1	1	1
Opportunity for Adv.	4	2	2	4
Medical Facilities	58	56	2	4
Teamwork	17	10	7	49
Tools, Methods & Equip.	33	45	12	144
Paid Vacation	34	44	10	100
Cleanliness	53	53	0	0
Pride in Impor. Job	8	6	2	4
Hospitalization Plan	51	49	2	4
Fair Treatment	20	13	7	49
Non-discrimination	12	9	3	9
Steady Work	3	7	4	16
Cafeteria	57	47	10	100
Suggestion Plan	22	18	4	16
Job Description	18	14	4	16
Recreation	7	8	1	1
Saving Plan	42	41	1	1
Working Hours	29	29	0	0
Free Enterprise	31	30	1	1
Comp. with Other Cos.	9	11	2	4
Company and America	19	16	3	9
Air and Temperature	44	39	5	25
Pride in Years Service	38	38	0	0
Personal History	28	26	2	4
Lighting	46	36	10	100
Personnel Policies	6	35	29	841
Plant Loca. & Transp.	52	40	12	144

TABLE 6 (CONTINUED)

Theme Category	Chi-square Test	Information Theory	Difference	Difference Squared
Wash Rooms	54	43	11	121
Comp. with Other Jobs	15	15	0	0
Suitable Placement	23	21	2	4
Employee Relations	21	19	2	4
Personnel Department	39	37	2	4
Pride in Commu. Rela.	48	34	14	196
Modern Plant	25	24	1	1
Locker Rooms	55	54	1	1
Parking Facilities	49	32	17	289
Paid Holidays	47	31	16	256
Information Serv.	27	25	2	4
Pension Plans	6	17	11	121
Seniority	40	28	12	144
Success Theme	16	20	4	16
Parties & Picnics	1	12	11	121
Rest Periods	50	27	23	529
Leaves of Absence	13	23	10	100
Pride in Bldg. Gd. Pro.	5	22	17	289
Open House	41	41	0	0
TOTAL				5,467

From the data in Table 6 a rank correlation coefficient may be determined. This correlation coefficient may be determined by direct substitution in the following formula:

$$r = 1 - \frac{6 \sum D^2}{n(n^2-1)}$$

$$r = 1 - \frac{6x5467}{58(58^2-1)}$$

$$r = 1 - \frac{32802}{295054}$$

$$r = 1 - .111 = .889$$

It may be seen that the rank correlation coefficient is rather high which indicates that these two methods tend to rank the theme category

deviations of a Division from the total General Motors average in very nearly the same order.

A more meaningful correlation coefficient for comparing the results obtained by the two methods is the Pearson r. This coefficient takes into consideration the magnitude of differences between the results for each theme category. It would, therefore, be possible to have a rather high rank correlation coefficient and a rather low Pearson r.

Table 7 lists the data necessary for the calculation of the Pearson r.

TABLE 7

Difference Between Division 48 and All Divisions Determined By Chi-square and Information Theory

Theme Category	X Information Theory Index	Y Chi-square Index	XY
Supervision	-78	0	0
Associates	-24	1	-24
Wages	-152	-13	1,976
Work Type	95	20	1,900
Pride in Company	122	32	3,904
Management	-78	-12	936
Insurance	-76	-5	380
Pride in Product	-66	-5	330
Benefit from Wages	-60	-5	300
Pride in Stability of Co.	-8	0	0
Safety	-195	-82	15,990
Security	93	41	3,813
Training, Education, Exp.	177	116	20,532
Opportunity for Advancement	137	85	11,645
Medical Facilities	-182	-175	31,850
Teamwork	33	11	363
Tools, Methods and Equipment	-30	-3	90
Paid Vacation	-29	-4	116
Cleanliness	-90	-74	6,660
Pride in Important Job	75	51	3,825
Hospitalization Plan	-72	-60	4,320
Fair Treatment	24	7	168
Non-discrimination	40	31	1,240
Steady Work	70	89	6,230

TABLE 7 (CONTINUED)

Theme Category	X Information Theory Index	Y Chi-square Index	XY
Cafeteria	-62	-119	7,378
Suggestion Plan	7	3	21
Job Description	16	11	176
Recreation	46	69	3,174
Saving Plan	-22	-12	264
Working Hours	-4	0	0
Free Enterprise	-5	0	0
Comparison with Other Companies	29	41	1,189
Company and America	12	8	96
Air and Temperature	-17	-12	204
Pride in Years Service	-15	-7	105
Personal History	-1	0	0
Lighting	-12	-14	168
Personnel Policies	-9	-8	72
Plant Location & Transp.	-20.8	-60	1,248
Wash Rooms	-24.3	-79	2,710
Comparison with Other Jobs	13	18	234
Suitable Placement	4	3	12
Employee Relations	4.7	5	24
Personnel Department	-13.7	-2	27
Pride in Commu. Rela.	-8.3	-25	208
Modern Plant	0.0	1	0
Locker Rooms	-92.4	-81	7,484
Parking Facilities	-5.9	-30	177
Paid Holidays	-5.1	-17	87
Information Services	-0.3	0	0
Pension Plans	11.7	70	819
Seniority	-3.1	-10	31
Success Theme	4.5	14	63
Parties and Picnics	28.8	503	14,486
Rest Periods	-1.8	-34	619
Leaves of Absence	2.4	25	60
Pride in Bldg. Gd. Product	3.5	71	249
Open House	0.0	-11	0

$\Sigma X = 450.5 \quad \Sigma Y = 367 \quad \Sigma XY = 157,928$

$\Sigma X^2 = 251,881.98 \quad \Sigma Y^2 = 387,388 \quad \Sigma X \Sigma Y = 165,333.5$

$\Sigma(X)^2 = 202,950.25 \quad \Sigma(Y)^2 = 134,689$

The Pearson r may be determined by substituting in the following formula:

$$r = \frac{Sxy}{\sqrt{(Sxy)\ (Sy^2)}}$$

$$SX^2 = SX^2 - \frac{(SX)^2}{n}$$

$$SX^2 = 251881.98 - 3499.14 = 248382.84$$

$$Sy^2 = SY^2 - \frac{(SY)^2}{n}$$

$$Sy^2 = 387399 - 2322.22 = 385076.78$$

$$Sxy = SXY - \frac{SXSY}{n}$$

$$Sxy = 157928 - 2850.58 = 155077.42$$

$$r = \frac{155077.42}{\sqrt{(248382.84)(385076.78)}}$$

$$r = \frac{155077.42}{\sqrt{95646580491}} = \frac{155077}{309260} = .50$$

It may be seen that the Pearson r is considerably lower than the rank correlation coefficient. This indicates that when the magnitude of difference obtained for each theme category by the two methods is considered the correlation is rather low. When it is considered that the identically same data was analyzed by these two methods, the correlation seems especially low. This seems to indicate that the two methods of analysis do not yield the same results.

Additional measures of overall morale may be obtained by the information method of analysis. For the purposes of this discussion, it will be assumed that the theme categories are independent although very likely this is not true. It seems natural that if an employee were satisfied with one job aspect he would also likely be satisfied with other aspects which he perceives as being related in some way to the original

job aspect. Because of established social norms within the organization, other employees might also perceive the job aspects in a similar manner which would cause the mention of a number of categories to be correlated. If this is true, these related job aspects would show up as a cluster in a factor analysis of the data. Since the necessary data is not available for determining the degree of interpendence, it will be necessary to assume independence.

One measure of morale that can be made is the total level of morale in each Division. This total level within each Division can be compared to the overall morale of the Corporation. For example, a measure of the total morale of Division 48 is the total average amount of information transmitted by the employees. This is given in Table 5 to be 1.0585 bits. This is compared to an average total amount of information received from all Divisions of 1.0882 bits. It may be seen that the overall morale of Division 48 is lower than the GM average. The same type of comparison could be made between each of the Divisions of the Corporation and all Divisions. The chi-square results do not allow an overall comparison to be made but only comparisons by theme categories or morale areas. It is undoubtedly valuable to the management to know the areas in which employee satisfaction is relatively high and those areas in which employee satisfaction is relatively low in order that proper corrective action may be taken. It is also believed that a measure of overall morale would be a valuable thing to know. If overall employee morale were much lower than the Corporation average, it would seemingly indicate that intensive corrective action should be taken in the low morale areas indicated by the theme category breakdown and perhaps even take some action in those areas of relatively

high morale.

These overall measures of morale would also be valuable in comparing the level of morale at one period of time with another. If management takes corrective action in these areas of relatively low morale and then after a reasonable period of time has passed, it is desirable to measure the morale again to see if the action taken has achieved the desired results. This cannot possibly be determined by the chi-square type of analysis. For example, if a Division were relatively low in satisfaction with locker rooms, cafeteria, lighting and parking facilities and intensive corrective action were taken in these areas, it would be expected that employee satisfaction would increase as a result of the action. It is possible that employee satisfaction in the Division may have improved considerably in these areas and the chi-square results indicate that the Division is still relatively low in these areas. This would happen if the other Divisions had made similar progress in these areas and there is no way of determining whether or not they have. It is absolutely impossible to determine whether morale has changed at all unless some fixed reference point is established from which the amount and direction of change can be measured. The chi-square method of analysis has no such reference point, all measures are cross-comparisons, whereas the information theory method provides several. First, it may be determined whether the overall morale of the corporation has increased or decreased and how much. Second, it may be determined whether the overall morale has increased or decreased and how much in each of the divisions, or in any other sub-population such as women, men, supervisory personnel, non-supervisory personnel, white collar personnel, or long and short

service employees. Third, it may be determined whether morale has increased or decreased and how much within any morale area of the total Corporation population, any Division, or other sub-population. These reference points makes possible a number of invaluable evaluations of the effectiveness of past action.

Before these total amounts of information can be measured with precision, the intercorrelation, if any, must be determined. After the intercorrelations are determined, the amount of information may be determined by a formula of the Form $H_{(x,y)} = H(x) + H_{(y)} - C$ which was discussed in CHAPTER III.

This data could be obtained from the General Motors IBM cards. The process of determining these correlations would be a tremendous job. An estimate of the IBM time it would take to sort the 174,854 cards will give some indication of how big the job would be. It would be necessary to determine of the number of employees that mentioned each theme the number that also mentioned each of the other themes. This would require $\frac{N!}{(N-)!}$ or 1,653 sorts. This means that some 80,000,000 individual cards must be sorted. If the IBM handles 500 cards per minute, it would take about 276 ten hour days to do the sorting. The job could be completed in a smaller number of days by the use of more than one machine.

As big as this sorting job seems to be, it might be practical for the General Motors Corporation to do it if the information theory method should prove to be a highly valid method of measuring morale. General Motors has a very large sum of money invested in the MJC and the cost of this sorting would not be too great if it would provide

these valuable reference points that could be used when an MJC is conducted again. With these additional measures, the effectiveness of the corrective action taken could be evaluated. This sorting process would not be so formidible in morale measurement in relatively small organizations.

CHAPTER IV

SUMMARY AND CONCLUSIONS

A Summary of Communication Theory and Morale Measurement

The morale survey has been presented as a feedback communication channel in the conceptual model of cybernetics. This channel is designed for the purpose of transmitting information about employee satisfaction and dissatisfaction from the employees or members of the organization to management, or the decision center of the organization. Management needs this information in order to make intelligent decisions about the type and amount of incentives required to increase employee satisfaction and thus willingness to serve the organizational purpose.

Most types of morale surveys attempt to measure the level of employee morale from verbal behavior or information communicated by the employees. Heretofore, this measurement has been based upon qualitative rather than quantitative communicative behavior. In other words, this measurement has been inferred by what the employees say rather than how much they say. It has been proposed that a quantitative measure of how much information the employees transmit can be a measure of morale if the amount of information is directly related to the level of morale. It has been assumed that if employees are perfectly free to transmit any and all of the information that they feel is important to their own morale this relationship will exist.

This type of quantitative measurement has been made possible by the development of a mathematical method of measuring the amount of information transmitted by any communication channel provided the probabilities of the occurrence of the communicative symbols are

known. The determination of the probabilities of the occurrence of the statements of any type of morale survey is a simple problem.

It was believed that the amount of information transmitted by the participants in the General Motors Corporation's My Job Contest would be an indicator of their morale because the participants were free to communicate what they felt to be important.

The published data on the MJC was analyzed by the mathematical theory of communication and compared with the chi-square method of analysis utilized by General Motors. It was not expected that the external validity of the results obtained by these two methods could be compared because no external criterion data was available for this comparison. It was expected that the results could be compared for the purpose of determining whether the two methods would yield the same results. It was found that they do not yield identical results since the correlation between the results was .50. One of the methods, therefore, would presumably have a higher validity than the other.

The MJC data was also analyzed for the purpose of illustrating the methodology of the information theory approach to morale measurement and the type of measurements that may be obtained. It has been shown that the following measures of morale can be obtained by the information theory analysis:

1. A comparative measure of overall morale between the total organization and any sub-populations and between sub-populations.
2. A comparative measure of morale in the various morale areas between the total organization and sub-populations and between sub-populations.

3. Although it was not illustrated, a comparison of levels of overall morale and morale in the various areas can be made from one survey to the next survey. This allows invaluable checks to be made of the effectiveness of the action taken between the surveys.

A comprehensive research program is needed to determine the validity and possible applications of this proposed method of measurement.

A Suggested Research Program

One of the first steps in a comprehensive research program on the amount of information as a measure of morale should be the determination of its external validity. It has been assumed that the statements made by employees who are free to express attitudes toward their job life are related to their own morale. This is a judgment made by the individual employee which determines the internal validity of the measurement. The internal validity cannot be checked directly but it seems that high external validity would also indicate high internal validity.

It has been assumed that employees with high morale would transmit more information expressing satisfaction with their job life and less information expressing dissatisfaction with their job life than would employees with low morale. This assumption will be proved to be correct if it can be demonstrated that the technique has relatively high validity. There is some evidence to indicate that this is correct if the General Motors MJC results, as calculated by the chi-square method, have some validity. It will be recalled that a rank correlation coefficient of .89 and a Pearson r of .50 was obtained between the re-

sults of the two methods. This is rather weak evidence because both of the methods of analysis rest upon the correctness of the above assumption and the validity checks made by General Motors were not in accordance with good experimental practices.

It is, therefore, proposed that the results of an information theory survey should be validated on a number of external criteria. The availability of criterion data will, of course, determine which can be used, but the following types of data should be used, if available:

1. Personnel data
2. Production data
3. Judgment of qualified executives or staff personnel
4. Results of other accepted morale measurement techniques.

This technique may also be validated as a technique for measuring other attitudes and opinions other than morale. If the total amount of information should prove to be a valid measurement, it would seemingly provide a convenient reference point from which the direction, amount, and rate of change of important attitudes in the social, political and cultural areas. It might be possible, for example, to determine the direction and rate of change of attitudes toward Negroes in the South, or to determine the direction and rate of change of attitudes toward Communism or Democracy in various parts of the world.

Along with validation procedures, the method of obtaining the information from the respondents should be improved. The method used in the General Motors MJC was a letter writing contest. This technique

may have high internal validity, but it presents a difficult content analysis problem. Also, a large amount of information is obtained that is not used in that frequently a whole paragraph is reduced to one category of theme mention. It seemingly would be more economical to obtain only theme mentions to begin with. It is believed that the necessary information could be obtained by simply allowing the participants to list those aspects of their job life with which they are relatively well satisfied. This seemingly could be done without a large promotional campaign and without prize awards. The more simple procedure seems to work satisfactorily with questionnaire techniques.

It should also be determined whether or not the expression of both favorable and unfavorable attitudes has any effect upon the validity of the technique. General Motors wished to direct employee thinking toward only the favorable aspects of their job life. As desirable as this may be, it may result in lower validity.

Since the measurement of the total amount of information requires the correlation coefficients between the various categories, a factor analysis of the data would be feasible. A factor analysis might show the presence of clusters or constellations of theme categories. If this should be true, a measure of the amount of information in each cluster or factor could be interpreted as a quantitative measure of the various dimensions of morale as it exists in an organization at one particular time. This type of measure of morale would seemingly be useful to management.

The mathematical theory of communication may possibly be used as a method of measuring the information transmitted by other feedback channels in organizations. One such channel is that of merit or per-

formance rating. A relatively new technique of merit rating developed by Flanagan[1] called The Critical Incident Technique seems to transmit information back to management in a form that could possibly be measured by information theory. This technique differs from others in that only reports of observed behavior that are judged to be particularly effective or inefficient are transmitted back to management. In this situation it again seems reasonable to assume that a relatively large number of good incidents and relatively few bad incidents would be reported on employees of high merit. The opposite would be expected of employees of low merit. If this should prove to be true, the amount of information communicated would be a measure of employee merit.

The mathematical theory of communication seems to offer a new approach to some of the difficult problems of quantitative measurement in the social sciences. If the validity of this method of measurement can be demonstrated it would apparently be a valuable contribution to the social sciences. It is, therefore, hoped that the method has been shown to have enough merit that a comprehensive research program will be undertaken designed to conclusively prove or disprove the validity of the method; and if it does prove to have validity, to determine under what conditions, in what situations, and on what types of phenomena the measurement is valid.

---

[1]John C. Flanagan, "Critical Requirements: A New Approach to Employee Evaluation," Personnel Psychology, Vol. 2 (1949), pp. 419-425.

BIBLIOGRAPHY

Barnard, Chester I. The Functions of the Executive. Cambridge: University Press, 1950.

Deutsch, Karl W. "On Communication Models in the Social Sciences." Public Opinion Quarterly, (Fall, 1952).

Evans, Chester E. and Laseau, Lavern N. "My Job Contest." Personnel Psychology, Vol. 2 (1949).

Flanagan, John C. "Critical Requirements: A New Approach to Employee Evaluation." Personnel Psychology, Vol. 2 (1949).

Likert, Rensis. "A Technique for the Measurement of Attitudes." Arch. Psychol., No. 140 (1932).

McNemar, Quinn. "Opinion-Attitude Methodology." Psychological Bulletin, Vol. 34, No. 4 (July, 1946).

Miller, George A. Language and Communication. New York: McGraw-Hill, 1951.

Miller, George A. "What is Information Measurement." The American Psychologist, Vol. 8, No. 1 (January, 1953).

Newman, E. B. "Computational Methods Useful in Analyzing Series of Binary Data." American Journal of Psychology, 64 (1951).

Shannon, Claude E. and Weaver, Warren. The Mathematical Theory of Communication. Urbana: The University of Illinois Press, 1949.

Stouffer, Samuel A., Guttman, Louis, Suchmann, Edward A., Lazarsfeld, Paul F., Star Shirley A., and Clausen, John A. Measurement and Prediction. Vol. IV, Princeton: Princeton University Press, 1950.

Thurstone, L. L. "Theory of Attitude Measurement." Psychological Bulletin, Vol. 36 (1929).

Wiener, Norbert. Cybernetics. Cambridge: The Technology Press, 1948.

Wiener, Norbert. The Human Use of Human Beings. Boston: Houghton Mifflin, 1950.

INFORMATION TABLE[1]

Values of $(-p\text{Log}_2 p)$ for p from 0.001 to 0.999

p		0	1	2	3	4	5	6	7	8	9
.00	0.0	000	100	179	251	319	382	443	501	557	612
.01		664	716	766	814	862	909	955	999	043	086
.02	0.1	129	170	211	252	291	330	369	407	444	481
.03		518	554	589	624	659	693	727	760	793	825
.04		858	889	921	952	983	013	043	073	103	132
.05	0.2	161	190	218	246	274	301	329	356	383	409
.06		435	461	487	513	538	563	588	613	637	662
.07		686	709	733	756	780	803	826	848	871	893
.08		915	937	959	980	002	023	044	065	086	106
.09	0.3	.27	147	167	187	207	226	246	265	284	303
.10		322	341	359	378	296	414	432	450	468	485
.11		503	520	537	555	571	588	605	622	638	654
.12		671	687	703	719	734	750	766	781	796	811
.13		826	841	856	871	886	900	915	929	943	957
.14		971	985	999	012	026	040	053	066	079	092
.15	0.4	105	118	131	144	156	169	181	194	206	218
.16		230	242	254	266	278	289	301	312	323	335
.17		346	357	368	379	390	401	411	422	432	443
.18		453	463	474	484	494	504	514	523	533	543
.19		552	562	571	581	590	599	608	617	626	635
.20		644	653	661	670	678	687	695	704	712	720
.21		728	736	744	752	760	768	776	783	791	798
.22		806	813	821	828	835	842	849	856	863	870
.23		877	883	890	897	903	910	916	923	929	935
.24		941	948	954	960	966	971	977	983	989	994
.25	0.5	000	006	011	017	022	027	032	038	043	048
.26		053	058	063	068	073	077	082	087	091	096
.27		100	105	109	113	118	122	126	130	134	138
.28		142	146	150	154	158	161	165	169	172	176
.29		179	183	186	189	192	196	199	202	205	208
.30		211	214	217	220	222	225	228	230	233	235
.31		238	240	243	245	248	250	252	254	256	258
.32		260	262	264	266	268	270	272	273	275	277
.33		278	280	281	283	284	286	287	288	289	291
.34		292	293	294	295	296	297	298	299	300	300
.35		301	302	302	303	304	304	305	305	306	306
.36		306	306	307	307	307	307	307	307	307	307
.37		307	307	307	307	307	306	306	306	305	305
.38		305	304	304	303	302	302	301	300	300	299
.39		298	297	296	295	294	293	292	291	290	289
.40		288	287	285	284	283	281	280	278	277	276

[1] E. B. Newman, "Computational Methods Useful in Analyzing Series of Binary Data." American Journal of Psychology, 64 (1951) pp. 252-262.

INFORMATION TABLE (CONTINUED)

p		0	1	2	3	4	5	6	7	8	9
.41		274	272	271	269	267	266	264	262	260	258
.42		257	255	253	251	249	247	244	242	240	238
.43		236	233	231	229	226	224	222	219	217	214
.44		212	209	206	204	201	198	195	193	190	187
.45		184	181	178	175	172	169	166	163	160	157
.46		153	150	147	144	140	137	133	130	127	123
.47		120	116	112	108	105	102	098	094	090	086
.48		083	079	075	071	067	063	059	055	051	047
.49		043	039	034	030	026	022	018	013	009	004
.50	0.5	000	996	991	987	982	978	973	968	964	959
.51	0.4	954	950	945	940	935	930	926	921	916	911
.52		906	901	896	891	886	880	875	870	865	860
.53		854	849	844	839	833	828	823	817	812	806
.54		801	795	789	784	778	772	767	761	755	750
.55		744	738	732	726	720	714	709	702	697	691
.56		684	678	672	666	660	654	648	641	635	629
.57		623	616	610	604	597	591	584	578	571	565
.58		558	551	545	538	532	525	518	511	505	498
.59		491	484	477	471	464	457	450	443	436	429
.60		442	415	408	401	393	386	379	372	365	357
.61		350	343	335	328	321	313	306	298	291	283
.62		276	268	261	253	246	238	230	223	215	207
.63		200	192	184	176	168	160	152	145	137	129
.64		121	113	105	097	089	081	072	069	056	048
.65		040	032	023	015	007	998	990	982	973	965
.66	0.3	957	948	940	931	923	914	906	897	888	880
.67		871	862	854	845	836	828	819	810	801	792
.68		783	774	766	757	748	739	730	721	712	703
.69		694	685	675	666	657	648	639	630	621	611
.70		602	593	583	574	565	556	546	537	527	518
.71		508	499	489	480	470	461	451	441	432	422
.72		412	403	393	383	373	369	359	344	339	329
.73		315	305	295	285	275	265	255	245	235	225
.74		215	204	194	184	174	164	154	144	133	123
.75		113	102	092	082	072	061	051	040	030	020
.76		009	999	988	978	967	957	946	935	925	914
.77	0.2	903	893	882	872	861	850	839	828	818	807
.78		796	785	774	764	752	742	731	720	708	697
.79		686	676	665	654	642	631	620	609	598	587
.80		576	564	553	542	530	519	508	497	485	474
.81		462	451	440	428	417	405	394	383	371	259
.82		348	336	325	313	301	290	278	266	255	243
.83		231	219	208	196	184	172	160	148	137	125
.84		113	101	089	077	065	053	041	029	017	005
.85	0.1	993	981	969	957	944	932	920	908	896	884
.86		871	859	847	834	822	810	798	785	773	760
.87		748	735	723	712	698	686	673	661	648	635
.88		623	610	598	585	573	560	547	534	522	509

INFORMATION TABLE (CONTINUED)

p		0	1	2	3	4	5	6	7	8	9
.89		496	484	471	458	445	432	420	407	394	381
.90		368	355	342	329	316	303	290	277	264	251
.91		238	225	212	199	186	173	159	146	133	120
.92		107	094	080	067	054	040	027	014	000	987
.93	0.0	974	960	947	934	920	907	893	880	866	853
.94		839	826	812	799	785	771	758	744	730	717
.95		703	689	675	662	648	635	621	607	593	579
.96		565	552	538	524	510	496	482	468	454	441
.97		426	412	398	384	370	356	342	328	314	300
.98		285	271	257	243	229	215	200	186	172	158
.99		144	129	115	101	086	072	058	043	029	014

VITA

Raymond Curtis Stokes
candidate for the degree of
Master of Science

Thesis: THE MEASUREMENT OF MORALE BY THE MATHEMATICAL THEORY OF COMMUNICATION

Major: Psychology

Biographical:

Born: The writer was born near Mena, Arkansas, December 18, 1921, the son of Mary Ethel and John H. Stokes.

Undergraduate Study: He graduated from Weleetka High School in 1940. In 1940-41 he attended Cameron State College. He attended Oklahoma Agricultural and Mechanical College during the years 1941-43 and 1949-50, from which he received the Bachelor of Science Degree, with a major in Electrical Engineering in June, 1950.

Graduate Study: In June, 1950 he entered the Graduate School of the Oklahoma Agricultural and Mechanical College. Requirements for two Master of Science Degrees were completed in August, 1953, one of which is in the Industrial Engineering and the other in Psychology.

Experiences: He entered the United States Army in 1943 and served six years as an officer in the Signal Corps, serving in both Asia and Europe. He has been employed as an Instructor and Research Associate in the School of Industrial Engineering and Management of the Oklahoma Institute of Technology during the years 1951-53.

THESIS TITLE: THE MEASUREMENT OF MORALE BY THE MATHEMATICAL THEORY OF COMMUNICATION

AUTHOR: Raymond Curtis Stokes

THESIS ADVISER: Dr. Harry K. Brobst

The content and form have been checked and approved by the author and thesis adviser. The Graduate School Office assumes no responsibility for errors either in form or content. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

TYPIST: Mary B. Peo