One of the outcomes of intuition is often the *categorization* or *classification* of experience. As a result of extensive observation, one might intuit certain underlying similarities among aspects of experience. We notice, for example, that all people are unique, each with invididual differences and idiosyncracies that makes us different from every other person. Yet we believe that there we share something or some things fundamental enough so that we can all be called by the same name: human. And, although basketballs, footballs, soccer balls, tennis balls, ping pong balls, bowling balls and the like are all different, there is something about them all that is similar enough so we refer to them all as "balls"; that is, we place them all in the same category.

There are two important points of view as to how people form categories. The classical view, which

we inherit from Aristotle and Plato, is that all members of a category share some essential, identifying characteristic or characteristic. People, for example, are *rational animals*. This means that they have all the features of other animals -- living, locomotive, sentient, and so on, but, unlike all other animals, they also have the power of rationality. This is the essence of humanity; it is what makes us human and essentially different from all other animals, according to Aristotle. (Aristotle did not include women or slaves within the category "rational," and so did not consider them completely human.) The "essence" of a thing is what makes it what it is; it is its defining characteristics.

Within the classical view, objects either belong to a category or they do not. But a more modern view of categorization has developed by modern cognitive scientists, which is sometimes called an "archetypal" or "prototype" model. Within this modern model, objects are not classified into a category because they all

possess the "essence" of the category, but rather because they are more similar to each other than to objects not in the category. Within this category, there maybe a single object which is the "archetype" or "prototype" of the category, that is, a "best" representative of the category. Collies, German Shepherds, Pomeranians, Dachshunds and Chihuahuas are all dogs, for example, but most people think collies and shepherds are more "doglike" than the others.

Categories in the modern view are not sharply bounded, but rather just "fade away" as one moves farther and farther from the central members. Coyotes and wolves, for example, are doglike, but not doglike enough to be called dogs in the modern view. Because these categories are not sharply but rather "fuzzily" bounded, they are usually called "fuzzy sets."

Classification, or placing objects into categories, is part of scientific method, because it makes it possible to describe relationships among objects and even to

predict future observations. There are two ways to go about this.

The first way is called "induction," and it involves learning about the category itself from observing its individual members. We may notice, for example, that each and every human being ever observed has, at one time or another, died before reaching an age of much more than, say, 100 years. From this we may induce that all humans are mortal. This is a general statement based on observations, which can be tested by future observations. Or, we may notice that no dog we have ever observed has had the power of speech; we can induce that no dogs can speak. Again, this is a generalization that can be tested by future observations. You may notice that there is no specific rule by which we induce knowledge about a category from observing its individual members (and you may also notice that there is no accepted rule or procedure for determining what objects ought to be grouped

together into a category). Induction is usually thought of as an intuitive method such as those discussed in the previous chapter, and it is fair to say that no one completely understands how induction takes place, although theorists in neural networks and parallel data processing have made promising hypotheses that may well provide an answer.

The second way we can determine relationships and make predictions is called "deduction." Deduction is the process by which we make statements about members of a category based on our knowledge of the category itself. We can say, for example,

All humans are mortal.
Socrates is a human.
Therefore, Socrates is mortal.

In this example, we have reasoned to a conclusion about a member of a category (Socrates) on the basis of our knowledge of the category itself. This

elementary example is a type of *syllogism*, or a kind of formal mechanism for deducing particular conclusions from more general premisses. This second kind of reasoning is a type of logic, and the example given here is of the most widely-recognized logic, the formal logic developed by Aristotle. Classical Aristotelian logic has been studied in enormous detail over the last two thousand years, and elaborate classifications of different types of syllogism, rules for forming syllogisms correctly, and the types of errors usually committed when using them incorrectly has been assembled. Although powerful mathematical and statistical forms of logic have been developed more recently, classical logic remains an important tool of reasoning, one well worth learning, since the kinds of logical errors carefully identified and classified by classical and medieval scholars are still committed -- often -- by modern thinkers, including those who know the rules.

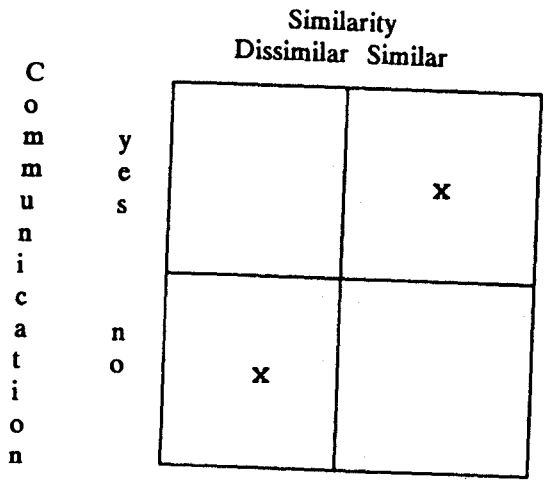
Virtually every aspect of human experience can

be classified into categories, and this is one of the most fundamental ways in which both laypersons and scientists think. One might notice, for example that people who communicate with each other tend to be similar in their attitudes and beliefs, while those who do not communicate with each other appear more dissimilar. It might also appear from observations that you have made that people who communicate tend to like each other more than those who don't communicate. Or one might intuit that groups differ among themselves in their patterns of communication; in some groups everyone might communicate about equally with everyone else, while in another each person might communicate only with the same single person but not with each other (as in a classroom); or that in still other kinds of groups there appear to exist two or more clusters of people who communicate among each other but not with the people in the other clusters. These initial intuitions might lead you to categorize or

classify these experiences in a more formal way. You might classify frequency of communication into *high* and *low*; you may classify similarity of beliefs and attitudes into high and low, and you might classify groups into several types of communication structure. These classes or categories might then serve as the basic concepts from which you could begin to formulate a *theory*. The theory would consist of your hypotheses about how the various categories "go together."

One of the methods developed by modern thinkers for the analysis of categorical information is the *table*, and analysis of categorical information using tables is often called *tabular analysis*. Powerful and complicated rules for tabular analysis have been developed in the last century, particularly since the development of the computer, but we will consider only some very simple tables here.

As a first hypothesis, you might try something like the table in Figure 4.



Similarity of Beliefs and Attitudes
by Frequency of Communication

Figure 4.

VI Logic and Scaling

Figure 4 represents the crudest theory that can be written; it is called a "2 X 2 Table," because it divides up communication into two categories (Yes and No), as it divides up similarity into two categories (Similar and Dissimilar). You should also notice that the "communication" variable is arrayed along the horizontal, or "x" axis, while the "similarity" variable is located along the vertical, or "y" axis. In this theory, we assume that similarity "depends on" communication and not vice versa. "Communication" is called the *independent* variable, because we assume it does not depend on similarity; "similarity" is called the "dependent" variable, because this theory assumes similarity depends on communication frequency. [1] It is a conventional rule that the independent variable should

[1] Remember that this is a very simple example, just for the sake of learning. Modern communication theorists believe that these variables influence each other, or are interdependent. But for the sake of the example, we well pretend that communication influences similarity, but that similarity does not influence communication.

always be arrayed along the horizontal (x) axis, and the dependent variable along the vertical (y) axis.

Your theory hypothesizes that you will only be able to find observations in the two cells marked with "X". Notice that this crude theory suggests at once what kinds of observations you ought to make, and even suggests something about the way you should go about making them. Although this is a very simple and clumsy theory, it illustrates what scientists mean when they say that theory guides observations. Clearly, to test the theory, you need to observe people, and classify them into groups according to whether they communicate or not, and whether they are similar or not. If all the observations fall into the cells with X's, your observations tend to confirm your theory; any observations that fall into cells without X's tend to disconfirm your theory.

By "confirm" we mean that your theory is able to predict in advance what your observations will turn

out to be, and by "disconfirm," we mean that your theory does not predict your future observations very well. In a technical sense, if *any observations whatever* fall into the cells without X's, the theory is false. But you should convince yourself that, even though the theory were false, if a great majority of your observations fell into cells with X's, the theory could still be fairly useful, even though it was not completely true. You would not reject the theory simply because it turned out to be false, since a "nearly true" theory is much better than no theory at all; you would only reject it if a better theory were available.

Although we have referred to the table in Figure 4 as a "theory," many writers would prefer to call it only an hypothesis, and to use the word "theory" to apply to a set of interlinked hypotheses. Suppose that we (and other independent observers) have tested the theory sufficiently to justify some confidence that people who communicate are more similar than those that

don't. We might then combine that finding with the classification of organizations we have made. We might then hypothesize, for example, that organizations in which all the members communicate with each other would be more homogeneous than those in which communication was more limited. We might also hypothesize that organizations that were divided into subgroups which communicated widely within each group but not at all across groups would develop clusters of people who were similar within clusters but different across clusters.

This would be a significant extension of the theory, and, like the earlier version, it makes clear suggestions as to what kinds of observations should be made. In this case, it would be necessary to examine several organizations, classify them according to whether they were characterized by high levels of common communication internally or low levels, and to classify the people in those organizations into categories

according to whether they were homogeneous or heterogeneous. This model, too, could fit into a 2 X 2 table, and, once again, the theory would predict observations would fall into two of the cells and not in the other two.

The theory could be expanded even further by examining the third hypothesis: people who communicate with each other like each other more than those who don't. If that hypothesis were also supported, it might be included in the theory, so that it could predict, for example, that people in organizations having high levels of internal communication would like each other better than those in organizations with no communication among members. It could hypothesize that organizations which had internal clusters of communication would also have groups whose members liked each other more than they liked those in the other clusters.

While the original hypotheses were formed

inductively by intuition, once the theory has been formed, it is possible to generate new hypotheses by *deduction*. As we said earlier, deduction is the process whereby specific hypotheses are derived logically from more general hypotheses. Unlike induction, which is an intuitive process not well understood by anyone, deduction is a formal, systematic process that follows well-developed rules. The first formal sets of rules of logic go back to Plato and Aristotle, and are been carefully studied by philosophers and mathematicians even today. Logic, like science, is public, and everyone who begins with the same general statements (premisses) and who applies the formal rules of logic will arrive at identical conclusions. Thus the theory not only suggests what observations ought to be made, but it suggests such observations in a way that is public and common, so that all those who understand the theory and the logical methods by which its hypotheses are deduced will agree on what needs to be observed. If the

observations, too, are made in a public and common way, it becomes possible to form an agreement about the theory and the observations it generates. This formalization of insight into a system of formal categories which make deduction of hypotheses possible is a powerful mechanism, then, for changing the rich insights of intuitive observations into an objective, testable theory which can guide future observations.

But every theory involves a simplification of experience. While a great deal of benefit has been gained by classifying the original insights of the intuitive observers into a formal theory, much of the detail and richness of the observations has been lost by classifying them into such a simple scheme. In order to make the theory testable, we have traded away a great deal of subtle information, and, in this sense, the public reality we have created is much poorer and less detailed than the private reality of our intuitive observations. This means that scientists may well reject a theory that is

"true" or nearly true simply because it is uninformative; that is, it trades away too much information and richness of experience to be worth the formality and testability gained. Other factors equal, science would prefer a rich, informative, detailed theory over a simple, uninformative theory. Some find the simplifications, particularly of early and undeveloped theory, so objectionable that they prefer to continue intuitive observations rather than try to provide an objective, testable theory. This is particularly true in the social sciences, where most theories are at a very early stage of development. And it is fair to say that a good number of social scientists believe that no theory in the social sciences will ever be very precise or rich. Any individual scientist may believe whatever he or she wishes, of course, but the proper attitude for science as a whole is, "We'll see." Some researchers will continue unstructured, intuitive observations, others will work on structuring classifications and theories, some will test hypotheses

derived from these theories, and still others will do combinations of these things. None of these things, alone, is either scientific or not scientific; *science* refers to the whole process, the combination of all these activities.

A well-formed theory makes predictions about what observations are likely to turn up under a given set of circumstances. When observations agree with predictions made by the theory, the theory is strengthened; when they disagree, the theory is weakened. But making a theory which agrees with observations is not the sole criterion for a good theory. If this were the case, one could make a perfect theory by simply devising a theory which makes predictions of such ambiguity that virtually any observations at all will appear to confirm the predictions. Thus the theory "Sometimes you win, sometimes you lose" can predict every event in the future of your life without any risk of

being disconfirmed. Yet it is essentially useless, because it is extremely ambiguous; it doesn't say what "win" or "lose" means, and it doesn't say *which* times you will win or lose.

The theory about communication and similarity we just developed is not as bad as this, but it is pretty bad. It doesn't say what communication is, or how to observe whether people are communicating or not, nor does it say what "similar" means in terms of attitudes and beliefs, or how to tell whether peoples' attitudes and beliefs are different or not. It doesn't say what it means to "like" someone, or how to determine whether a person likes another or not. The theory relies completely on ordinary language definitions of these words, which, as we know, differ greatly from person to person. As a result, the predictions the theory makes are highly ambiguous, so that reasonable people could disagree about whether the theory were confirmed or not in any specific instance. Because the theory is so

imprecise, it could never be confirmed precisely, and it would have to be very far off the mark to be disconfirmed decisively.

The ambiguity in this theory is caused by the way in which its basic terms, or *variables* have been defined. First, the terms in the theory need to be defined in a common, public way that makes it unambiguous how to observe them. Second, the classification scheme, which divides each concept (or variable) into only two categories, does not allow for much range or precision in prediction. (Consider how difficult life would become for you if the speedometer on your car only gave two values: "moving" or "stopped;" or if your bank only sent you a monthly statement that said that you had some money or you didn't.)

The basic terms of a theory are usually called "variables," and terms are defined by specifying what *values* each variable can take and what observations correspond to each value. In the present theory, the

variable "communication" is defined to take on either of two values, essentially "yes" or "no," that is, communication either takes place or it doesn't. The theory does not specify how to tell which value communication takes on in any given instance, which is a flaw in the theory. Thus the definition of communication that this theory offers is flawed in two ways: first, it specifies such a small range of values (2) that the variable can take on that it is about as imprecise as it can be. Second, it does not specify what observations correspond to each of the possible values.

A more satisfactory definition (but still not a very good one) might say something like this: "Communication is the passage of spoken words between two or more people. Zero words in any day is no communication; between zero and 50 words per day is *low* communication, 51-1000 words per day *medium* communication, while over 1000 words per day is *high* communication." This definition is much improved, since

it now allows the variable to take on 4 values rather than 2,[2] and provides a clear, unambiguous and public way to determine, based on observations, what value the variable takes on in any circumstance.

There are many reasons to criticize this definition. It refers only to a small fragment of the possible ways people communicate; it fails to take into account the meaning (if any) of the words spoken; it doesn't distinguish words which have been heard from those not heard; and it assigns values to the categories in a fairly arbitrary manner, and so on, but it illustrates the essential way a theory defines a variable: *a variable is defined by assigning values to observations according to*

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[2] It might seem that this definition is therefore twice as precise as the former, but this is not the case. The amount of information that can be expressed by any variable is equal to the natural logarithm of the number of possible values it can take on divided by the natural logarithm of 2,

$$H = lnX / ln2$$

where H = information in bits, and X = number of possible values.

an unambiguous, public rule.

Notice that this definition of definition establishes only the essential conditions a scientific definition must meet, but it is entirely possible to construct a definition that meets these conditions which is nonetheless a poor or even stupid definition. The classification of the insights derived from intuitive observation is the first step on the road to public scientific understanding, but, if the classification is arbitrarily or ineptly done, the resulting public understanding will also be arbitrary and inept.

Scaling

Sometimes the categories resulting from classification are assigned names (such as "none," "low," "medium" and "high" in the previous example), but sometimes they are assigned numbers. We could, for example, define "similarity" in belief and attitude as the

numbers recorded by individuals responding to a question like this one:

"Person X and I are very similar in our beliefs and attitudes"

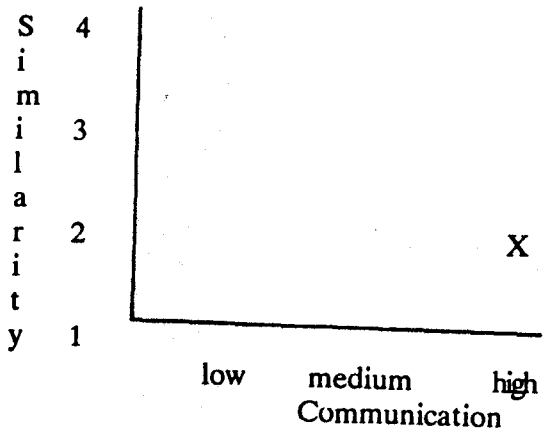
1 Strongly disagree
2 Disagree
3 Neither agree nor disagree
4 Agree
5 Strongly agree

This device assigns observations to numbered categories, and is called a *scale*. (This particular type of scale is called a Likert scale, after Rensis Likert, who invented it.) Another way to assign observations to numbered categories might be with a device of this type:

"How similar are you and person X, if 1 = not at all similar and 10 = extremely similar?"

Each of these devices will assign observations to

Figure 5
Similarity and Communication



numbered categories, but obviously each of them will assign the same observations to different numbers, and so each of them will result in observing and recording experience in a different way. We can illustrate this by drawing a plot, similar to the table in Figure 4. Instead of a table, however, we can make two perpendicular lines or *axes*, as in Figure 5. (You may notice that this plot or graph is formally similar to the tables we analyzed earlier, but uses numbers on the axes instead of names of categories.)

To use this graph, we look at which category a person checked for his or her communication with another person (none, low, medium or high), and we look a the number he or she chose to represent how similar he or she felt to that other person. (In the example in Figure 5, the person chose "medium" for communication and "3" for similarity, so we place an "X" (or a dot) at the point at which "medium" and "3" cross each other on the axes. If we do this for many people,

you will notice that a pattern of X's will appear on the axes. This pattern of X's represents the observations we have made. To check the theory, we need to compare this pattern with the pattern the theory predicts should appear. (You should convince yourself that, in the very simple form we made up, the theory predicts that all the X's ought to be on or close to a line that moves up and right from the origin -- where the axes meet -- to the upper right corner of the plot.)

Now, however, consider what would happen if we made another plot, this time using the two-valued frequency of communication variable from our first example, and the 10 valued similarity scale we developed instead of the four-valued communication variable and the five-valued similarity scale. You should convince yourself that *both the pattern predicted by the theory and the pattern that resulted from observations using the different devices would appear quite different on the different graphs.* In a very simple way, this illustrates

the fundamental point that different theories and different agreements about how to conduct observations produce different "realities." Two observers who used different version of our theory and compared their observations directly *could not tell whether their observations were different because what they observed was different, or because the way they observed was different, or a combination of both.* In a fundamental way, their observations were made in different reference frames and are not directly comparable.[3]

Earlier we asked why communication researchers have not weeded out the many contending theories about the effects of communication on people's

[3] The differences between these scales are not simply differences of the size of the units of measure, as is the case when something is measured in feet or meters, or hours or minutes. In these cases it is a simple matter to change from one scale to the other. These scales, however, are related to each other by nonlinear functions which are, in general, not known. Although it is, in principle, possible to find out what the functions relating the scales are, there are so many different scales in use by social scientists that, in practice, there is probably no likelihood it will be done.

attitudes and beliefs. Now it is possible to show that the different theories, using different definitions of communication, and different methods of classifying and scaling, produce outcomes that are very difficult and sometimes impossible to compare to each other. Is it the case, for example, that a theory that makes a prediction accurate to within .75 units on a five-point scale ranging from "strongly agree" to "strongly disagree" is more or less accurate than a theory that makes a prediction accurate to within 6.9 units on a 100 point scale that ranges from "very similar" to "very dissimilar?" It's probably safe to say that no one knows. Because communication scientists have yet to make an agreement about how variables are to be defined and measured, comparison of results from study to study are fraught with difficulty.

Chapter VII

COMPARATIVE METHODS: MEASUREMENT

The American philosopher Youngman once said:

"How's your wife?"

"Compared to what?"

Nothing has meaning by itself. All meanings consist of relationships among objects. Nothing is "tall" except in comparison to something that is short. Categorical methods often obscure this important idea, and lead us to think things have absolute meanings. To help understand both the nature of comparative methods and the limitations of categorical methods, consider the following simple questionnaire:

Distance Questionnaire

1. How far apart are a flea's eyes?
a)Very close b)Close c)Medium d)Far e)Very far

2. How far is your wrist from your elbow?
a)Very close b)Close c)Medium d)Far e)Very far

3. How far is your knee from your ankle?
a)Very close b)Close c)Medium d)Far e)Very far

4. How far apart are the protons in a helium atom?
a)Very close b)Close c)Medium d)Far e)Very far

5. How far away is The Campus Book Store?
a)Very close b)Close c)Medium d)Far e)Very far

6. How far away is New Haven, Connecticut?
a)Very close b)Close c)Medium d)Far e)Very far

7. How far away is Melbourne, Australia?[1]
a)Very close b)Close c)Medium d)Far e)Very far

8. How far away is the Moon?
a)Very close b)Close c)Medium d)Far e)Very far

9. How far away is the Sun?
a)Very close b)Close c)Medium d)Far e)Very far

10. How far away is the Andromeda Galaxy?
a)Very close b)Close c)Medium d)Far e)Very far

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[1] If you are reading this book in Australia, please substitute Buffalo, New York for Melbourne.

If you are like most people, you probably thought that a flea's eyes were either close or very close together. This is because, in the absence of any explicit standard for judging distance, people tend to choose arbitrary everyday objects as standards, and, compared to most things we might deal with in everyday life, a fleas eyes are very close together indeed. After answering question 1, questions two and three tend to be judged compared to the distance between a flea's eyes, and, compared to this very small distance, they tend to be at least a medium or even a large distance apart. But by question 4, when we are asked how far apart the protons in a Helium atom are, we are confronted with a distance that is extremely tiny, even compared to the distance between a flea's eyes. If you already reported that the distance between a fleas's eyes was 1, very close, you might even want to change your answer to "make room" for answer number four. But, when you reach question 5, you may need to change

again, because, compared to the distance between protons in a helium atom, the bookstore is very far away (unless you are reading this in the bookstore, in which case you should buy the book and take it home). And, unless you are in New Haven, Connecticut, you may find you need to change your standard of reference again when you reach question six. Regardless of where you live, you might find you need to change again for questions eight, nine and ten, because these distances are all so large they make the earlier distances seem quite small by comparison.

The Distance Scale is familiar and an easy example to understand, but the problem extends to *any quality whatsoever that you might want to measure.* Compare the Distance Scale to the following Liking Scale to see that this is true:

Liking Scale

1. How much do you like chocolate ice cream?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

2. How much would you like failing this course?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

3. How much do you like getting a good grade?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

4. How much do you like a new sports car?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

5. How much do you like a million dollars?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

6. How much do you like your mother?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

7. How much do you like freedom?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

8. How much do you like cancer?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

9. How much do you like Adolph Hitler?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

10. How much do you like nuclear war?
a) Strongly dislike b) dislike c) neutral d) like
e) strongly like

There are two serious problems with the numbered category scale in the Distance Questionnaire and the Liking Scale. First, and easiest to understand, is that you are asked to evaluate ten different distances, or ten different degrees of liking, no two of which are the same, yet you are only given five numbered categories into which to sort them. This means that you will be forced to report some of them to be ties even though

you know they are different.

But the problem is deeper than that. Even if there were ten numbered categories, or a hundred or even an infinite number of them, the problems would still not be solved. *Every* judgment a person makes always involves some comparison. As Youngman's joke points out, how a man's wife (or anyone) is to be evaluated depends on what she or he is being compared to. And her husband might not seem so good compared to the ideal man, but might be much better than a sharp stick in the eye. But when no specific standard of comparison is given, the human mind automatically supplies an implicit standard. By "implicit" we mean that no one, even you yourself, knows what the standard is. When asked to evaluate several objects, the mind may change its implicit standards without anyone, even yourself, being aware of it. That's what happened in the case of the Distance Questionnaire and the Liking questionnaire. That means that the meanings of the

categories, and the numbers that go with each category, can change -- and change by a lot -- from one object to the next. What you might consider big in one context you might consider small in another, and what you might consider very good in one context -- say a "B" in an advanced calculus course -- you might consider unsatisfactory in another course. In this case, the meaning of the word "good" changes from one moment to the next, and, what's worse, changes in an unknown way.

The solution to this problem requires making the standard of comparison explicit rather than implicit. Consider these three questions:

1. How big is a flea?
2. Compared to an elephant, how big is a flea?
3. Compared to an atom, how big is a flea?

Or these three:

4. How much do you like chocolate ice cream?
5. Compared to Freedom, how much do you like chocolate ice cream?
6. Compared to Hitler, how much do you like chocolate ice cream?

In questions 1 and 3, the standard of comparison is not explicit. Different people will choose different standards, and it will be impossible to compare the answers of one person to another. In questions 2 and 4, comparisons are explicitly made to a very large or very well liked standard, so the resulting answer ought to be quite small. Questions 3 and 6, on the other hand, use an explicit standard that is either very small (an atom) or highly disliked (Hitler), so the answers ought to be large numbers.

Measurement

Whenever we observe anything, in order to remember what we have observed and communicate it to others, we must assign some *symbol* to each *observation* according to some *rule*. Putting an observation into a category involves assigning the name of a category (which is a symbol) to the observation. Sometimes the rule is quite explicit and well known to everyone, like the rule which says that animals that purr and meow are cats. Other times the rule is explicit but not well known except to experts. (Most of us can easily assign certain plants to the category "flower", but do you know the rule?) In some cases, the rule is in dispute. Not everyone agrees, for example, what kind of music ought to be called "great." In some cases, particularly when exploring unknown areas, no rule exists as yet (What are those things?), and the observer may have to invent a rule on the spot. Assignment of observations

into categories is usually called *classification* or *categorization*.

Sometimes the categories into which we assign observations have a numerical value, as in the Likert and Likert-type scales we saw earlier. Assignment of observations into numerical categories is called *scaling*, and the rules that control how the numbers are assigned to the observations are called *category scales* or sometimes just *scales*. Several types of rules or scales have already been presented earlier, but there is no limit to the number of scales that can be devised. Specialists in scaling argue among themselves about the best kinds of scales for each kind of observations, as we mentioned earlier, but the fundamental idea behind scaling is that the numbers that result from scaling are meant to convey some sort of *quantity*. A person who scores, say, 5 on a happiness scale is supposed to be

happier than another person who scores, say 3.[2] As we saw earlier, however, it is easy to make a scale in which this is not true. While it is possible to develop scales that have genuine quantitative meaning, doing so is much more difficult than most people expect. With very few exceptions, developing a useful scale is a demanding, time consuming process which is not to be taken lightly. Scales that are made casually and used in haste are usually likely to cause more confusion than knowledge.

The most precise and widely used way to assign numerical values to observations uses the *rule of ratios*. The rule of ratios states that all magnitudes to be measured are to be compared to a standard magnitude as ratios. While this may sound complicated, it is

[2] Not all numbers express quantities. The numbers on the back of football jerseys, for example, are assigned according to a rule, but they do not have any quantitative meaning. There is no point in adding or multiplying the numbers on the back of players' uniforms, just as it is not true that two quarterbacks make a halfback.

actually very simple, and is in fact the most commonly used rule for measurement in the world, used even by untrained people in the most undeveloped areas. Consider this simple example: Compared to the amount of grain one person can harvest in one day, how much grain is in this field? Notice the two parts of the rule. The first is the standard magnitude -- the amount of grain one person can harvest in a day. The second is the rule for comparison, which is a ratio rule. If there is enough grain in the field to require two people to harvest it in a day (or two days work for one person, which is the same), then the field has two person-days worth of grain.

Although this rule is simple, it is quite powerful, since it allows different observers to make observations and compare them to each other. If one field contains 10 person-days of grain, and another contains 20 person-days of grain, we can compare these two numbers as ratios to show that the second field is

twice as large as the first. What's more, the comparative ratio scale has no limits on either how large or small a magnitude can be measured, and has an infinite number of possible values rather than two or five or ten or so, so it is much less sensitive to the kinds of problems we encountered with categorical scales.

The ratio rule for comparative scales is the most common form of measurement used in the world, and some authorities consider only ratio type comparative scales to be measurement at all. (Other experts consider any observation at all to be a measurement.) Most of the variables which make up what we call the "physical world" (such as time, distance, velocity, acceleration, mass, force, energy, work, power, temperature, and many more) are measured with ratio type comparative scales. These scales are less commonly used in measuring social, cultural, and psychological variables, but the reasons for this are mainly historical. The Liking Scale, for example, could be rewritten as a

ratio comparative scale quite easily:

Ratio Comparisons Liking Scale

Please write a number that shows how much you like each of the following things. If you don't like one of the items at all, write zero (0). If you like it as much as you like good food, write 100. If you like it *twice as much* as you like good food, write 200. If you like it *half as much* as good food, you would write 50. (If you *dislike* the item, place a minus sign (-) in front of your answer.)

How much do you like:

1.) Chocolate Ice Cream ____
2.) Failing this course ____
3.) Getting a good grade ____
4.) A new sports car ____
5.) A Million Dollars ____
6.) Your mother ____
7.) Freedom ____
8.) Cancer ____
9.) Adolf Hitler ____
10) Nuclear War ____

You may notice that you do not run out of "room to answer" with this scale as you did with the categorical Liking Scale earlier. No matter how large or small an answer you have already written, there is always an infinite amount of room for a smaller or larger one. You may also notice that there is no limit of values you can assign to any item; there is no need, as there was with the categorical scale, to assign two items the same value even if they are different. As a rule, it is theoretically possible to make comparative ratio scales which are more precise and less troublesome than any other kind of scale. In practice, however, no measurement is easy, and the process of designing a successful measurement device cannot be taken lightly. The reason science can measure time and distance very precisely today is not that it was easy to do, but because a truly enormous amount of time, effort and resources have been spent to make it so.

From what we've observed in the Distance

Questionnaire and the Liking Questionnaire, we can form the three important rules for the use of the comparative method:

1. Standards of comparison should be explicit,
2. Standards should not change unknowingly during observations, and
3. Standards of comparison should be conventional.

The first rule means that the standard to which we are making our comparisons must be spelled out, and not left unclear. In implicit comparisons, when we do not know what the standard of comparison is, the results of observation are almost meaningless. If you are asked "How much do you like chocolate ice cream," and you say, "It's the best thing on earth!" using, as your standard of comparison, other foods you might eat, and another person says, "It's pretty good," but is comparing

it to love, freedom, and deep family values, it's impossible to determine which of you likes chocolate ice cream better. When comparisons are made to unknown standards, results may not be compared.

The second rule means that the standard of comparison must not change while the measurements are going on unless the change is made explicit. If you say you like chocolate ice cream "very much", and are comparing it to other food you might eat, and you say next you like a new sports car "very much", but are comparing it to other cars you might have, may we conclude that you would just as soon have a chocolate ice cream cone as a new Porsche?

Notice that this second rule does not demand that the standard of reference never change, but only that it must not change *without our being aware of the change*. It is not only permissible for the standard to change, but sometimes it is convenient that it change. For example, if we are measuring the distance between

your eyes, we would be best off to compare that distance to the millimeter. Your eyes are probably between 70 and 80 millimeters (mm) apart (more precisely, the distance between your eyes is probably 70 to 80 times as large as a millimeter). But if we now wish to measure the distance from Buffalo to Toronto, we'd be best off to compare it to the kilometer. The distance between Buffalo and Toronto is about 120 times as large as a kilometer (they are about 120 kilometers apart). If we compared that distance to the millimeter, we would find they are 12,000,000 mm apart, which is a fairly inconvenient number.

In order to change the reference standard without confusion, two things are necessary: first, we must know explicitly that we are changing the standard, and second, *we must know the relationship between the two standards*. Because we know that a kilometer is a million times larger than a millimeter, we can convert back and forth between the two standards easily.

The third rule is the rule that makes observations public. If our goal as scientists is to create a *public* reality in which we *agree* about our observations, it is essential that we *agree* about our standards of comparison. We have seen that the categories into which we place our observations, and the values we assign to our observations depend on the *standards of comparison* we use in making our observations. We will not agree about our observations unless we agree about the *standards of comparison* before we make our observations. The meter, millimeter and kilometer are highly conventional and public measures. Anyone familiar with the metric system can, with little difficulty determine from these two observations that the distance from Buffalo to Toronto is about 160,000 times as great as the distance between your eyes. (Because the distance between your eyes is about as great as the length of your little finger, you could say Toronto is about 160,000 little fingers from

Buffalo.) Those who are not familiar with the metric system, however, will not be able to figure this out, no matter how brilliant and hardworking they might be.

We make use of such conventional comparative standards every day. In the United States, we compare most distances and lengths to such standard lengths as inches, feet, yards, miles and the like. (The United States is, of course, the only major nation in the world that does not use the basic unit of the International Standard, or SI system, the *meter*, and this has begun to cause problems for the US as it engages in international trade. Parts, wrenches and other tools built to US standards do not fit equipment from anywhere else in the world.) Every nation uses the same reference standard of time, the *second*, even the US, so we have achieved exceptionally good agreements about how long events and processes take all over the world. This is very enlightening, because our individual perceptions of time, without reference to a clock, are quite subjective

and variable. When waiting in line in a boring place, for example, a minute can seem like a very long time, but the same minute spent on a roller coaster can seem quite short. By comparing our private, subjective experiences of time to a conventional standard, the second, we are able to agree about as mystical and intangible and elusive a variable as time.

For those who were born into a time when a vast and precise set of agreements about standards of measure (such as those found in the SI system) already exist, it is quite natural to assume the world of observation was always as clear as it is now, but this is not the case. Before the development of the extensive standards of measure we now enjoy were adopted, the world we think of as "physical" was every bit as chaotic and confused as is the internal world of attitudes and beliefs now. People did not know whether the earth was round or flat, nor did they have much of an idea how large it was or where they were on its surface. Precise

clocks had not been invented, and so the duration of events was mysterious and subject to interpretation. Motion was considered inscrutable, and the best scholars on earth disagreed wildly among themselves on the trajectory of a cannon ball or thrown or falling rock. Not only did no one know what time it was to the nearest hour, but people in different countries could not agree on what year it was. The world of experience was very mysterious indeed.

The Treaty of the Meter, which established the SI system and the constant process by which it is updated, was itself the result of centuries of struggle to bring order out of the chaos of non-standard measurement systems that were found in every country and every village in Europe.

Before the introduction of the SI system, observations made by one observer in one place could not be compared to those made by others in other places. If one sold a barrel of ale in England, for

example, to a buyer in France, they would find they could not agree about how much ale is in a barrel. And a barrel of ale could not be assumed to be the same size as a barrel of wheat or even a barrel of wine. To be sure, those with resources and interest could keep track of the different sizes to some extent, but they tended to be the wealthy merchants and nobility, who could use this knowledge to the disadvantage of ordinary citizens who couldn't possible afford the research and bookkeeping needed to keep the varying standards straight.

The result of this lack of standards was that experience was confusing and obscure, commerce difficult and unfair. Nor were these minor inconveniences. Many revolutions, including the revolution that led King John of England to sign the Magna Charta in 1215, were fought at least in part to demand standardization of measurement rules so that commerce could be conducted more fairly. This may

seem quite strange, and the average college student might find it hard to imagine taking up arms in the name of measurement. Even though you buy a "2 x 4" at the lumber yard and find out it is actually only 1.75" x 3.5" (which is allowable under current US government standards), it's hardly worth fighting over. But, if you were a peasant who harvested crops and were paid in barrels of grain in return for barrels of harvest, you might be extremely upset to find that the barrel the landowner paid you with was a good deal smaller than the barrel he used to collect your harvest.[3]

Western scholars in particular have always been

[3] Some critical theorists fear that the development of standards of measure can lead to increased control of the masses of people by the elite. Throughout history, however, the elite have almost always maintained their own standards which they do not make public, so that they are more able to take advantage of those who are unaware of the standards. Demands for reform of measurement standards are usually demands made by those being exploited for fair and public standards which can help them gain access to the information, formerly the possession only of elites, which was being used to exploit them.

infatuated with the individual scholar and the great idea. We tend to attribute our modern state of advances to great achievements of great individuals like Shakespeare, Newton, Bach, Mozart, and the like, and to their ideas. Without denying these great individuals the honor that is truly due them, we should realize that the cohesiveness and understandability of the world as we now know it comes as much from the diligent hard work of those who worked out the agreements we now enjoy about standards of observation and measurement as it does from the brilliant insights of our brightest individuals.

Chapter VIII

PRINCIPLES OF COMMUNICATION SCIENCE

Communication Science is a very special discipline. Like human beings, it is self-reflexive; it examines itself and changes due to the examination. That is because science and communication are intimately intertwined. Since science is a collective process, it emerges out of the communication among scientists, and between scientists and their experiences. As they communicate about their experiences, scientists develop symbols and concepts and theories which change the way they experience the world. As they develop understandings of communication and its effect on our experiences, scientists must reconsider the way they observe and think about the world.

The fact that the way we observe the world affects what we see, and the fact that what we see affects the way we observe, means that there are choices to be made. The world is not simply standing by to be

seen for what it is no matter how we look at it. But, at the same time, the choices that we make have consequences, and decisions we make about the tools we forge for understanding our experiences must be weighed against those consequences.

This book has tried to describe some of the decisions science makes in its choice of ways to describe and understand experience. First and foremost, *science always chooses ways of understanding which rely ultimately on observations*. Systems of understanding which rest on faith or belief alone are never part of scientific method. Secondly, scientists choose to include *only those observations about which they can agree* within their system of understanding. Observations made by only one or a few observers which cannot be repeated by others are never included in science. Third, *precise, detailed observations are always preferred to coarse, crude descriptions*. And last, all other things being equal, *science prefers simple descriptions and explanations to*

more complicated notions.

Taking all these principles together, *we can say that Communication Science tries to find the simplest, most precise descriptions and explanations of communication processes that we can agree on*.