

ASSESSING DIFFERENCES IN DATA AND INFORMATION MAKEUP
AT TWO DIFFERENT ORGANIZATIONAL LEVELS
USING TWO MANAGERIAL JOBS

by

D. Steven Berube

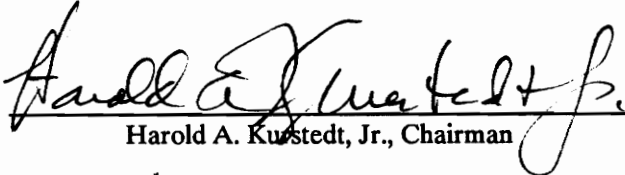
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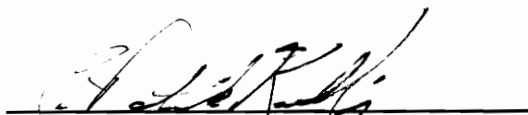
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Industrial Engineering and Operations Research

(ABSTRACT)

In this research I tested for differences in data and information needs at two different organizational levels. I used the makeup of data and information to measure these differences. I first defined data, information, and the makeup of data and information, since the literature doesn't consistently define them. I selected endeavors as a surrogate for organizational levels, since endeavors relate to what managers do, not where managers are in the organization. I related data and information needs to different endeavors, and developed testable hypotheses to measure and test differences in data and information makeup for two different specific endeavors.

I designed an experiment in which subjects ranked tasks (a strategic endeavor) and then used the same tasks to develop a weekly schedule for an employee (an operational endeavor). Subjects were selected from managers at Management Systems Laboratories, a research organization at Virginia Tech. As subjects performed the experiment, they were asked to verbalize what data and information they used off the test documents and how they used it to perform each endeavor. Using my definitions of the makeup of data and information, I found that subjects ranking tasks used 1) more information as a percentage of all data and information used; 2) more references to evaluate each indicator; and 3) more references external to the task scope, expressed as a percent of all references used, than subjects developing a weekly schedule. I was not able to show that managers ranking tasks use more data and information than managers developing a weekly schedule.

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Introduction

Hierarchical organizations have overlapping domains of responsibility. This means events or activities performed at the bottom of the organization are directly managed at the bottom of the organization and indirectly managed up through the organizational hierarchy. Do managers at different organizational levels need different data and information about these events or activities for their decision-making? If so, different managers may go to the same formal data stores and not find what they need. What are these differences in data and information needs? If designers of large computer systems don't know the answers to these questions, they can't meet managers' needs.

No comprehensive frameworks define data and information in enough detail to describe differences in data and information needs at different organizational levels. Worse, the terms "data" and "information," are generally confused and often are used interchangeably (Appleton, 1986; Bryce, 1983). I've assembled portions of definitions of data, information, and their makeup I've found in the literature into definitions of the makeup of data and information. I use my definitions of the makeup of data and information to develop and evaluate four testable hypotheses relating differences in the makeup of data and information to differences in data and information needs at different organizational levels.

Research Objectives

This research began with the question, "What are the differences in data and information needs for managers at different organizational levels who manage the same events or activities?" Knowing these differences will help improve information sharing and will aid in the design of management information and reporting systems. This research has three objectives:

1. To suggest the makeup of data and information.
2. To develop testable hypotheses relating differences in the makeup of data and information to data and information needs for different endeavors using theories and observations from the literature. I use endeavors¹ as a surrogate for organizational levels by assuming that a manager at a given organization level performs endeavors at only or mostly that level. I use endeavors as a surrogate for organizational levels through the rest of my research because my research focuses on what managers do instead of where they are in the organizational hierarchy.
3. To evaluate my testable hypotheses by identifying the makeup of data and information on test documents, having subjects perform two different specific endeavors using the same test

¹ An endeavor is any serious determined effort toward a purpose (Kurstedt, 1990). Endeavors focus on what managers do instead of where they are in the organizational hierarchy.

documents to identify the makeup of data and information used, and statistically analyzing the results.

Importance of the Study

First, this study distinguishes between data and information. The makeup of data and information allows others to clearly identify and distinguish data and information. Second, my definitions for the makeup of data and information can be applied to analysis of data and information in a variety of situations. Third, the testable hypotheses on differences in the makeup of data and information needed for different endeavors can set the groundwork for further tests in measuring and improving management information and reporting systems, data and information portrayal, data and information sharing, decision making, and management. Fourth, and the key to my research, this study suggests what is different in the makeup of data and information needed by managers performing different endeavors.

Problems Addressed

My problem statement is, "Determine the differences in the makeup of data and information and apply these differences to managers performing two different specific endeavors related to the same events or activities." This problem can be divided into three subproblems:

1. **Identify and characterize** the makeup of data and information.
2. **Link** the data and information managers need to the endeavors managers do.
3. **Distinguish** how the makeup of data and information about a given event or activity are different to support two different specific endeavors.

Outputs

My outputs are related one-for-one with my subproblems. In subproblem 1, I first interpret the available literature to distinguish data from information and define the makeup of data and information. The output of subproblem 1 is a framework showing the makeup of data and information. In subproblem 2, I then use the literature to link data and information needs to different endeavors. The output of subproblem 2 is a map linking data and information needs to different endeavors. In subproblem 3, I first tie changes in the makeup of data and information to changes in data and information needs for different endeavors, with the output being my four testable hypotheses. The remainder of subproblem 3 is quantitative, confirmatory research. I design and conduct an experiment to evaluate my four testable hypotheses. I use a non-parametric test (one for each testable hypothesis) to analyze my experimental data. In the output of the quantitative part of subproblem 3, I'll accept or reject each testable hypothesis and discuss my results.

Type of Research

The literature on data and information doesn't provide consistent definitions for the makeup of data and information, much less a framework for the differences in data and information needs at different organizational levels. As a result, I can't directly apply existing literature to form and evaluate testable hypotheses. Most of my work is qualitative, exploratory research, in which I develop definitions for the makeup of data and information and relationships between these definitions and endeavors. The qualitative research consists of subproblems 1, 2, and the formulation of subproblem 3. The quantitative research is confirmatory research using statistical analysis for subproblem 3.

Hypotheses

I first relate a research hypothesis to each subproblem. A research hypothesis is "a logical supposition, a reasonable guess, an educated conjecture which may give direction to our thinking with respect to the problem and thus aid in solving it." (Leedy, 1980).

1. Data and information are different in their makeup².

2 Data and information are different in other ways. I'll deal with variables representing the other differences as moderator variables.

2. Data and information needs are different for different endeavors.
3. Managers doing two different specific endeavors need different data and information distinguishable by their makeup.

The following testable hypotheses relate to research hypothesis 3 and subproblem 3 above. I'll restate these testable hypotheses and then write them in null hypotheses format on page 53.

1. Managers ranking tasks (a strategic endeavor) use more data and information than managers developing a weekly schedule (an operational endeavor).
2. Managers ranking tasks (a strategic endeavor) use more information (expressed as a percent of all data and information used) than managers developing a weekly schedule (an operational endeavor).
3. Managers ranking tasks (a strategic endeavor) use more references³ to evaluate indicators⁴ than managers developing a weekly schedule (an operational endeavor).
4. Managers ranking tasks (a strategic endeavor) use more references external to the scope of their endeavor (expressed as a percent of all references used) than managers developing a weekly schedule (an operational endeavor).

3 By reference I mean a datum or unit of information selected to evaluate another datum or unit of information.

4 By indicator I mean a datum or unit of information selected to be evaluated to produce information.

Research Scope

In this study I develop 1) a framework showing the makeup of data and information (subproblem 1 and research hypothesis 1), 2) a map linking data and information needs to different endeavors (subproblem 2 and research hypothesis 2), 3) four testable hypotheses linking changes in the makeup of data and information to changes in data and information needs for different endeavors (subproblem 3 and research hypothesis 3). I design test documents to evaluate these testable hypotheses in a research organization. The study demonstrates only that the testable hypotheses are reasonable and have validity for a research organization. I don't generalize these testable hypotheses to all documents or organizations.

I characterize endeavors as strategic, tactical, operational, and clerical in that order. I use only strategic and operational endeavors in my research to 1) limit the time required for each subject to perform the experiment and 2) reduce overlap and clarify my results. I have to select specific endeavors to represent strategic and operational endeavors. I select the endeavor of ranking tasks based on perceived importance or urgency to represent all strategic endeavors. I select the endeavor of developing a weekly schedule for an assigned employee to perform designated tasks to represent all operational endeavors. I use these specific strategic and operational endeavors to make inferences about all strategic and operational endeavors. I don't test different specific strategic and operational endeavors to see if I would obtain similar results.

In this study I relate the makeup of data and information to managers' needs in doing strategic and operational endeavors. My definitions for the makeup of data and information may not be complete and applicable for other purposes. I also don't use my definitions or testable hypotheses to look at improving hierarchical information and reporting systems, to look at the performance or evaluation of management tools, or to determine the completeness of data and information. I leave these areas for other research.

Assumptions

This research is conducted under several assumptions to limit and bound the scope of the research domain.

- * Structurally, a datum is different from a unit of information.
- * Ranking tasks based on perceived importance or urgency is a strategic endeavor.
- * Developing a weekly schedule for an assigned employee to perform designated tasks is an operational endeavor.
- * Both the manager and the subjects use all data and information they believe are applicable to performing the specific endeavors. However, subjects can only draw from the pool of data and information provided to them in the experiment.

Literature Review

I need to review five areas of the literature to support my research. I first review the literature on data and second, the literature on information to establish my definitions of the makeup of data and information. Third, I look at the literature on organizational levels to show why I choose endeavors as a surrogate for organizational levels. Fourth, I look at literature describing data and information needs at different organizational levels as a basis for relating data and information needs to endeavors. Fifth, I look at verbal protocols, the method I used to collect data to evaluate my testable hypotheses. This section will set the foundation for my research model and the research I perform to evaluate my testable hypotheses. Since I intend to use the literature to support my definitions of the makeup of data and information in research hypothesis #1, the first two areas of the literature search also serve as data gathering for research hypothesis #1.

1. Data Literature

The data literature provides many perspectives on the definition and characteristics of data. By and large, these perspectives don't agree. Each author defines a datum and its characteristics to support

her/his specific needs or point of view. It's impossible to determine a consistent definition or list of characteristics, categories, or structures for data that agrees with all the literature.

I want to demonstrate the variety in the data literature and find authors with perspectives that substantiate my perspective. I've developed a continuum to help me do this (Figure 1). I've placed a number of authors along my continuum. I label the left end of the continuum **structural** (What are the components that make up data?) because some of the perspectives tend to be very mechanical. I label the right end of the continuum **cognitive** (How are data used or perceived by the user?) because some of the perspectives seem to be very human. I label the midpoint of the continuum **representative** (What is the function of data or what do they represent?) because some of the perspectives fall between human and mechanical views. I'll place all my data literature on this continuum and use this continuum to analyze each literature source.

Peterson (1977) lays out a framework for information, and part of his information framework is referred to as data. He types data as being relative, relational, aggregated/disaggregated, macro/micro, and price data. Relative data express a comparison between two data. Relational data are created to show cause-effect relationships, such as statistical significance. Aggregated/disaggregated data refer to the appropriate level of detail at which data should be presented. Peterson suggests that data are at the right level of aggregation if subdividing the data reveals no new significant differences. Micro/macro data refer to the manager's span of control. If a project has many teams with many employees on each team, team leaders would consider data about the team members micro data, and data about the project as macro data.

Dearden (1965) breaks data into types according to what they represent. He defines three main types of data--financial, personnel, and logistic; and three smaller, specialized data types--marketing,

DATA CONTINUUM

AUTHORS

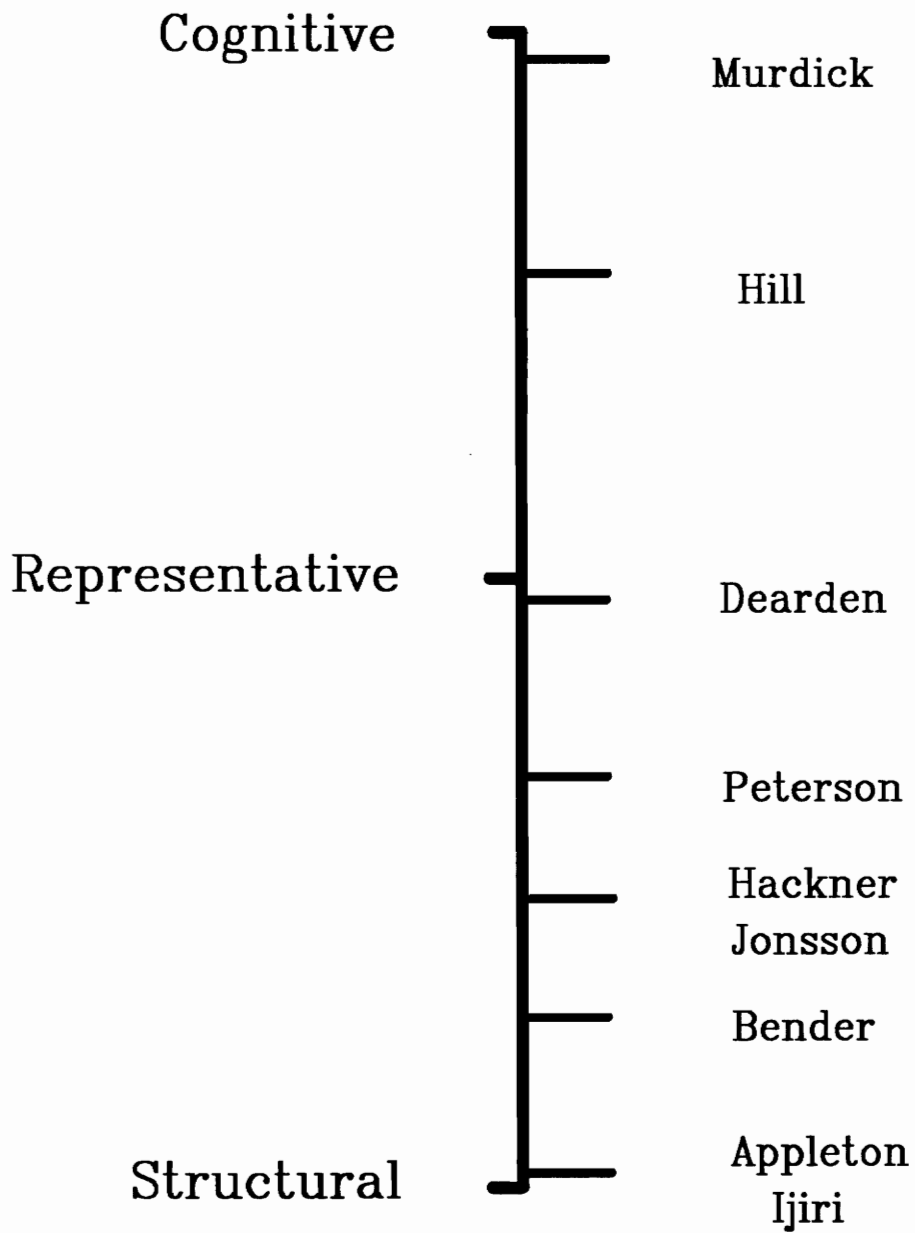


Figure 1. The data literature can be placed on a continuum from structural to cognitive.

strategic planning, and personal observation. Dearden says the main data types are shared by everyone, while the smaller, specialized data types are only used locally and aren't shared throughout the organization. Dearden makes these observations about data while focusing on information systems.

Both these authors identify categories of data by the data's function. Thus, I classify this data literature as representative. Recall that representative literature defines data according to their function or what they represent. I find several problems with representative literature. First, the distinction between data and information isn't clear. Both Peterson and Dearden use the terms data and information interchangeably. Second, Dearden's data types aren't mutually exclusive. (An employee's salary would be both financial and personnel.) I also believe an employee's salary wouldn't be shared throughout the organization, as Dearden claims for his three main data types. Third, these data categories seem to be developed largely on the opinion of the author. Peterson did conduct an extensive literature review to develop his data framework, but the final categories were selected based on his views. Another scholar could develop a totally different framework and be as correct as Peterson. Peterson's framework also leaves out important characteristics of data, such as timeliness. For more examples of representative literature, review Davis and Olson (1985), Epstein and King (1982), Gallagher (1974), Hicks (1984), Snavely (1967), Swanson (1974), and Zmud (1978). I don't plan to use representative literature in my study.

Murdick (1980) describes data as symbols and experience-stimuli not relevant to behavior at a given point in time. The key to data for Murdick is whether these symbols and experience-stimuli are not relevant to the behavior of the manager. If symbols do not initiate behavior, they represent data. If they do initiate behavior, they are information. What is information to one manager can be data to another manager, or data to the same manager at another point in time.

Hill (1989), in measuring information-oriented productivity and performance, classifies data as accurate, timely, or relevant based on the data's context with the user. Based on the needs of the user, data can be broken into three dichotomies: accurate or inaccurate, timely or untimely, and relevant or irrelevant.

Murdick's and Hill's definitions fall on the cognitive end of the continuum. Data and information can't be defined without considering the manager and the manager's information needs at a specific point in time. Murdick's definitions of data and information relate to Hill's definition of relevant and non-relevant information, where, according to Murdick, data would be non-relevant information and information would be relevant information. I won't use cognitive data definitions for my study.

Bender (1983) defines data as symbolic representations of reality. Data describe reality in terms of entities, relationships, or attributes of these entities or relationships. Bender describes three types of data: images, sounds, and characters. These data types refer to the medium by which the data are transmitted.

Appleton (1986) defines data as fact plus meaning. For Appleton, an example of a fact is the number 12345, and an example of a meaning is "the zip code of Washington, D.C.," or "a part number in the warehouse." Appleton states that for each meaning, there may be zero, one, or many facts.

Ijiri (1975) describes the requirements for "hard" data--verifiable facts, well-specified, with the measurement rules well-defined and limited. This description agrees with Appleton's views on data components, if we combine the specification and measurement rules into the meaning.

Hackner (1985) and Jonsson (1987) describe two types of data: hard (quantitative) data and soft (qualitative) data. These types of data aren't specifically defined, although hard data are referred to as data that resist the influence of critical reflection. The main problem with Hackner and Jonsson is they use information and data interchangeably, so it's difficult to determine whether they refer to data or information in their description of hard and soft data.

I place Bender, Hackner, and Jonsson between the representative point on the continuum (the midpoint) and the structural end. Bender is closer to the structural end of the continuum than Hackner and Jonsson because Bender says data describe entities, relationships, or attributes of entities or relationships, thus providing a glimpse of the structure of data. I place Appleton and Ijiri on the structural end of the continuum. Both authors describe the makeup of data in terms of required components. I'll use the structural literature, specifically Appleton, Ijiri, and Bender, in my study.

2. Information Literature

I'll look at three categories of literature to determine information definitions: information, bias, and data-to-information processes. After each category of information literature I'll summarize what I'll use in my research.

Information

Murdick (1980) describes information as symbols and experience-stimuli that are relevant to behavior at a given point in time. For Murdick, information must be behavior-initiating stimuli, so information

depends on the manager receiving the symbols and stimuli and the time at which the manager receives the symbols and stimuli. Tushman and Nadler (1978) state that information must effect a change in knowledge. Tushman and Nadler's definition also depends on the manager and his knowledge. Once a manager receives information, the manager's knowledge is increased, and the same presentation of information to the manager at a later date may no longer be information to that manager. Tushman and Nadler further define information as data that are relevant, accurate, timely, and concise. McDonough (1963) says knowledge is data evaluated for future use in general, while information is data evaluated for a specific situation. McDonough sees knowledge as a broader time-and-content context of information. Henderson (1979) uses McDonough's (1963) work to claim that information is data plus knowledge. In reading McDonough, I can't see how he arrives at this conclusion. I don't think Henderson uses the term "knowledge" in the same manner that McDonough does. What Henderson means to imply is that data are gathered and stored away for future use using knowledge. When information is needed to support a decision, data are retrieved using the knowledge of whether the data are useful in producing the desired decision.

Appleton (1986) defines information as an aggregation of data for a specific purpose, an aggregation being at least one, but probably many, data. Appleton requires a purpose for aggregating data to produce information: random data aggregations may not produce information. Bryce (1983) states information is the result of processing data to gain insights from which to make decisions and take actions. Bryce requires that data be processed, not simply aggregated as Appleton proposes, to produce information. Bryce also says the purpose of this processing is to gain insights for decision-making.

Peterson (1977) developed an information framework by collecting over eighty adjectives that describe some aspect of information. By using his judgment and experience, he reduced the list to ten

descriptors. Five of these descriptors he says apply to the decision maker, and are termed information types. The other five descriptors apply to the decision maker's helpers, and Peterson calls these descriptors data types. These data types are discussed in the data section of the literature review. The five information types are decisive, implementation, persuasive, damaging, and required. Decisive information is information that changes decisions. Implementation information is routine, unsurprising information that indicates project processes are within their control limits. Required information is constraint-fulfilling information, collected for use by external bodies such as federal regulatory agencies. Damaging information is information which would be detrimental if it were released or became generally known, such as employee evaluations. Persuasive information is filtered and biased information designed to influence a decision or opinion.

Peterson says data acquire meaning when compared to other data. Peterson uses the word "meaning" to denote something that managers can use to make decisions. Comparison is the way data become information. One datum alone cannot become information: a datum must be compared to another datum to produce information. Kurstedt (1985) shows data being compared against setpoints or references to generate information. McDonough (1963) says data are evaluated to produce information.

Mintzberg (1972), in looking at the manager as an information processing system, says the manager receives information from two basic sources: the external environment and the internal organization. Mintzberg further categorizes a manager's information into five groups: internal operations, external events, analyses, ideas and trends, and pressures. Internal operations information reflects the workings of the manager's organizational unit. External events information describes actions of competitors, customers, and others. Analyses are analytical reports on a variety of subjects, both internal and external. Ideas and trends help the manager learn new ways of doing things and future directions,

projections, or forecasts. Pressures are external influences on the manager's organizational unit, such as customer complaints or regulations.

Shannon (1949) in looking at information in communications theory, defines information as the reduction of uncertainty. Suppose a transmitter sends a message to a receiver. What is the certainty of the receiver about the message sent by the transmitter? Before transmission, the receiver hasn't gotten any message and is totally uncertain. As the message is sent, the parts of the message the receiver can distinguish (information) from other interference (noise) reduces the receiver's uncertainty. The important points are 1) information reduces uncertainty, and 2) information is what the receiver can distinguish from noise.

Radford (1988) defines information as recorded experience that is, or can be, used in decision-making. Radford doesn't require that information be used in decision-making, just that information have the ability to be used in decision-making. Bender (1983) defines information as a set of data assembled in a meaningful fashion. He further states that information is expressed in terms of models that relate data.

To summarize the information literature, something is added to a datum to make a unit of information. Information requires more than one datum. Information is produced when data are compared to other data (Peterson, 1977) or evaluated (McDonough, 1963). Kurstedt (1985) calls these other data setpoints or references. This information is expressed in models that relate data (Bender, 1983). Information must have the capability of being used for decision-making (Radford, 1988).

Bias

Blumenthal (1969) calls information data that is recorded, classified, organized, related, or interpreted within context to convey meaning. Kurstedt (1985) calls this interpretation-with-context "bias." Kurstedt sees bias as the natural result of going from data to information, and sees no inherent negative connotations associated with bias. Kurstedt says bias occurs when data are compared to setpoints or references to produce information. It's the selection of setpoints or references to evaluate data that causes bias. There are many references data can be evaluated against. The selection of one reference from all possible references biases the information obtained from data. Using Kurstedt's definition of bias, all information is biased, and bias is not by itself negative or positive. Bias must be added to data to get information.

Most authors view bias as something to be avoided or eliminated. Evans (1987) claims two major types of bias: confirmation bias and belief bias. The premise is that people tend to agree with those things supporting their own beliefs and confirming their own ideas. In this case, bias is the predisposition of managers to accept and agree with things confirming their own beliefs. Evans defines the role of a decision support system as a debiasing mechanism for managers, eliminating their tunnel vision by forcing managers to consider other data and information in decision making, thus eliminating their tendency to select the same references. O'Reilly (1983) claims managers making decisions select a preferred outcome and look for data and information to support the desired outcome while ignoring conflicting data and information. Kurstedt (1985) states the bias on information should be the bias of the person using the information, not the bias of the person providing the information. Peterson (1977) discusses persuasive information as information biased for the purpose of influencing a decision.

Peterson indicates bias is used to unfairly influence decisions or opinions by the way data are filtered or reduced to produce information.

To summarize the bias literature, something is added to a datum to make a unit of information. Kurstedt (1985) calls this "something" bias. I agree with Kurstedt that all information is biased. Bias is not bad in itself. While bias may be bad for a manager when its used to promote a specific point of view or hide information, using a generally accepted reference to evaluate data when that reference is not relevant can produce information just as bad for the manager. The bias literature confirms that information is produced through evaluation, and the selection of a reference for evaluation biases the information. By adding bias to a datum through the selection of a reference we get information. Managers should know the bias used to produce their information so they can use the information effectively.

The Data-to-Information Process

Kurstedt (1985) identifies a process called the data-to-information chain, which describes how data are collected and portrayed as information to a manager for decision-making. The six steps of the process are *acquire data*, *store data*, *retrieve data*, *manipulate data*, *generate information*, and *portray information*. Data are acquired from the operation the manager is responsible for, and placed into storage. When they are needed, data are retrieved from storage and manipulated by application procedures, which may or may not be on a computer. The manipulated data are compared to setpoints or references, where they yield information. Some media type (tables, graphs, checklists, or text) is matched to the information, and the information is arranged in this medium to portray information to the manager. Although Kurstedt shows the portrayal interface as providing only information to managers, other authors claim some managers need only data. Chorba and New (1980) report some managers,

especially lower-level managers, only need data because they know the setpoints or references and can complete the data-to-information process on their own.

The remaining literature on the data-to-information process is much less detailed, and only identifies a portion of the data-to-information process. Bender (1983) says information is data assembled in a meaningful fashion, and this data assembly is some model that relates the data in the model. Blumenthal (1969) says information comes from data that are recorded, classified, organized, or interpreted within context to convey meaning. Peterson (1977) says data comparison is the process that converts data to information, while McDonough (1963) says evaluation converts data to information.

To summarize the data-to-information process literature, Kurstedt (1985) identifies a process called the data-to-information chain, which describes how data are collected and portrayed as information to a manager for decision-making. The six steps of the process are *acquire data*, *store data*, *retrieve data*, *manipulate data*, *generate information*, and *portray information*. Kurstedt shows the portrayal interface as providing only information to managers, but Chorba and New (1980) report some managers, especially lower-level managers, only need data to complete the data-to-information process. Bender (1983) says information is data assembled in a meaningful fashion, and this data assembly is some model that relates the data in the model. Several authors comment on the way data is manipulated to produce information. Blumenthal (1969) says information comes from data that are recorded, classified, organized, or interpreted within context to convey meaning. Peterson (1977) says data comparison is the process that converts data to information, while McDonough (1963) says evaluation converts data to information.

Summary

Here's the information literature I use in my research. Information requires more than one datum. Information is produced when a datum or data are compared to other data (Peterson, 1977). Kurstedt (1985) calls these other data setpoints or references. McDonough (1963) says data evaluation produces information. Bender (1983) says this information is expressed in models that relate data. All information is biased through selection of setpoints or references for comparison (Kurstedt, 1985).

3. Organizational Levels Literature

Organizational levels are defined in the literature as levels of managerial activity or decision-making. Managers are judged to be at the level of managerial activity or decision-making they primarily perform, although all managers may perform some of every activity and decision.

One of the earliest references to organizational level is Parsons (1960). Parsons proposed three levels of decision-making in an organization: institutional, managerial, and operational. Institutional decisions are performed primarily at the top of the organization and set broad goals and policy. Managerial decisions are at the middle of the organization and direct the activities of the organization and coordinate tasks. Operational decisions normally take place at the bottom of the organization and involve performing the activities of the organization.

Anthony (1965) developed a taxonomy for managerial activity similar to Parsons' framework. Anthony breaks managerial activity into three groups, stating these activities are sufficiently different to require different planning and control systems. Anthony's three groups are strategic planning, managerial control, and operational control. Managers performing strategic planning set policy, organizational objectives, and determine resources to be applied to attain these objectives. Managers performing management control assure resources are obtained and used wisely in the performance of the organization's objectives. Managers performing operational control are responsible for carrying out specific tasks.

Kurstedt, Mendes, and Polk (1988) adapt the Anthony framework to describe management endeavors. An endeavor is any serious determined effort toward a purpose. Kurstedt (1990) proposes four endeavors: strategic, tactical, operational, and clerical. Strategic endeavors are those where global efforts are aimed in a general direction using qualitative measures. Tactical endeavors represent wide efforts directed toward a tangible result using quantitative standards. Operational endeavors involve limited efforts focused on a fixed outcome using restricted methods. Clerical endeavors consist of local efforts constrained to explicit tasks. Three of these endeavors (strategic, tactical, and operational) are supervisory activities, matching Parsons' and Anthony's three levels of managerial activity. Clerical endeavors are not supervisory, although they are managerial⁵ activities. Managers at any organizational level may perform all endeavors, although one predominates if the manager is performing his/her job correctly.

Kurstedt provides operational characteristics for each endeavor (Table 1). In these operational characteristics, Kurstedt uses the terms "problem" and "opportunity" to mean essentially the same thing.

5 The word management here means simply decision-making (Forrester, 1961). Many decisions aren't supervisory, but they are, by definition, managerial.

Table 1. Operational Criteria for Different Endeavors.

OPERATIONAL CRITERIA	STRATEGIC ENDEAVORS	TACTICAL ENDEAVORS	OPERATIONAL ENDEAVORS	CLERICAL ENDEAVORS
WHAT THEY DO	Decide What Problems to Solve	Decide What Resources to Use	Decide How to Solve the Problem	Solve the Problem
WHAT THEY MANAGE	Outcomes	Outputs	Transformation Path	Execution of Steps
WHAT IS ACCOMPLISHED	Goals	Objectives	Missions	Jobs
SETS PRIORITIES FOR	Outcomes and Implied Tasks	Allocating Resources	Steps	NONE (They Monitor and Implement Priorities)
TYPE OF EFFORT	Pursuits	Activities	Tasks	Actions
FORMULATION TOOL OR GUIDANCE	Policies	Plans	Procedures	Instructions
EVALUATION OF FORMULATION TOOL	Relationships of Plans	Framework for Procedures	Value of Instruction	Yes/No on Steps
FORCING FUNCTIONS	Internal and External Organizational Environment	Chosen Outcomes, Goals, and Implied Tasks	Objectives and Resource Allocation	Steps and Their Sequence
INTERFACES	Time, People, Materials, and Other Resources	Decisions, Procedures, and Processes	Effort to Do Job	Materials and Machinery
CONSTRAINTS	Resource Availability and Requirements	Steps Needed to Allocate Resources	Work Needed to Carry Out Steps	Status of the Work

By comparing these characteristics against any endeavor we can determine if the endeavor is strategic, tactical, operational, or clerical. For purposes of this research, I'll use Kurstedt's four endeavors to represent my organizational levels. I like using endeavors as a surrogate for organizational levels because 1) they relate to what the managers are doing instead of where they are in the organization; 2) Kurstedt provides operational characteristics to categorize each endeavor; and 3) Kurstedt relates endeavors to organizational levels.

4. Data and Information Needs and Endeavors Literature

There is no literature directly relating data and information needs with endeavors. However, two literature sources give us clues relating information and data needs with endeavors. Gorry and Scott Morton (1971) identify a framework for management information systems based on decision types and managerial activities; Daft and Lengel (1984) describe a framework for information media type and organizational level. Decision type literature provides clues to relate information and data to organizational levels because unstructured decisions are primarily strategic while structured decisions are more operational. Media types relate data and information to organizational level by demonstrating the complexity and makeup of data and information at different levels. I'll discuss the decision type literature to provide a background for Gorry and Scott Morton's framework. I'll then discuss the literature on information and organizational levels. Finally, I'll present other literature that discusses aspects of data and information use at different organizational levels.

Decision Types

Simon (1960) defined the two extremes of decision types: programmed and nonprogrammed. Programmed decisions are repetitive and routine, and a procedure has been worked out for handling them. Nonprogrammed decisions are novel, unstructured, and consequential. There are no specific procedures to deal with nonprogrammed decisions. More data and information are required for nonprogrammed decisions than for programmed decisions. Galbraith (1973) made the point that, as the level of uncertainty increases, more information must be processed to reduce this uncertainty. Since nonprogrammed decisions are more uncertain, they require more information. Gorry and Scott Morton (1971) adapt Simon's definitions, and rename them structured and unstructured, for programmed and nonprogrammed, respectively. They define a third category, semistructured decisions, to account for all decisions that aren't purely structured or unstructured. I use the observation of Simon (1960) and Galbraith (1973) that more data and information are used for unstructured decisions as the basis for my testable hypothesis #1.

Thompson (1967) defines four decision types based on a two-by-two matrix, with one axis being beliefs about cause/effect, and the other axis being preferences regarding possible outcomes. Computational decisions are those where beliefs about cause/effect are certain and preferences regarding possible outcomes are certain. Computational decisions relate to Simon's programmed decisions and Gorry and Scott Morton's structured decisions. Inspirational decisions are unstructured or nonprogrammed decisions, where both cause and effect and preferences regarding possible outcomes are uncertain. Thompson's judgmental and compromise decisions both are semi-structured decisions in Gorry and Scott Morton's terminology. In judgmental decisions, cause/effect beliefs are uncertain, but

preferences regarding possible outcomes are certain. In compromise decisions, cause/effect beliefs are certain, but preferences regarding possible outcomes are uncertain.

Gorry and Scott Morton

Gorry and Scott Morton (1971) present a framework for management information systems. They use Anthony's (1965) three categories of managerial activity (strategic, management, and operational) and Simon's (1960) decision types (structured, unstructured, and what Gorry and Scott Morton define as semistructured) to create a three-by-three grid. This grid "provides a useful framework within which to examine the purposes and problems of information systems activity." Gorry and Scott Morton say that each one of the nine cells in their grid constitutes a unique combination of managerial activity and decision type, therefore each cell requires its own specialized management information system. They say aggregating data from the operational level for use by management or strategic levels is expensive, technically difficult, and unnecessary. If strategic managers need operational data, it's more cost effective to statistically sample or estimate the data. Gorry and Scott Morton also say most of the management information systems concentrate on the structured decisions, especially the operational ones. Management information systems should be created to provide management and strategic levels the information they need.

Gorry and Scott Morton look at several characteristics of information across different organizational levels. The information characteristics they look at are information source, scope, level of aggregation, time horizon, currency, required accuracy, and frequency of use. As we go from the operational to the strategic level, Gorry and Scott Morton say the information characteristics change in the following manner. Information source moves from internal to external. Scope moves from narrow to broad. Aggregation moves from detailed to aggregate. Time horizon moves from historical to future.

Currency moves from current to old. Required accuracy moves from high to low. Frequency of use moves from very frequent to infrequent. I use the observation of Gorry and Scott Morton (1971) that information sources move from internal to external as we go from the operational to the strategic level as the basis for my testable hypothesis #4. I won't use Gorry and Scott Morton's other observations because my definitions for the makeup of data and information can't measure these observations.

Daft and Lengel

Daft and Lengel (1984) look at the use of different types of media at different organizational levels. They define five types of media: numeric formal, written formal, written personal, telephone, and face-to-face. They also define information richness as the information-carrying capacity of these media. They found the information richness of the media increased from numeric formal to written formal to written personal to telephone to face-to-face. They then used Parson's (1960) institutional, managerial, and operational levels of decision-making to see what media types were used at each level. Daft and Lengel found that the richest media (face-to-face, telephone) were the main media used at the institutional level of the organization, while the least-rich medium (numeric formal) was the primary medium used at the operational level. Daft and Lengel state that managers at upper organizational levels perform tasks that are broad, wide-ranging, equivocal, and less defined. Rich media allow managers to quickly bring definition to their unstructured tasks. The use of less-rich media would be ineffective at this level. Managers at operational levels perform structured tasks. Less-rich media are sufficient for them to complete their structured tasks, and the use of rich media would be inefficient. Daft and Lengel say that less-rich media tend to contain data, while rich media tend to contain information. Daft and Lengel point to Leifer (1979), who says that inputs used at the top of the organization tend to be informational while inputs at the bottom of the organization tend to be data. I use the observation of Daft and Lengel (1984) and Leifer (1979) that higher organizational levels tend

to use information while lower organizational levels tend to use data as the basis for my testable hypothesis #2.

Daft and Lengel also discuss the need for using multiple informational cues to understand highly equivocal information. Simple organizational phenomena tend to be mechanical, routine, predictable and well-understood. Managers can typically follow an objective, computational procedure to solve these problems. Complex organizational phenomena are difficult, hard to analyze, and unpredictable, and no objective, computational procedure tells managers how to respond. Managers need multiple informational cues and information outside normal procedures to solve these problems (Daft and Lengel, 1984). I use the observation by Daft and Lengel that higher-level managers need multiple informational cues to understand highly equivocal information as the basis for my testable hypothesis #3.

Other Literature

Concerning data use within an organization, Dearden (1965) says that some data types are shared by everyone, while the smaller, specialized data types are only used locally and aren't shared throughout the organization. Other authors support the concept of shared data. Glasgow and Graham (1988) discuss the use of core data bases for rapidly prototyping information systems. This core of data is common to the whole organization. For a manufacturing firm, production counts and costs would be part of the core data. Senn (1987) discusses shared data as the only component of a good information system database and states that other data are used only within one functional group. Non-core data should be excluded from the database.

As we move up the organization, managers use more data and information from outside the organization as references for evaluating their domains of responsibility. Aiken and Hage (1972) have talked about the role of environmental scanning in strategic management. Rockart and Treacy (1982) have noted that CEOs tend to compare their company against competitors, other industries, and against their customer base.

Summary

As we move up the organization, decisions become more unstructured. Unstructured decisions require more data and information than structured decisions (Simon, 1960; Galbraith, 1973). (See testable hypothesis #1). Also, as we move up the organization, managers use less data and more information (Daft and Lengel, 1984; Leifer, 1979). (See testable hypothesis #2). Unstructured decisions require multiple informational cues to evaluate data and information because these evaluations aren't clear cut (Daft and Lengel, 1984). (See testable hypothesis #3). Information sources move from internal to external to the manager's domain as we move up the organization (Gorry and Scott Morton, 1971; Aiken and Hage, 1972; Rockart and Treacy, 1982). (See testable hypothesis #4).

5. *Verbal Protocols*

Verbal protocols is a straightforward method of obtaining data about the knowledge and thought processes of an individual performing a task. Verbal protocols have proved valuable and are often used in the areas of cognitive psychology (Newell and Simon, 1972), decision making (Payne, Braunstein, and Carroll, 1978; Clarkson, 1962; Payne, 1976), and knowledge engineering (Greenwell,

1988). In verbal protocols, the subject is asked to give continuous verbal narration, "to think aloud," while performing an endeavor. The verbal protocols are treated as "a record of the subject's ongoing behavior, and an utterance at time t is taken to indicate knowledge or operation at time t " (Newell and Simon, 1972).

The process for using verbal protocols has three steps. In the first step, the verbal protocols are recorded using an audio or video tape recorder. In the second step, the verbal protocols are transcribed and divided into short phrases. Each phrase should constitute a single task assertion or reference by the subject. In step three, the short phrases are encoded into formal categories that correspond with the variables the researcher wants to measure.

Verbal protocols evolved from the more general practice of verbal reports, which include interviews and introspection. In introspection, highly trained observers (sometimes the researchers themselves) report thought processes while performing a task. In interviews, data are collected after the task is completed. The criticism raised against introspection is objectivity of the data collected. Observers trained to look for specific research variables in their thoughts tended to seek out these research variables and think in ways that generated the research variables. The criticism raised against interviews is the ability to recall specific thoughts and actions. Subjects being interviewed tended to mix current knowledge with past knowledge and leave out observations.

Most criticisms of verbal protocols tend to lump verbal protocols with all other verbal reports (Payne, Braunstein, and Carroll, 1978). For example, Nisbett and Wilson (1977) say verbal reports have no ability to describe higher-order cognitive processes, such as the factors that cause a person to change their behavior. However, Nisbett and Wilson don't look specifically at verbal protocols, but look instead at introspection and interviews. Verbal protocols eliminate problems associated with

introspection and interviews. Verbal protocols have the advantage of providing data during the actual performance of the task rather than recalling actions after the task. Verbal protocols also require little or no subject training. Tests have shown that, given only the simple instructions to "think aloud," subjects can provide much useful data (Payne, Braunstein, and Carroll, 1978). Since subjects aren't trained to look for specific items, verbal protocols provide an objective record of what the subject does (Dulaney and O'Connell, 1963; Schwartz, 1966; Frankel, Levine, and Karpf, 1970).

Verbal protocols, along with information boards, are the two major process-tracing methods used by researchers today (Ford, Schmitt, Schechtman, Hults, and Doherty, 1989). Information boards are primarily used for problems of selection among alternatives. Information boards require subject training and provide the researcher data about what data and information were used, but not how the data and information were used. Verbal protocols can be used for a wider variety of problems. Verbal protocols provide the researcher data about what data and information were used and how the data and information were used. Verbal protocols do require more effort during transcription and coding than information boards and rely on the researcher's judgment in interpreting and coding the protocols.

Indeed, the main criticism directed specifically at verbal protocols is the reliability of their interpretation by the researcher. However, many studies have been conducted that demonstrate a high reliability for verbal protocols. Montgomery (1976) reported a 95% reliability for protocols interpretation between judges. Svenson (1974) reported interpretation of verbal protocol agreement between judges of 87.8%. Montgomery and Svenson performed the only significant attempts to judge and measure the reliability of protocols. These studies by Montgomery and Svenson at least show that verbal protocols are a tool that can give repeatable results from researcher to researcher. While reliability of verbal protocols may need further investigation, it seems reasonable to trust their

reliability (Payne, Braunstein, and Carroll, 1978). Ericsson and Simon (1984) encourage the use of verbal protocols as a reliable method for data collection, saying verbal protocols are one of the few methods available to researchers to understand decision processes. Newell and Simon (1974) say: "The interpretation of a protocol . . . is not completely free from subjectivity, although experience in carrying out such an analysis suggests that the leeway for the interpreter is not great in most cases."

Methodology

In this section I describe how I determined the differences in the makeup of data and information for different endeavors. I first present the research model to structure my methodology and describe what I'm doing and why. I then define and discuss my independent and dependent variables. I developed a set of test documents for subjects to use when gathering data and information for their strategic and operational endeavors. As I discuss my variables I show how they are operationalized in my test documents. As I discuss and develop these variables, I base my work primarily on the literature of Appleton (1986), Kurstedt (1990), and Daft and Lengel (1984). I develop and discuss four testable hypotheses, each relating one of the four dependent variables to the independent variable. Next I discuss any moderator variables, defined as other variables affecting the relationships between the dependent and independent variables (Borg, 1983; Graziano and Raulin, 1989).

I then present the detailed methodology used in performing the pilot test and experiment and analyzing the results. I have data and information--each of which I have identified and characterized--on my test documents. In my pilot test and experiment, subjects performed both a strategic and operational endeavor using these test documents as sources for data and information. First I conducted a pilot test with two subjects to improve the test documents and procedures. I then conducted my experiment using ten subjects selected from managers at Management Systems Laboratories. As each subject performed the experiment, I determined what data and information the subjects used from the test

documents by using verbal protocols. I tallied the data and information subjects reported using to provide numbers for statistical analyses of my hypotheses.

The Research Model

My research model is shown in Figure 2. The basic question I want to answer is this: How does the makeup of data and information differ as managers select data and information for doing two different specific endeavors? Remember, I use the endeavors defined by Kurstedt as a surrogate for organizational levels. Therefore, the independent variable is endeavors, and the dependent variables are the makeup of data and information. I separate the makeup of data and information into four dependent variables I define later. I've identified five moderator variables: organization size, organization type, and three decision maker attributes: subject personality type, subject experience, and subject effectiveness. I next discuss these variables and their relationships in greater detail.

Discussion of Independent Variable

In summarizing the literature on organizational levels, most authors provide a three-level hierarchy of organizations: strategic, tactical, and operational. None of these authors except Kurstedt (1990) operationally defines these levels. I use Kurstedt's endeavors to make statements about organizational levels because 1) endeavors are concerned with what managers are doing instead of where they are in the organization; 2) Kurstedt provides operational characteristics to categorize each endeavor; and 3) Kurstedt relates endeavors to organizational levels. As such, I'll assume Kurstedt's endeavors as my independent variable and apply his operational characteristics in constructing my research endeavors.

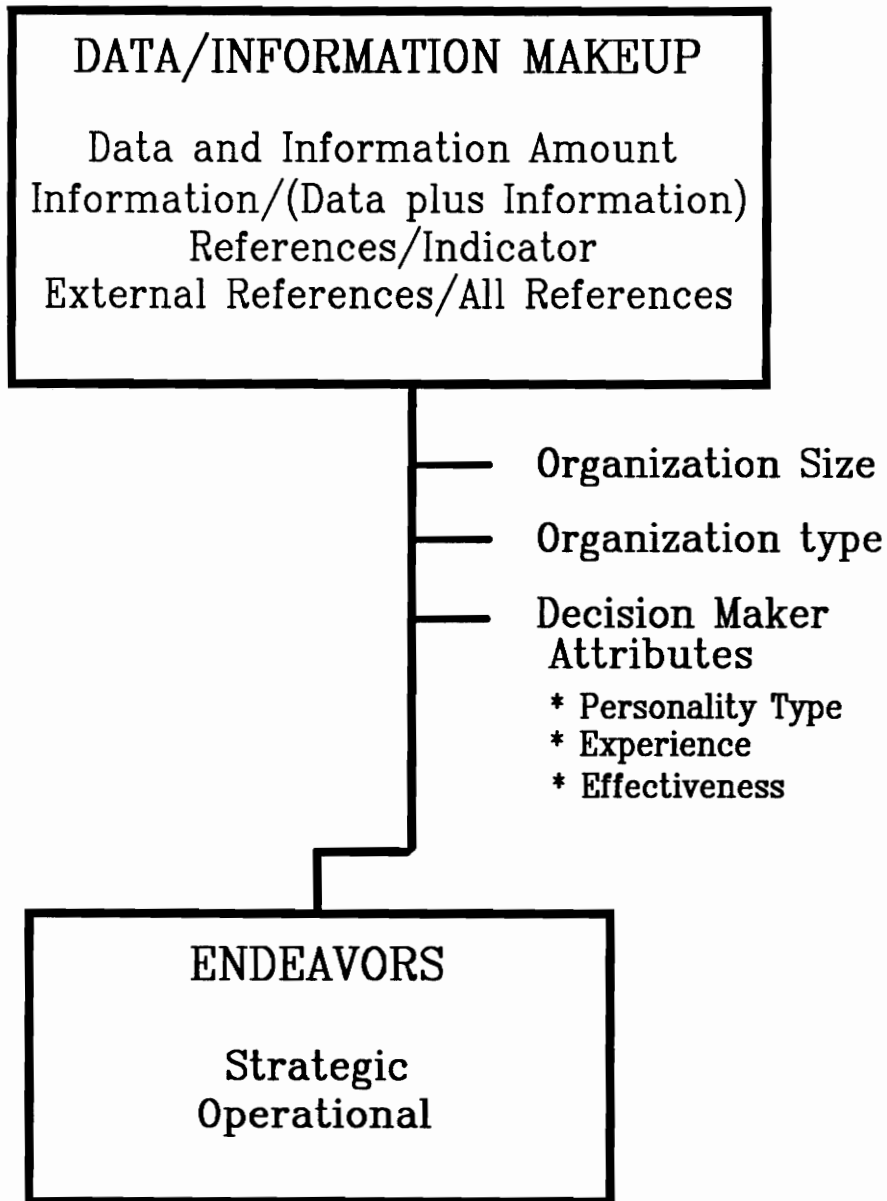


Figure 2. A research model of differences in data/information makeup across endeavors.

For this experiment I select two values of the independent variable (strategic and operational endeavors) to limit the scope of my research. Endeavors are really a continuum of management efforts. For simplicity I approximate the continuous variable as a discrete variable and use four discrete levels. By selecting two non-adjacent endeavors I intend to stay away from possible overlap in my experiment, and thereby clarify my results.

For my strategic endeavor I'll have subjects rank tasks based on desired outcomes and implied importance or urgency of the tasks. Kurstedt (1990) defines strategic endeavors as global efforts focusing on problem, or opportunity, identification and scoping aimed in a general direction using qualitative measures to evaluate the efforts. Managers doing a strategic endeavor choose the outcomes, opportunities, problems, and thereby, specify the implied tasks and rank the tasks by basing their choices on importance and urgency. Using Kurstedt's definition, ranking tasks based on desired outcomes and implied importance or urgency of the tasks is a strategic endeavor.

For my operational endeavor I'll have subjects develop a weekly schedule for assigned employees to perform tasks. Kurstedt (1990) defines operational endeavors as limited efforts focused on developing solution procedures for a given problem based on a fixed outcome and output using restricted methods to accomplish the task. Managers doing operational endeavors figure out what steps to take to use the designated resources to solve a given problem or take advantage of a given opportunity. Using Kurstedt's definition, developing a weekly schedule for assigned employees to perform tasks is an operational endeavor.

To show that my specific endeavors are non-adjacent, I'll describe the specific tactical endeavor between the strategic and operational endeavors I selected. In between the decisions of ranking tasks

(strategic endeavors) and decisions scheduling designated resources (operational endeavors) are the decisions of designating the resources (tactical endeavors). Kurstedt (1990) defines tactical endeavors as wide efforts focusing on resources needed to solve a problem or take advantage of an opportunity aimed toward a tangible result using quantitative measures to evaluate the efforts. Managers doing a tactical endeavor choose the outputs to satisfy the desired outcomes, the challenges to meet to take advantage of the appropriate opportunity, and the resources needed to solve the designated problem, and thereby, specify the implied resources to deal with tasks. Using Kurstedt's definition, designating resources used to solve the tasks is a tactical endeavor.

Discussion of Dependent Variables

In this discussion I develop definitions for the makeup of data and information in enough detail so I can develop an instrument to measure differences in these dependent variables as test subjects perform strategic or operational endeavors. Specifically, for my dependent variables I need to identify 1) what is a datum and what is a unit of information; 2) if each datum or unit of information subjects need acts as an indicator or a reference; and 3) whether each datum or unit of information is internal or external to the scope of the endeavors.

First I define a datum and its makeup. Then I define a unit of information and its makeup. Next I summarize my definitions of data, information, and their makeup and provide examples to lend face validity to my definitions. I discuss how I'll identify indicators and references during the pilot test and the experiment. I finally identify data and information on the test documents and determine whether data and information are internal or external to the scope of the endeavors.

A Datum and its Makeup

I use Bender's (1983) definition of data as symbolic representations of reality. I also modify Appleton's (1986) and Ijiri's (1975) definition of data to define the structure of data. I define a datum as composed of a kernel and a set of specifiers (Figure 3). The kernel is the value of the symbol. The kernel is called a "fact" by Appleton (1986) and Ijiri (1975). A kernel has the potential to mean something to a manager, but by itself, a kernel is meaningless. We have to add ingredients, called specifiers, to get meaning. Specifiers are called "meaning" by Appleton (1986). Appleton's "meaning" can apply to zero, one, or many "facts," but any set of specifiers uniquely characterizes one kernel. Appleton's (1986) work is useful in showing that widgets can apply to many kernels. (See Figure 3.) So can July 22, 1989. So can machine A. So can 3:00 PM. But the set of all these applies uniquely to one kernel. Recording data kernels removes them from context. Specifiers are used to carry the context of the kernel to the manager who uses the data. Specifiers are recorded much as kernels are, and, when recombined with kernels, give the kernel meaning again.

For example, when I measure the widget throughput of a machine as 23 units, the units are widgets and the measurement is taken at 3:00 PM on July 22. When I record the number 23 on the data collection sheet, I have to be careful about headings like widgets and recording the date and time or all the specifiers may be lost and the kernel has no context. Specifiers must be included with the kernel to convey the context of the data to the manager. Specifiers fulfill Ijiri's (1975) requirement for data, who says data must be well-specified. Kernels and specifiers can be kept in a database, but they're kept separately. A computer or human algorithm must assemble the kernels with the appropriate specifiers to get meaning.

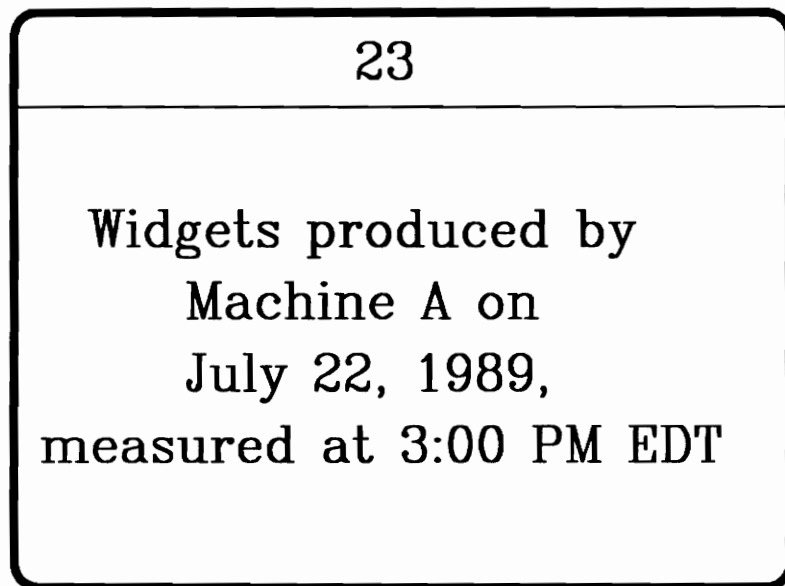
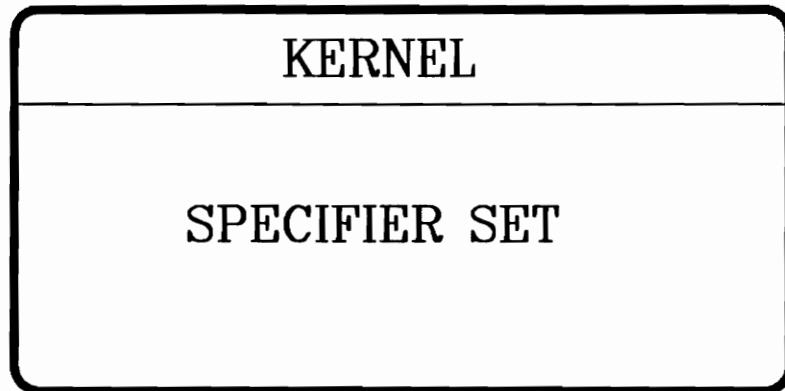


Figure 3. A datum is composed of a kernel and a set of specifiers.

A Unit of Information and its Makeup

Here I summarize the information literature I use in my research. Information requires more than one datum. Information is produced when a datum or data are compared to another datum or other data (Peterson, 1977). Kurstedt (1985) calls these other data setpoints or references. McDonough (1963) says data are evaluated to produce information. This information is expressed in models that relate data (Bender, 1983). All information is biased through selection of setpoints or references for comparison (Kurstedt, 1985).

Peterson (1977) uses the term "data comparison" while McDonough (1963) uses the term "data evaluation" in describing how information is produced. I think both authors, through their selection of terms, bring to light important points about producing information. The word compare comes from the Latin word *comparare*, meaning "to pair." Therefore any comparison is, by definition, a pairwise comparison. Thus, from Peterson we learn that two and only two data create one unit of information. Evaluate means to judge the merit or value of something; to assess something. One datum of the pair is used to judge the value or merit of the other datum. Evaluation, by definition, shows precedence in the selection of each datum in the pair. One datum is first selected to be evaluated. Then the other datum is selected to evaluate the first datum. Also, since one datum evaluates the other, the data must have common points or similarities. Any two data can be compared, but only similar data can be used for evaluation.

Thus, from Peterson we get the requirement of two and only two data (pair) to produce one unit of information. From McDonough we learn of precedence in selecting each datum for the pair and the requirement for similarity between the two data. I use the term "evaluate" to describe how information

is created, since it more closely matches the process of creating a unit of information. In doing so, I attach to the word "evaluate" Peterson's requirement that the evaluation is a pairwise evaluation.

A pair of data must be evaluated to produce a unit of information. Must this pair contain only data? The literature I've reviewed supports only data as the pair of something that can produce information. Given the confusion in the literature between data and information, I want to see if information can't also be used to produce information. The rules for creating information are (1) information is produced by a pairwise comparison (Peterson, 1977) and (2) the information must be expressed in a model that relates the pair being compared (Bender, 1983). Based on these rules I see no reason why two units of information can't produce another unit of information.

According to my definitions, all information must ultimately come from data. A unit of information produced by evaluating two other units of information can be seen as a complex series of evaluations of the data that make up the information being evaluated. This complex series of evaluations can be visualized as a tree structure on its side (Figure 4). The branches of the tree are on the left. As pairwise evaluations are made, the tree narrows until the last evaluation yields one unit of information used to support a decision. In looking at all the evaluations required to produce information, it's easy to say that all information is produced from data comparison; some comparisons are just more complex than others.

I prefer not to look at information as a complex series of data evaluations for two reasons. First, I see each evaluation as producing information, not just the last evaluation. Data are measured, but information are created through evaluation. I concentrate on each evaluation. Even if each evaluation is performed in the manager's mind, it's important to capture this intermediate information and determine the assumptions embedded in its creation. Second, managers don't always start with data to

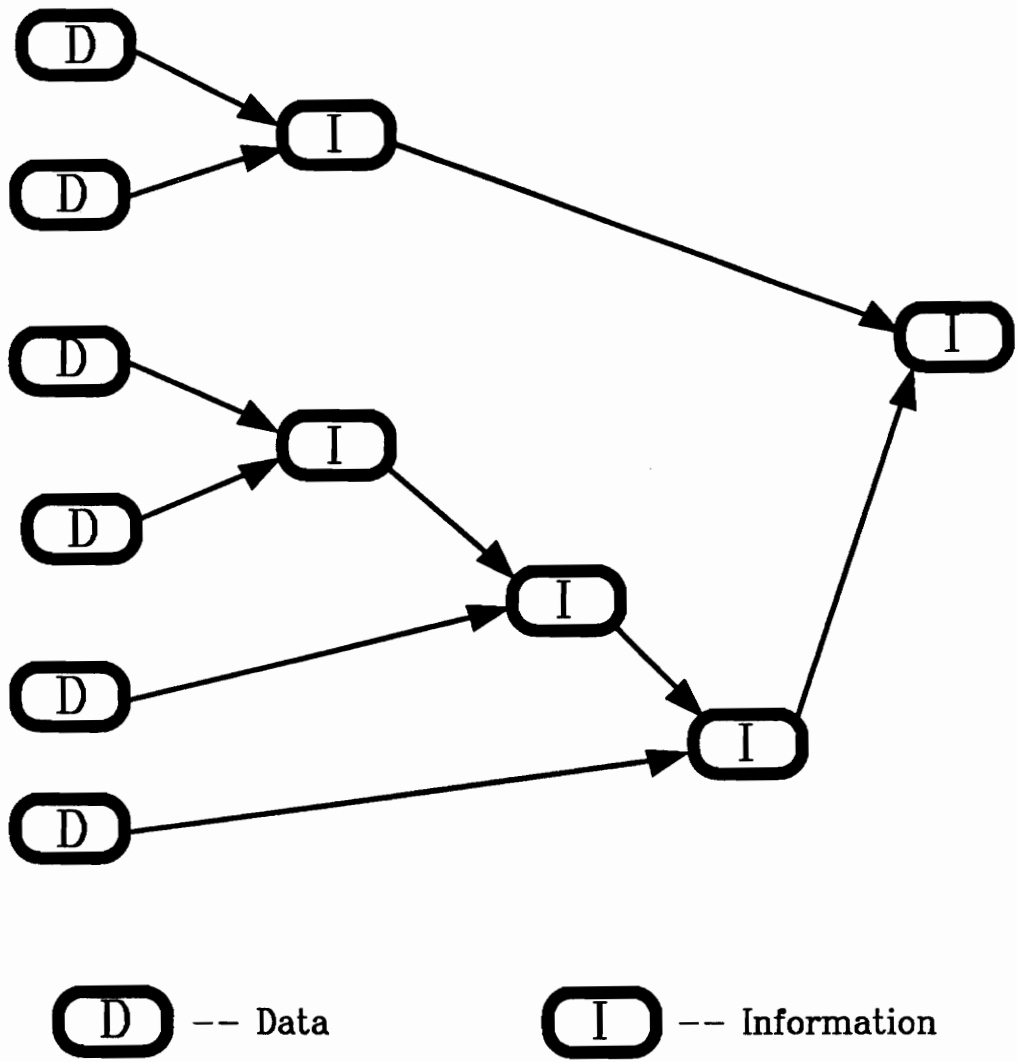


Figure 4. Information is produced through complex pairwise evaluations of data.

solve a problem. Many times managers get information that someone else has produced from data evaluation or even from evaluating other information. Managers can't convert information into the fundamental data that make it up, because once data produce information, the data may be lost forever. Managers should know whether they start with data (which come from direct measurement) or information (which are at least one step removed from direct measurement).

A pair is a necessary condition to produce information. By looking at Peterson (1977) and McDonough (1963) we know a unit of information is produced by a pairwise evaluation. If more than two data and/or units of information are to be evaluated, they're evaluated in pairs with each evaluation yielding a unit of information. Thus, evaluating two data and/or units of information yields one unit of information, three data and/or units of information yield three units of information, four data and/or units of information yield six units of information, etc. The general formula for the number of units of information produced is

$$\frac{n!}{2!(n-2)!}$$

where n is the number of data and/or units of information being evaluated.

To summarize, information requires a pairwise evaluation of information and/or data. One datum or unit of information is selected to be evaluated. I define this datum or unit of information as an indicator. The other datum or unit of information is selected to evaluate the indicator. I call this datum or unit of information a reference (Figure 5).

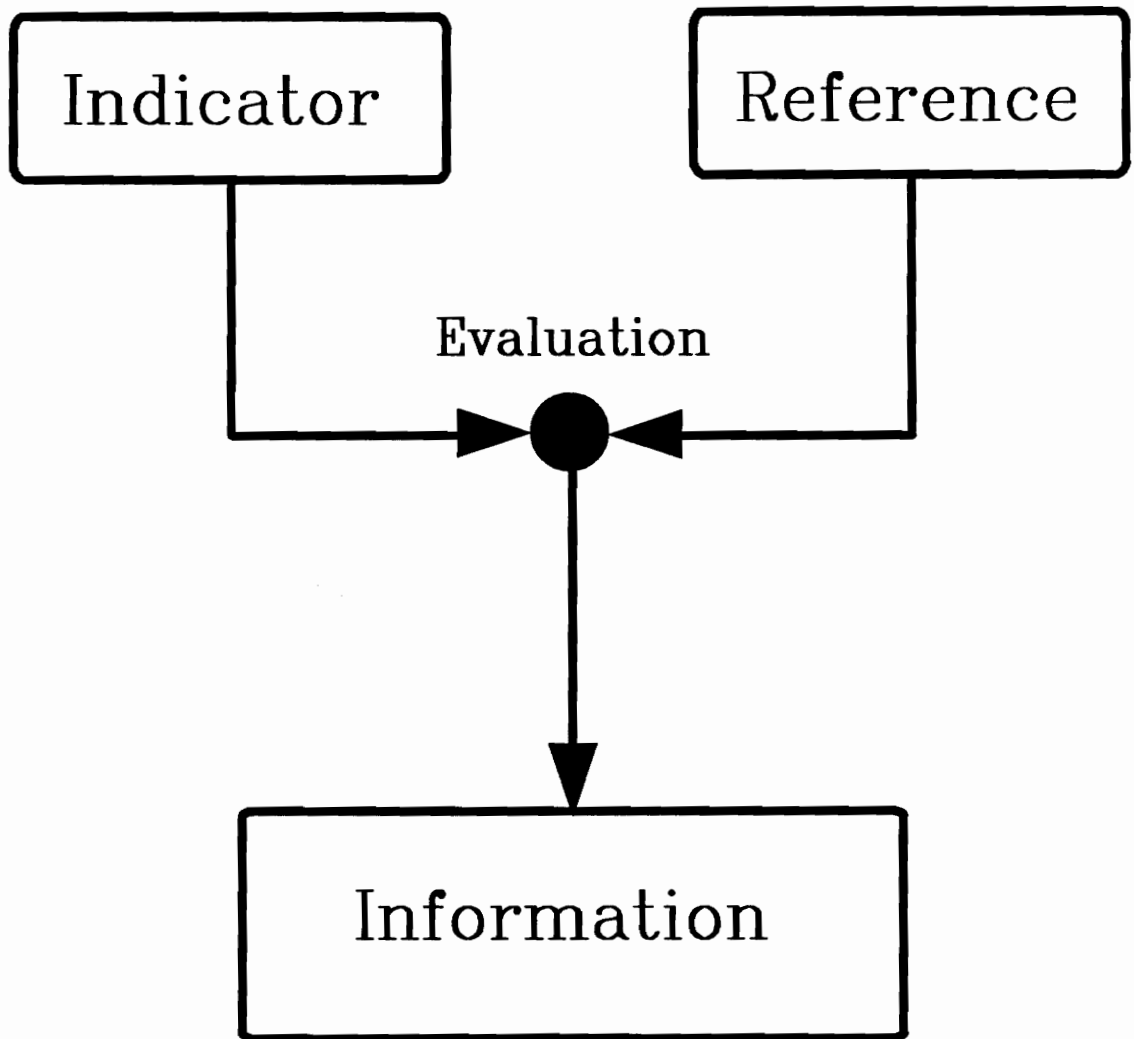


Figure 5. Information is created through evaluation of an indicator with a reference.

Definitions

A summary of my definitions for data, information, the makeup of data, and the makeup of information is listed below.

Kernel - A symbol produced as a result of measurement.

Specifier - A symbol used to give meaning to a kernel.

Datum - A symbolic representation of reality produced from direct measurement. A datum is composed of one kernel and one set of specifiers that uniquely gives meaning to the kernel.

Indicator - Any datum or unit of information selected to be evaluated to produce information.

Reference - Any datum or unit of information used to evaluate an indicator.

Information - The result of evaluating an indicator with a reference. It is expressed as a model relating the indicator to the reference.

Examples

In this section I'll present examples of two datums producing a unit of information, two units of information producing a third unit of information, and bias. In these examples I'll use the definitions listed above.

A manager may want to evaluate the performance of a machine. For the indicator, the manager may use the production of the machine, in units, for this week. Suppose, for this indicator, the kernel is 120; the specifier set is "type A widgets produced on machine 1 for the week of July 10-17, 1989." For the reference, the manager may choose the production on the same machine for last week. Suppose, for this reference, the kernel is 110; the specifier set is "type A widgets produced on machine 1 for the week of July 3-9, 1989." The manager evaluates the indicator with the reference and produces a unit of information. The information is "machine 1 produced 10 more units this week than last week." Notice that this information is expressed in a verbal model (Bender, 1983) that relates the indicator to the reference.

The selection of the reference to evaluate the indicator biases the information produced from the evaluation. The manager could evaluate the indicator by using a production standard for that machine, the average production rate for that machine for the past year, or the production rate of other machines of the same kind. Selecting different references changes the bias of the information produced.

Suppose the manager introduced an incentive program for the machine operators, and that program caused an increase in production on one of two machines with which the manager produces widgets. The manager implemented a different incentive program for each machine operator and wants to determine the difference in incentive programs between the two. From the previous example, we know the information that machine 1 produced 10 more units this week than last week. In the same manner, the manager evaluates machine 2's production this week using last week's production and obtains the information "machine 2 produced 25 more type A widgets this week than last week." The manager uses the information from machine 2 as the indicator and the information from machine 1 as the reference.

The indicator is evaluated using the reference and the information "the incentive program for machine 2 produced 15 more type A widgets than the incentive program for machine 1" is created. This evaluation of information is also information. The unit of information was created by evaluating an indicator with a reference, and the unit of information expresses the information in a verbal model relating the indicator to the reference.

Separating Indicators from References

In my experiment and pilot test I'll ask subjects to tell me what data or information they use during each endeavor and how they use it. Data or units of information they select to be evaluated I'll classify as indicators. Data or units of information they select to evaluate these indicators against I'll classify as references. A datum or unit of information may be used more than once as an indicator or a reference. If so, the datum or unit of information will be counted as an indicator or reference more than once.

The Test Documents

My test documents are shown in Appendix A, along with a history of the development of the test documents. The test documents consist of a scenario, two procedures, a priority sheet, and a weekly schedule worksheet. The test documents will be used for strategic and operational endeavors relating to ranking tasks. The scenario asks subjects to assume they're managers in a research organization. At the strategic level, the subjects will rank tasks based on perceived importance or urgency. At the operational level, the subjects will develop a weekly schedule for an assigned employee to perform designated tasks. The scenario gives the subjects data and information normally available to employees within the organization about the organization, its culture, and its environment. For example, knowing the research organization has a culture based on responsiveness to their sponsors may affect how

subjects rank tasks or develop a weekly schedule. Likewise, knowledge of competitors, sponsors, and other environmental data and information will also affect these endeavors. These informal data and units of information would be used within an organization, although they might not be recorded or discussed. Each of the two procedures instructs the subjects to either rank tasks or develop a weekly schedule using the priority sheet and scenario. The priority sheet lists tasks and associated data and information about tasks. The weekly schedule worksheet is a blank worksheet completed by each subject during the operational endeavor.

The priority sheet and scenario must support the completion of both procedures. I include superfluous data and information on the scenario and priority sheet to make subjects select only the data and information supporting the completion of the procedures.

Identifying Data and Information on the Test Documents

For this section, refer to the test documents in Appendix A. Remember, a datum is a symbolic representation of reality--something that can be measured directly or that is assigned. A unit of information results from evaluating an indicator with a reference. For the test documents, I need to identify what is a datum and what is a unit of information.

The scenario lists fifteen items that may be used for the test. Items 10 and 15 are data; items 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, and 14 are information. Item 10 is a tally of the research organizations submitting a proposal for Contract 1. Item 15 is a characteristic or attribute of the sponsor for Grant 1. Item 1 shows the evaluation of the research organization's academic reputation with other research organizations' academic reputations. Item 2 evaluates other academicians' opinions of the prestige of Conference 1. Item 3 evaluates the amount of business from repeat business with the total business of

the research organization. Item 4 is a precedence relationship between a task in this work group and a task in another work group. Item 5 evaluates managers' criteria against what is best for the research organization. Item 6 is an evaluation of writing papers with other activities by Employee 1. Item 7 evaluates the sponsor for Grant 1 against the list of previous sponsors. Item 8 is an evaluation of the research organization's competitiveness with other research organizations. Item 9 evaluates the content of the Grant 1 presentation against possible factors that will initiate a new grant. Item 11 evaluates employees' criteria against what is best for the research organization. Item 12 is the evaluation of the research organization's number of employees and research dollars against its main competitor. Item 13 evaluates the consequences of research organization employees working 40 hours each week against the consequences of working more or fewer hours. Item 14 evaluates the requirements of completing annual reports against the sponsors' expectations for annual reports.

The priority sheet consists of eight columns. Columns A, C, D, E, and G are information; columns B, F, and H are data. Column A (Priority) contains information generated from evaluating each task with the other tasks to generate a priority list. Column C (Task Type) is generated by evaluating each task with the definitions of each task type. Column D (Due Date) is generated by evaluating task content against expectations of the sponsors (who pay the research organization to do research) or to requirements of other tasks. Columns E and G (Total Planned Hours) are generated by evaluating task scope and worker skills against other similar tasks or to a performance standard. Column B (Task Name) contains data, the assignment of a symbol to represent the task. Columns F and H (Hours Completed To-Date) are data, generated through aggregating actual hours spent on each task to-date by each worker.

The priority sheet title, column headers, and other items not in the columns on the form are identified as neither data nor information. These items support the data and information in the columns. For

data, the column header, date, and title are specifiers. For information, the column header, date, and title describe the type of information produced by the comparison. Each column header only applies to the data or information in the column. The date and title on the priority sheet applies to all data and information on the priority sheet.

Identifying Data/Information External to Endeavor's Scope

The procedures include a description of the strategic and operational endeavors. I define the scope of an endeavor as the unit of analysis of the endeavor. Both endeavors relate to the same tasks for the same work group. Therefore, the scope of both endeavors is the work group.

I assume that anything established or set external to the scope of the endeavor will be external to that endeavor, even if it affects the performance of the endeavor. In the following section, I determine whether the data and information on the test documents are internal or external to the scope of the endeavors.

First I'll look at the data and information on the scenario. For both endeavors, only item 6 is set or established within the work group. Therefore, only item 6 is within the scope of both endeavors. Items 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, and 15 are outside the scope of both endeavors. These items are set outside the work group.

On the priority sheet, all eight columns except Task Type (Column C) and Due Date (Column D) are inside the scope of both endeavors. Task Types and Due Dates are set at the research organization level.

Relating the Dependent and Independent Variables

In this section, I relate differences in the makeup of data and information (dependent variables) to different endeavors (independent variable). I do this by noting that 1) managers at a given organizational level, when doing the right things, do mostly the endeavors representative of that level (Kurstedt, 1990); and 2) in going from lower to higher organizational levels (and thus, lower to higher endeavors), decisions move from structured to unstructured.

There are changes in data and information needs provided by the literature that I chose not to use in my research. (See Data and Information Needs and Endeavors Literature section within the literature review.) Data and information currency, time horizon, and level of aggregation were difficult to measure using my definitions of the makeup of data and information. Data and information frequency of use and required accuracy required different experimental procedures to test. The measures I selected as the basis for my testable hypotheses can use the same experiment and test documents, reducing the time required for the subject to perform the experiment.

For the measures I selected, I first make a statement (in bold type) the literature supports. I then present and discuss literature references to support the statement, and apply my definitions of the makeup of data and information where appropriate. From these statements I've supported and discussed, I develop my four testable hypotheses relating to research hypothesis 3.

At higher endeavors, managers use more information and data. At higher endeavors, decisions become more unstructured. Unstructured decisions require more data and information than

structured decisions (Simon, 1960; Galbraith, 1973). Managers performing higher endeavors require more data and information processing due to the complex, unstructured nature of their tasks.

At higher endeavors, managers use more information and less data. As we move up the organization, managers use more information and less data (Daft and Lengel, 1984; Leifer, 1979). Daft and Lengel use the term *information richness* to describe the information-carrying capacity of media. Rich media have more information, and less-rich media have more data. Managers performing higher endeavors face unstructured tasks requiring rich media to quickly bring definition to the task.

At higher endeavors, data and information must be evaluated by a greater number of references to make a decision. Daft and Lengel (1984) note that higher-level managers need multiple informational cues to solve a problem. Using my terms of indicator and reference, I say these multiple informational cues are references. For structured decisions, producing units of information is more clear-cut, because references for indicators are few and well understood. As decisions become less structured, producing units of information becomes more undefined, and the selection of suitable references to evaluate indicators becomes more difficult. For highly unstructured decisions, no one reference may suitably evaluate an indicator, and many references may be employed to evaluate each indicator.

At higher endeavors, data and information are evaluated by more references external to the scope of the endeavor. As we move up the organization, information sources move from internal to external to the manager's domain (Gorry and Scott Morton, 1971; Aiken and Hage, 1972; Rockart and Treacy, 1982). These external information sources provide references to evaluate internal indicators. At lower endeavors, managers may select an internal standard as a reference to evaluate their performance. As we move to higher endeavors, managers may compare their divisions to other divisions within the same

company, or their companies to other companies in the same business, other companies in different businesses, other investments, and possibly other references.

Thus, from the preceding discussion, I can develop four testable hypotheses relating differences in makeup of data and information to different endeavors. These testable hypotheses are repeated here from page 6.

1. Managers ranking tasks (a strategic endeavor) use more data and information than managers developing a weekly schedule (an operational endeavor).
2. Managers ranking tasks (a strategic endeavor) use more information (expressed as a percent of all data and information used) than managers developing a weekly schedule (an operational endeavor).
3. Managers ranking tasks (a strategic endeavor) use more references to evaluate indicators than managers developing a weekly schedule (an operational endeavor).
4. Managers ranking tasks (a strategic endeavor) use more references external to the scope of their endeavor (expressed as a percent of all references used) than managers developing a weekly schedule (an operational endeavor).

Stating these testable hypotheses in null hypothesis format yields the following:

1. There is no significant difference in the total amount of data and information used for ranking tasks or developing a weekly schedule.

2. There is no significant difference in the amount of information, expressed as a percent of all used data and information, used for ranking tasks or developing a weekly schedule.
3. There is no significant difference in the number of references used per indicator for ranking tasks or developing a weekly schedule.
4. There is no significant difference in the amount of external references, expressed as a percent of all references, used for ranking tasks or developing a weekly schedule.

Moderator Variables

I've found several other variables in the literature in addition to endeavors (independent variable) which influence the makeup of data and information (dependent variables) needed by managers. First I discuss these moderator variables and then I describe how I plan to compensate for them.

Organization Size. In small organizations, everyone may work on the same tasks or at least know what other workers are doing. In large organizations, increased specialization leads to more isolation among workers. In larger organizations, there is increased need for formalized data transfer, where in smaller organizations data are transferred informally or are commonly known. If we look at data transferred formally, we'll miss much data used by managers in smaller organizations (Radford, 1978).

Organization Type. Formal organizations and government organizations tend to use more formalized information systems and rely more on data (Daft and Lengel, 1984). Informal organizations use richer

media, such as face-to-face meetings, and use more information than data. This will affect the quantity and content of data transferred at different organizational levels.

Decision Maker Attributes. If decision makers are knowledgeable about a problem or task, they tend to use less data (Chorba and New, 1980). They supply needed data from their experience with the problem to make a decision. Also, more-effective managers will select better data to solve a problem than will less-effective managers; however, decision maker effectiveness is difficult to measure (Thompson, 1967). The manager's personality type also influences the type of data used by managers for decision making (Dermer, 1973). All these decision maker attributes must be considered when looking at data used by the manager, in addition to the standard demographic differences of age, sex, etc.

I account for organization size and organization type by presenting the same scenario and procedures to subjects in the same organization. I'll reduce the impact of experience by selecting subjects with as close as possible to the same amount of experience in managing other people. I'll use demographic data supplied by the subjects at training to determine experience. Although literature is available to adjust data use according to personality type (Dermer, 1973; Robey and Taggart, 1981), I won't account for personality type in my experiment due to the small sample size. Likewise, decision maker effectiveness is difficult to measure, so I won't account for decision maker effectiveness in my experiment. I'll also collect demographic data on the sex and age of my subjects, although I've found no literature to show these variables as moderator variables for data and information needs. I collect these variables only to describe my experimental subject population.

Methodology for Testing the Hypotheses

In this section I describe my methodology for evaluating my testable hypotheses. My experimental process consisted of two phases. The first phase is a pilot test; the second phase is an experiment. The pilot test is a formative evaluation⁶; the experiment is a summative evaluation⁷.

I first discuss verbal protocols as the method I used to gather data during the pilot test and the experiment. I then discuss the subject population used in training, the pilot test, and the experiment. Next, I discuss the training I provided to the subjects before the experiment. I then describe the data collection process used during both the pilot test and the experiment. Next I describe my pilot test and its results. I then describe my experiment and, finally, analyze the data I collected.

Verbal Protocols

I used verbal protocols to collect data during my pilot test and experiment. Verbal protocols, along with information boards, are the two major process tracing methods used by researchers today (Ford, Schmitt, Schechtman, Hults, and Doherty, 1989). Information boards are primarily used for problems of selection among alternatives. Verbal protocols can be used for a wider variety of problems, but they require more effort during transcription and coding than information boards. Because my problem

6 A formative evaluation is used to identify improvements and modifications needed during development. I'll use this formative evaluation to improve my test documents and procedures.

7 A summative evaluation is performed after development is completed to decide if development objectives are satisfied or not.

isn't a selection from among alternatives problem, I used verbal protocols as my process tracing method.

Subject Population

Fourteen subjects arrived for training on March 27, 1990. I invited subjects to participate that I knew had some experience in managing employees. All subjects are employees of Management Systems Laboratories (MSL), a research organization within the Department of Industrial Engineering and Operations Research at Virginia Tech. After training, the subjects were asked to complete a Demographic Data Sheet. (See end of Appendix C.) Subject demographics are summarized in Table 2.

Subjects have a moderate amount of experience in managing other employees. Since subjects 13 and 14 were outliers based on the large number of employees they supervised and the number of years experience in managing others, I decided to select them for the pilot test. By using subjects 13 and 14 for the pilot test, a more homogeneous population was left for the experiment. Subjects 3 and 8 were unable to attend the experiment due to scheduling conflicts, leaving ten subjects who participated in the experiment. These ten subjects, 3 females, 7 males, range in age from 26 to 41. The subjects have 1 to 12 years experience in managing employees. The maximum number of employees the subjects have supervised range from 2 to 22 employees. Most subjects reported no experience in assigning hours to employees, although most did establish priorities, rank tasks, and develop a schedule for their employees.

Table 2. Subject Demographics

SUBJECT	SEX	AGE	MAX. NUMBER OF EMPLOYEES SUPERVISED	YEARS MGMT. EXPERIENCE	ESTABLISH PRIORITIES (YEARS)	RANK TASKS (YEARS)	ASSIGN HOURS (YEARS)	DEVELOP A SCHEDULE (YEARS)
1	F	35	9	1	1	1	0	1
2	M	26	3	1.5	1.5	1.5	0	0
3*	F	40	2	2	2	2	2	0
4	F	26	22	3	3	3	1	1
5	M	27	4	4	2	2	0	0
6	M	35	5	5	0	3	0	3
7	F	26	5	5	5	5	5	5
8*	M	35	2	7	7	7	0	7
9	M	40	8	7	7	4	0	4
10	M	31	15	8	8	8	8	8
11	M	41	13	10	10	0	0	10
12	M	40	4	12	12	7	0	12
13(P)	F	46	150	14	14	14	0	14
14(P)	M	41	400	23	23	20	20	15

* Subjects did not participate in the experiment due to scheduling conflicts.

(P) Subjects participated in the Pilot Test because they were outliers based on the maximum number of employees supervised and years management experience.

Training

All subjects were trained simultaneously on March 27, 1990, to make sure they all received the same instruction. Before training, the experimental package consisting of training materials, test documents, and Post-Test Questionnaire (Appendices A, B, and C) was sent for Institutional Review Board (IRB) approval. The IRB's role is to assure the safety of experiments to the test subjects, and to make sure subjects are aware of their rights and what they will be asked to do in the experiment. After all subjects arrived, subjects were asked to read a two-page description of the experiment. (See Appendix C.) The subjects asked no questions about the two-page description. After all subjects read the description, they were shown an overhead transparency of a sample priority sheet containing fictitious data. (See Appendix C.) I described to the subjects what the columns and titles on the priority sheet indicated. For example, I explained that the Total Planned Hours columns on the priority sheet were the hours planned for each employee to spend on a particular task, and the hours represent a reasonable estimate of the time required for the employee to complete their work on the task. The subjects had no questions about the sample priority sheet. I showed the subjects an overhead transparency of a sample weekly schedule worksheet containing fictitious data to demonstrate how to fill out the weekly schedule worksheet. (See Appendix C.) The subjects had no questions. Subjects were then asked to read the Participant's Informed Consent Form. All subjects signed the Participant's Informed Consent Form, so none of the subjects were dropped from the experiment. I asked the subjects to complete a Demographic Data Sheet. In response to questions about the number of people they managed, subjects were instructed to list the maximum number of people who worked for them at one time. Subjects asked about the differences between assigning hours and scheduling. Scheduling was seen by the subjects as completing tasks by certain dates, while assigning hours was more detailed. After completing the demographics data sheet, training was complete.

Data Collection Process

I used the following data collection process with the first subject in my pilot test. I made only minor modifications to the data collection process as a result of the pilot test. These changes are identified and described in the discussion of the pilot test.

At the start of the data collection process, the subject was asked to sit behind a desk. I sat across the desk from the subject. I placed the test documents face down on the desk. (See Appendix A.) The test documents consist of a scenario, two procedures, a priority sheet, and a weekly schedule worksheet. I told the subject he or she would be asked to perform two management jobs using these documents, and the subject could use as little or as much of the data and information on the test documents as he or she felt necessary. I instructed each subject to use only test-document data and information during the experiment. I gave the subject all test documents except the procedures, and asked the subject to read them (scenario sheet first, then the priority sheet, then the weekly schedule worksheet). For each endeavor, I handed the subject the corresponding procedure and asked the subject to read it. The subject then performed the endeavor identified on the procedure. As each subject performed the endeavor, I recorded on audio tape the subject's verbal protocols. Through verbal protocols, each subject told me what data and information he or she used and how he or she used them. The subject was given a five-minute break, then given the second procedure to perform. After the subject read and completed the second procedure, he or she was given a Post-Test Questionnaire (Appendix B). I asked the subject to write his or her answers to these questions. Once the post-test questions were answered, the data collection process was complete. I used the Post-Test Questionnaire to determine if I needed to exclude subject responses from the experiment to improve the validity of my data. If subjects had answered on the Post-Test Questionnaire that they didn't

understand the instructions or weren't able to complete the procedures, I would have had to discard their responses. Fortunately, no subject responses had to be discarded.

All subjects first completed the strategic endeavor of ranking tasks, then they completed the operational endeavor of developing a weekly schedule. Developing a weekly schedule depends on the task priorities assigned when ranking tasks. Thus, I couldn't counterbalance the experiment by having half the subjects develop a weekly schedule first and half rank tasks first. The inability to counterbalance the experiment may have caused subject learning to influence my results. Hopefully, my training was sufficient to dilute the effects of incremental learning between ranking tasks and developing a weekly schedule.

Phase I--Pilot Test

The pilot test was performed March 29, 1990. I used the pilot test to improve my test documents and procedures. After each subject completed the pilot test, I asked if the subject had difficulties using the test documents and procedures and what improvements the subject recommended. Since I used the pilot test to improve my test documents and procedures, the pilot test was a formative evaluation (Nitko, 1983; Borg, 1983). A formative evaluation is used to "form," modify, and improve the experimental procedures or test documents before the experiment is performed.

My pilot test objectives were to modify my test documents and procedures until 1) the test documents were clear and understandable, 2) the subjects understood the procedures they performed, 3) the test procedures were doable, and 4) the tests gave me the data I wanted. After each subject read the instructions, I asked if he or she understood them and ask how they could be improved. After each subject performed the pilot test, I asked him or her if the test documents were easy to use, and if he or

she was able to complete the procedures. I asked for comments and suggestions. I then looked at the data I collected to see if the subjects performed the procedures completely.

I used subjects in my pilot study until a subject reported only minor or no difficulties. I used two subjects in the pilot test. I originally intended to use three or four subjects in the pilot test, but I stopped after two subjects since the pilot test turned up so few problems and I needed the remaining subjects for the experiment.

The first subject took 50 minutes to complete the pilot test. The first subject recommended grouping similar items on the scenario and providing more scenario information. On the scenario, no information was provided for some tasks, such as Grant 2 activities. The first subject especially wanted data and information about these tasks. The first subject had questions about task interdependence and employee interdependence. After analyzing the first subject's results, I found the first subject used only five tasks in developing the weekly schedule, while using all twelve tasks in ranking.

I made few changes to the test documents and procedures based on the first subject. I decided not to group similar items on the scenario because I didn't want subjects to indicate they used a group of items when only one item of the group applied. I didn't add more scenario items because I wanted to avoid increasing the time required to perform the task. I observed that the first subject missed scenario items that applied to tasks, and I felt increasing the number of scenario items would only increase the number of missed items. I observed that tasks took so long to complete that only 4 or 5 could fit on a weekly schedule. So, I needed to increase the number of tasks considered in scheduling an employee's week. I reduced the task length and shortened the due date so 8 to 10 tasks could be scheduled for the employee's week. I wanted to avoid having different numbers of tasks used for each procedure affect the type and quantity of data and information used by the subjects. I eliminated the impact, if any, of

number of tasks on the type and quantity of data and information used by making the number of tasks subjects used when developing a weekly schedule close to the number of tasks subjects used when ranking tasks. Increasing the number of tasks considered in scheduling an employee's week made the number of tasks used in each procedure about the same, but increased the time required to perform the procedures. To account for task interdependence and employee interdependence questions, I modified the instructions to tell each subject that tasks are independent unless otherwise stated, and employees have the same skills and can work independently on the same tasks.

The second subject took 71 minutes to complete the pilot test. The second subject recommended adding more information on the scenario about tasks not currently mentioned, as did the first subject. As with the first subject, I didn't add more information because the subjects already had difficulty using existing data and information. The second subject scheduled 9 tasks for employee 1, as opposed to 5 tasks for employee 1 scheduled by the first subject. So, I was successful in increasing the number of tasks used in developing a weekly schedule. Based on results from the second subject, I modified the time required to complete two tasks so the tasks wouldn't be impossible to schedule on time. I assumed modifying the time required to complete the two tasks would decrease the difficulty in developing a weekly schedule. I made no further modifications to the test documents and procedures.

Phase II--Experiment

The experiment was conducted over three days, April 4, 5, and 6. I planned to have twelve subjects in the experiment. Eight subjects is the minimum number of subjects I needed for my statistical analysis to be able to reject the null hypothesis with a 99% level of confidence (Siegel, 1956). Twelve subjects would allow me to exclude the responses of subjects who told me they misunderstood the instructions or were unable to complete the experiment.

Ten subjects kept their appointments for the experiment. The subjects followed the data collection process outlined earlier. Based on findings from the pilot test, each subject was also told that tasks on the priority sheet are independent unless otherwise stated, and employees listed on the priority sheet have the same skills and can work independently on the same tasks. Experiment times ran from a low of 55 minutes to a high of 80 minutes. All subjects were able to complete the experiment.

From the Post Test Questionnaire, all subjects said the instructions on the procedures were what they expected from the training session, and all subjects felt they understood the instructions. Three subjects ranked the procedures very difficult to complete, five ranked them moderately difficult, and two ranked them not difficult. Two of the three subjects ranking the procedures very difficult to complete had little experience, but the third subject had extensive experience. Nine of the ten subjects said they were able to complete the procedures moderately well or very well, and all subjects said the data and information supported the procedures moderately well or very well. Seven out of ten subjects would have liked more data and information on the test documents. Two of the three subjects who didn't want more data and information on the test documents were managers with the most experience, suggesting that more experienced managers need less data and information. Most requests for data and information asked for more items on the scenario, specifically about tasks not mentioned on the existing scenario items. Requests for other data and information were job specific, such as questions concerning the amount of leeway the subject had in meeting due dates. Since all subjects were able to complete the procedures and reported that they understood the instructions, no subject data were dropped from the experiment.

Data Analysis

The first step in data analysis was transcribing the audio tapes. To aid in transcription, I labelled each task name with a letter. When subjects referenced a task name or an item from the scenario, I substituted a letter or number in its place. This method of transcription provided more compact protocols that were easier to read.

Next, I had to identify protocols that applied to the procedures and those that did not. I wanted to concentrate on protocols directly involved in ranking tasks and developing a weekly schedule. Protocols not directly involved in ranking tasks or developing a weekly schedule I grouped into two categories: superfluous protocols and preprocessing. Also, most subjects made some assumptions that provided data and information not on the test documents that the subjects then used in the procedures. I call these extraneous protocols.

Superfluous protocols were assertions made by the subjects that had no bearing on completing the procedures or weren't followed by the subjects when completing the procedures. For example, some subjects said they'd use hours for Employee 2 when developing a weekly schedule for Employee 1, yet when they scheduled Employee 1 they didn't use Employee 2 hours. Also, some subjects indicated specific scenario items as useful for completing a procedure, but then didn't use those scenario items in the procedure. Superfluous protocols were identified and not used.

Preprocessing was manipulation of the data and information on the test documents before or during the procedures that was not directly related to completing the procedures. Most subjects performed some preprocessing of the data and information on the test documents. For example, most subjects

subtracted Hours Completed To-Date from Total Planned Hours to get hours remaining to complete each task. Also, many subjects broke tasks into categories, ranking the categories and then ranking tasks within categories, according to scenario items. Preprocessed data and information were included in the tallies only when they were used in the decision process to complete the procedure. Some subjects calculated hours remaining to complete each task for Employee 2 and didn't use it in either procedure. By not counting data and information until they're directly used in the procedure, I avoided counting data and information that were manipulated but not used. When subjects used preprocessed data and information, I referred back to the transcription of the preprocessing to see what data and information were manipulated. The subject then got credit for using the manipulated data and information.

For extraneous protocols, I made my best estimate in classifying them as a datum or a unit of information and counted them in my experiment. Most extraneous protocols were assumptions about the importance of tasks not mentioned in the scenario items or about the ability to delay specific types of tasks, such as conference papers.

Next I coded the protocols. I broke the protocols into phrases, each phrase consisting of a decision by the subject. After coding, I identified the data and information makeup in the protocols. Specifically, I identified indicators, references, external references, data, and information on the protocols. I first identified all indicators and references in the verbal protocols. A datum or unit of information used to evaluate another datum or unit of information is a reference; the datum or unit of information being evaluated is an indicator. Data or units of information used more than once as an indicator or a reference were counted more than once as an indicator or a reference. Next I looked at each reference and determined if it was internal or external to the scope of the endeavors based on my preclassification of data and information on the forms. I then marked all the indicators and references

identified in the protocols on the subjects' test documents. I used my preclassification of data and information on the test documents to identify data and information used by the subjects.

For example, a subject might decide that task A is higher priority than task B because task A is due before task B and there are more hours remaining to be worked on task A than task B. This example is one verbal protocol, because one decision was made. In this example, task A due date is an indicator, task B due date is a reference. Task A hours remaining is an indicator, task B hours remaining is a reference. Due dates are predefined as information and as external to the scope of the endeavor, so task B due date is used as external reference. Hours remaining to be worked on each task is calculated by the subject by subtracting Hours Completed To-Date from Total Planned Hours. Hours Completed To-Date are predefined as data, while Total Planned Hours are predefined as information. Both Hours Completed To-Date and Total Planned Hours are internal to the scope of the endeavor. Task A Hours Completed To-Date and Total Planned Hours are counted as indicators, and Task B Hours Completed To-Date and Total Planned Hours are counted as references. After I coded all verbal protocols in the same fashion as this example, I could then tally values for all my measures.

I then tallied the items counted for each procedure for each subject. I tallied the total number of units of data and information used, the number of indicators used, and the number of references used. I also tallied how many references were external to the scope of each endeavor.

I tested two groups (ranking tasks and developing a weekly schedule) to see if significant differences existed between the two groups for four measures: 1) total amount of data plus information used, 2) the amount of information expressed as a percent of all data and information used, 3) the average number of references used per indicator, and 4) the number of external references expressed as a

percent of all references. Table 3 shows the four measures (across the top) for each subject (down the side) and procedure (rank and schedule, under each of the four measures). I used formulas based on the following definitions to calculate values for these measures from the tallies measured during analysis of verbal protocols.

Amount of Data Used is the number of data reported by the subject as used in the procedure.

Amount of Information Used is the number of units of information reported by the subject as used in the procedure.

Total Amount of Data and Information Used is the sum of the *Amount of Data Used* and the *Amount of Information Used*.

Percent of Information Used is the *Amount of Information Used* divided by the *Total Amount of Data and Information Used*.

Number of Indicators Used is the number of data and information reported by the subject as selected to be evaluated.

Number of References Used is the number of data and information reported by the subject as used to evaluate other data or information.

Number of References Used per Indicator is the *Number of References Used* divided by the *Number of Indicators Used*.

Table 3. The Four Measures By Subject And Procedure.

SUBJECT	DATA + INFORMATION		INFORMATION/ DATA + INFORMATION		REFERENCES/ INDICATOR		EXT. REFERENCES/ REFERENCES	
	RANK	SCHEDULE	RANK	SCHEDULE	RANK	SCHEDULE	RANK	SCHEDULE
1	74	59	.608	.644	1.49	1.21	.608	.500
2	85	41	.612	.512	1.74	1.70	.722	.647
4	84	45	.619	.578	1.73	1.18	.737	.424
5	91	80	.637	.588	1.52	1.24	.720	.429
6	70	46	.643	.652	1.87	1.80	.857	.444
7	81	41	.630	.537	1.86	1.43	.673	.150
9	47	75	.660	.573	1.33	1.33	.750	.300
10	57	40	.667	.550	1.86	1.35	.878	.478
11	41	47	.610	.511	1.58	1.35	.833	.074
12	38	36	.632	.611	1.40	1.24	.857	.539

* Subjects 3 and 8 did not participate in the experiment due to scheduling conflicts.

Number of External References is the subset of the *Number of References Used* that is outside the scope of the endeavor defined in each procedure.

Percent of External References Used is the *Number of External References* divided by the *Number of References Used*.

To analyze these data, I could have used parametric analysis (*t* test or similar test) or nonparametric analysis. I used nonparametric analysis for two reasons. First, nonparametric analysis does not require the populations to be distributed in a certain way, e.g., to be distributed normally. Second, nonparametric analysis yields conclusive results with small samples. This is especially important for my methodology, which required me to conduct individual tests, each lasting more than an hour, with a limited available population from which to draw subjects.

The nonparametric test I used is the Wilcoxon Matched-Pairs Signed-Ranks test, often called the Wilcoxon test. This test requires at least ordinal ranking and determines if two dependent groups have been drawn from the same population. The Wilcoxon test is often used for subjects serving as their own control group, as in longitudinal studies, or with subjects given two different treatments. Subject scores for each treatment must be paired, and the researcher must be able to determine the direction and relative magnitude of the differences within pairs. The Wilcoxon test provides almost the same power as the *t* test, even for small samples (Siegel, 1956). I ran four Wilcoxon tests, one for each testable hypothesis. The four tests determined whether there's a significant difference between Group 1 (ranking tasks) and Group 2 (developing a weekly schedule) in: 1) the amount of data and information used, 2) the amount of information expressed as a percent of all data and information used, 3) the number of indicators used per reference, and 4) the amount of external references expressed as a percent of all references.

For a sample size of ten, I needed a T value of five or less to be able to reject the null testable hypothesis with a 99% confidence interval. For testable hypothesis 1, the T value was 9 (See Table 4), so I was unable to reject null hypothesis 1. I couldn't show a significant difference in the total amount of data and information used by managers for ranking tasks or developing a weekly schedule. For testable hypothesis 2, the T value was 4 (See Table 5), so I was able to reject null hypothesis 2 and show that managers ranking tasks use more information (expressed as a percent of all data and information used) than managers developing a weekly schedule. For testable hypothesis 3, the T value was 0 (See Table 6), so I was able to reject null hypothesis 3 and show that managers ranking tasks use more references to evaluate indicators than managers developing a weekly schedule. For testable hypothesis 4, the T value was 0 (See Table 7), so I was able to reject null hypothesis 4 and show that managers ranking tasks use more references external to the scope of their endeavor (expressed as a percent of all references used) than managers developing a weekly schedule.

Table 4. Wilcoxon Table For Testable Hypothesis 1.

SUBJECT	DATA + INFORMATION RANK	SCHEDULE	DIFFERENCE	RANK OF DIFFERENCE	RANK WITH NEGATIVE SIGN
1	74	59	15	4	
2	85	41	44	10	
4	84	45	39	8	
5	91	80	11	3	
6	70	46	24	6	
7	81	41	40	9	
9	47	75	-28	-7	7
10	57	40	17	5	
11	41	47	-6	-2	2
12	38	36	2	1	
					T = 9

* Subjects 3 and 8 did not participate in the experiment due to scheduling conflicts.

Table 5. Wilcoxon Table For Testable Hypothesis 2.

SUBJECT	INFORMATION/ DATA + INFORMATION RANK	SCHEDULE	DIFFERENCE	RANK OF DIFFERENCE	RANK WITH NEGATIVE SIGN
1	.608	.644	-.036	-3	3
2	.612	.512	.100	9	
4	.619	.578	.041	4	
5	.637	.588	.049	5	
6	.643	.652	-.009	-1	1
7	.630	.537	.093	7	
9	.660	.573	.087	6	
10	.667	.550	.117	10	
11	.610	.511	.099	8	
12	.632	.611	.021	2	
					T = 4

* Subjects 3 and 8 did not participate in the experiment due to scheduling conflicts.

Table 6. Wilcoxon Table For Testable Hypothesis 3.

SUBJECT	REFERENCES/ INDICATOR RANK	SCHEDULE	DIFFERENCE	RANK OF DIFFERENCE	RANK WITH NEGATIVE SIGN
1	1.49	1.21	.28	6.5	
2	1.74	1.70	.04	2	
4	1.73	1.18	.55	10	
5	1.52	1.24	.28	6.5	
6	1.87	1.80	.07	3	
7	1.86	1.43	.43	8	
9	1.33	1.33	.00	1	
10	1.86	1.35	.51	9	
11	1.58	1.35	.23	5	
12	1.40	1.24	.16	4	
					T = 0

* Subjects 3 and 8 did not participate in the experiment due to scheduling conflicts.

Table 7. Wilcoxon Table For Testable Hypothesis 4.

SUBJECT	EXTERNAL REFERENCES/ REFERENCES RANK	SCHEDULE	DIFFERENCE	RANK OF DIFFERENCE	RANK WITH NEGATIVE SIGN
1	.608	.500	.108	2	
2	.722	.647	.075	1	
4	.737	.424	.313	4	
5	.720	.429	.291	3	
6	.857	.444	.413	7	
7	.673	.150	.523	9	
9	.750	.300	.450	8	
10	.878	.478	.400	6	
11	.833	.074	.759	10	
12	.857	.539	.318	5	
					T = 0

* Subjects 3 and 8 did not participate in the experiment due to scheduling conflicts.

Discussion of Findings

I first discuss the results of the Wilcoxon test of my four testable hypotheses. I then discuss my definitions of the makeup of data and information. Next I discuss the ability to generalize my testable hypotheses and definitions and apply them in other situations. I state what I would change if repeating my experiment, and finally, make suggestions for further research.

Results of Wilcoxon Tests

I first list each null testable hypothesis in bold type, then discuss the results of the Wilcoxon test.

There is no significant difference in the total amount of data and information used for ranking tasks or developing a weekly schedule. I was unable to reject this null testable hypothesis. Despite finding literature (Simon, 1960; Galbraith, 1973) that claimed managers performing strategic activities use more data and information than managers performing operational activities, some researchers claim the opposite is true. O'Reilly (1983) states that managers making complex decisions may select a desired outcome, then look for data and information to support the selected outcome. This would reduce the amount of data and information used by managers performing strategic activities, since

strategic activities tend to be complex and unstructured. Also, Cats-Baril and Huber (1987) state that strategic-level managers use heuristics that involve only a few key units of data and/or information.

I had two subjects who used more data and information for developing a weekly schedule than for ranking tasks. Both subjects were the oldest in the sample and had more managerial experience than most of the other subjects, suggesting that older, more experienced managers may use less data and information. One of these subjects ranked 7 out of 10 in the magnitude of the difference in the amount of data and information used in ranking tasks and developing a weekly schedule. This subject ranked tasks almost exclusively by due date. With a larger sample, the effects of one sizable measure might have diminished, allowing me to reject this null testable hypothesis.

There is no significant difference in the amount of information, expressed as a percent of all used data and information, used for ranking tasks or developing a weekly schedule. Although I couldn't show that managers ranking tasks use more data and information than managers developing a weekly schedule, I can say that managers ranking tasks use more information as a percent of all data and information used than managers developing a weekly schedule. This would support the observations of Daft and Lengel (1984) and Leifer (1979). Higher-level managers use information, which is richer, to quickly bring structure to their tasks. Lower-level managers tend to use more data, because their tasks aren't as equivocal. Ranking tasks was more uncertain and equivocal than developing a weekly schedule. Subjects did not know the importance of all tasks to the organization, and organizational importance and due dates were often in conflict.

There is no significant difference in the number of references used per indicator for ranking tasks or developing a weekly schedule. I was able to reject this null testable hypothesis and show that subjects ranking tasks use more references per indicator than subjects developing a weekly schedule. This

supports Daft and Lengel (1984), who say managers need multiple informational cues to evaluate equivocal information. Data and information used in ranking tasks was more equivocal than data and information used for developing a weekly schedule. Subjects ranking tasks applied more references to each indicator to evaluate the indicator.

There is no significant difference in the amount of external references, expressed as a percent of all references, used for ranking tasks or developing a weekly schedule. I was able to reject this null testable hypothesis and show that subjects ranking tasks use more external references as a percent of all references used than subjects developing a weekly schedule. Many authors discuss information sources moving from internal to external as we move up the organization (Gorry and Scott Morton, 1971; Aiken and Hage, 1972; Rockart and Treacy, 1982). I interpreted this to mean that internal indicators were evaluated by more external references. Results of this experiment seem to bear this out. Subjects ranking tasks used many more references external to the scope of the endeavor than subjects developing a weekly schedule. In ranking tasks, subjects felt more obligated to meet organizational needs than when developing a weekly schedule.

Discussion of Makeup of Data and Information

My definitions for the makeup of data and information received considerable support as a result of the experiment. I was able to take statements (from the literature) about data and information usage by managers at different organizational levels, make these statements measurable by relating the statements to changes in the makeup of data and information, then validate these statements using my definitions of the makeup of data and information in a limited experiment. Since my definitions for the

makeup of data and information were able to measure and support these statements from the literature, I feel I've demonstrated their face validity.

My definitions certainly need further testing in wider and more diverse experiments to determine whether they actually measure what they claim to measure. This research demonstrates, however, that my definitions for the makeup of data and information can be successfully applied to provide clear, unambiguous measures for data, information, indicators, references, and external references. The ability to apply the measures and the face validity provided by my experiment certainly warrants further investigation of my definitions.

Some of my definitions for the makeup of data and information weren't directly used in this experiment, such as a datum being composed of a kernel and specifier set. These definitions were necessary to show completeness for my definitions, even though I didn't directly use them. The support obtained for the definitions I used in my experiment lends some credibility to the remaining unused definitions, since the sum of the definitions provide a cohesive framework for data and information. Further testing needs to be done to see if the set of definitions do indeed provide a cohesive framework for data and information.

Ability to Generalize Results

Even though this experiment used only one specific ranking task and one specific scheduling task, it's reasonable to assume that the results would be much the same for other ranking and scheduling tasks. Many subjects commented that these procedures in the experiment seemed realistic and were representative of comparable ranking and scheduling tasks they had performed. Although a couple of subjects reported that the experimental procedures seemed more difficult than comparable ranking and scheduling tasks they'd performed, these subjects had less managerial experience than most of the other subjects.

In addition, the subject population seemed to be a reasonable representation of most other populations. Managers at MSL come from a wide variety of backgrounds, although most MSL managers do have technical training. Some subjects had received much of their management experience at MSL, while other subjects were new employees at MSL and had received their management experience at other organizations. No differences in responses were noted in the data between these two subject groups. Also, in looking at the data no differences in responses were noted between subjects of different gender. The main difference between my subjects and population of all managers is I had no managers with more than twelve years experience in my experiment. In general, the population of managers would have a substantial portion of its members with more than twelve years experience. This may affect the ability to generalize my results.

I don't think it's reasonable to generalize these results to all strategic and operational endeavors. There'd be significant differences in the procedures for developing a strategic plan as opposed to ranking tasks, for example. In this experiment I demonstrated these results for one specific strategic endeavor, ranking tasks, and one specific operational endeavor, developing a weekly schedule. I can say these results have been demonstrated in one example from the population of strategic and operational endeavors, and the remaining population may exhibit the same results.

Modifications to Existing Experiment

If I ran this experiment over again, I'd increase the sample size, provide more instructions to the subjects, and decrease the complexity of the procedures and test documents. With a larger sample, the effects of one sizable measure might have diminished, allowing me to reject my first null testable hypothesis. A larger sample would also have strengthened confidence in my results. Despite training and the written instructions each subject was given, questions arose during the experiment that I couldn't answer without providing different levels of instruction to the subjects. Questions often arose about the relationship of one task to another, despite instructions that the tasks were independent unless otherwise stated. I could've reduced this problem by providing examples to the subjects. In addition, some subjects were not used to verbalizing their thoughts and had to be prompted repeatedly. A short example of verbalization might have reduced this problem.

The test documents and procedures may have been too complex. The importance of some tasks to the organization weren't known to the subjects. Tasks known to be important weren't due first, and tasks that were due first had so many hours remaining to be worked that they couldn't be completed on time

by working eight-hour days. Tasks were stacked up at the beginning of the week, with some slack at the end of the week. Finally, Employee 2 had many more hours than Employee 1, requiring hours to be shifted to Employee 1 if tasks were to be completed on time. Subjects who began to rank tasks according to task importance to the research organization had to back up and account for due dates. Subjects scheduling Employee 1 had to back up and account for Employee 2 hours. Less complex procedures and test documents would have made analysis of verbal protocols much easier.

Suggestions for Further Research

This experiment needs to be tried using different test documents and endeavors. The experiment could be repeated using different ranking and scheduling tasks to see if the results are the same. Different specific endeavors could be substituted for ranking tasks and developing a weekly schedule to see if the results can be generalized to all strategic and operational endeavors.

This experiment needs to be repeated concentrating more on subject demographics, specifically managerial experience, age, and type of training. Using the same test documents and procedures, the experiment could be repeated with the subjects bifurcated into high and low experience, old and young, and technical and nontechnical groups.

My definitions for the makeup of data and information need to be applied and tested in other experiments. Specifically, in the areas of cognitive psychology and decision making, my definitions for the makeup of data and information could provide tools to identify and measure data and information and its use. My definitions for the makeup of data and information can be applied to measure other

observed differences in data and information needs for different organizational levels, providing useful insights for developing management information systems and corporate databases.

Last, my definitions of the makeup of data and information, while answering a few questions, raise many more questions. Can the specifiers, combined with a kernel to produce a datum, be divided into categories or types of specifiers? Is there a complete set of specifiers, and if so, what is its makeup? Do the specifiers managers need to understand and use data at different organizational levels differ? These questions, and many others, came up during the course of this research. While they were beyond the current scope, they demonstrate the areas where my definitions of the makeup of data and information may be applied to increase our knowledge of data and information usage and requirements.

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Appendix A. The Test Documents

Development of the Test Documents

The initial Priority Sheet contained twenty tasks. As I tried out the test documents, I found ranking and scheduling tasks was very procedural. Items on the Scenario contained enough rules to provide an exact method to rank and schedule tasks. I felt these endeavors, especially the strategic endeavor of ranking tasks, couldn't be procedural and still be representative of other endeavors. I changed items on the scenario so there was incomplete information provided to the subject, leaving no one right way to rank or schedule tasks. In trying the test documents and procedures again, twenty tasks took me almost two hours to rank and schedule. My limit for the time required to perform the experiment was ninety minutes. I felt longer experiments would affect the quality of my data and keep some subjects from completing the experiment. After reducing the number of tasks on the Priority Sheet to twelve, I was able to complete the experiment in forty minutes. I estimated that subjects unfamiliar with the test documents would take about an hour to complete the experiment. These modifications to the test documents, plus changes resulting from the Pilot Study, resulted in the test documents in this Appendix.

Scenario

A research organization performs a variety of tasks each week. These tasks are divided into the categories of Contracts and Grants (CG) or Papers and Presentations (PP). Each week all tasks to be done are listed, ranked, assigned to research organization employees, and performed.

There are two documents used to perform these management jobs: a Priority Sheet and a Weekly Schedule Worksheet. The Priority Sheet is used to rank tasks. The Priority Sheet contains task names, task type, task due dates, total planned hours, and hours completed to-date for employees. The Weekly Schedule Worksheet is a blank form used to schedule each employee's weekly tasks. Tasks are assigned by writing the task name in each half-hour slot on the sheet for each employee. Tasks taking more than a half hour are indicated by drawing arrows from the task name to the start time slot of the next task.

You are a manager in this research organization. I'll ask you to perform two management jobs using these documents. You can use as little or as much of the data and information on the test documents as you feel necessary to complete each job. I'll ask you to look over the test documents (scenario sheet first, then priority sheet, then weekly schedule worksheet). Then I'll hand you a procedure describing a management job I want you to perform. I'll ask you to read the procedure and perform the job described on the procedure. As you perform the job, whenever you use data and information from the test documents, say what you're using and how you use it. When making observations about the job you've been asked to perform, describe the data and information used to support your observations.

Finally, state aloud the line of reasoning you are using to go from the observations to your decisions. I'll record what you say on audio tape as you complete the job. After you complete the first job, we'll take a five-minute break, then I'll give you a second procedure and ask you to read it and perform the job described on this procedure. After completing the second job, I'll ask you to answer some questions about the experiment. After you answer the questions, your participation in the experiment will be completed.

Below are some items that may or may not apply to your jobs.

1. The research organization would like to enhance its academic reputation.
2. Conference 1 is regarded as a very prestigious conference by most academicians.
3. The research organization currently gets 82% of its contracts and grants through repeat business from satisfied sponsors.
4. A manager in another group has employees waiting to complete a task that depends on the completion of the Grant 1 Process Flowcharts.
5. Managers are evaluated on the amount of work they supervise and their ability to satisfy their sponsors.
6. Employee 1 likes writing papers more than doing contract and grant work.
7. The sponsor for Grant 1 is a first-time sponsor of the research organization.

8. **The research organization must increase in size and capability to compete with other similar research organizations.**
9. **The Grant 1 Presentation could result in a new grant for the research organization.**
10. **Three other research organizations will be submitting a proposal for Contract 1.**
11. **Employees are evaluated based on their ability to meet due dates.**
12. **The main competitor for the research organization has four times as many employees and performs three times the work based on research dollars.**
13. **Research organization rules state that each employee can only be assigned 40 hours of work per week.**
14. **Annual reports are required by the sponsors but can be delayed.**
15. **The sponsor for Grant 1 is a large government organization.**

Procedure 1: Rank Tasks

Your job is to rank tasks based on desired outcomes and implied importance or urgency of the tasks for the research organization. The tasks are listed on the Priority Sheet. Place the rank of each task next to the task name in column A of the Priority Sheet. Use whatever data and information from the test documents you feel is necessary to complete your job. Whenever you use data and information from the test documents, say what you're using and how you use it. When making observations about the task you've been asked to perform, describe the data and information used to support your observations. Finally, state aloud the line of reasoning you are using to go from the observations to your decisions.

Procedure 2: Develop a Weekly Schedule for Employee 1

Your job is to develop a weekly schedule for Employee 1. Place the weekly schedule for Employee 1 on the Weekly Schedule Worksheet by writing the task name in each half-hour slot on the worksheet for each employee. Tasks taking more than a half hour are indicated by drawing arrows from one task name to the start time slot of the next task. Use whatever data and information from the test documents you feel is necessary to complete your job. Whenever you use data and information from the test documents, say what you're using and how you use it. When making observations about the task you've been asked to perform, describe the data and information used to support your observations. Finally, state aloud the line of reasoning you are using to go from the observations to your decisions.

Priority Sheet

For the Week of:

March 19-23, 1990

Priority A	Task Name B	Task Type C	Due Date D	Employee 1		Employee 2	
				Total Planned Hours E	Hours Completed To-Date F	Total Planned Hours G	Hours Completed To-Date H
---	Conference I Paper	PP	3/21/90	18	14	40	35
---	Grant I Presentation	CG	3/21/90	80	74	40	30
---	Conference II Paper	PP	3/27/90	0	--	40	32
---	Grant II Model Prototype	CG	3/19/90	4	0	4	0
---	Conference III Abstract	PP	3/20/90	2	0	4	0
---	Grant I Literature Review	CG	3/23/90	180	172	40	12
---	Contract I Draft Proposal	CG	3/20/90	20	16	24	20
---	Complete Study B, Grant I	CG	3/20/90	80	77	140	130
---	Complete Study F, Grant II	CG	3/19/90	50	44	42	36
---	Grant II Annual Report	CG	3/27/90	6	0	0	--
---	Grant I Process Flowcharts	CG	3/26/90	4	0	8	0
---	Grant II Final Model	CG	3/30/90	100	80	60	40

WEEKLY SCHEDULE WORKSHEET

Employee Name: Employee 1

Week of: March 19-23, 1990

	MON	TUE	WED	THU	FRI
7:00					
7:30					
8:00					
8:30					
9:00					
9:30					
10:00					
10:30					
11:00					
11:30					
12:00					
12:30					
1:00					
1:30					
2:00					
2:30					
3:00					
3:30					
4:00					
4:30					
5:00					
5:30					

Appendix B. Post-Test Questionnaire

POST-TEST QUESTIONNAIRE

1. Were the instructions on the procedures what you expected from the training session?

Yes _____ No _____ Explain: _____

2. Did you feel you understood the instructions? Yes _____ No _____

Explain: _____

3. How difficult were the procedures to complete? (Circle one)

Not Difficult Moderately Difficult Very Difficult Extremely Difficult

4. How well were you able to complete the procedures? (Circle one)

Very Well Moderately Well Not Well Did Not Finish

5. How well did the data and information support the procedures? (Circle one)

Very Well Moderately Well Not Well

6. Were there data and units of information you wanted that were not provided on the test documents? Yes _____ No _____ If so, what? _____

Appendix C. Training Documents

Differences in Data and Information Needs at Two Different Organizational Levels

Introduction

The purpose of this study is to measure the differences in data and information needed by managers performing duties related to different organizational levels. Specifically, you'll be asked to perform a duty related to the strategic level of an organization, and a duty related to the operational level of the organization. The data obtained will be used to make recommendations on data and information needed by managers at these two organizational levels.

The study is being conducted by Management Systems Laboratories, Department of Industrial Engineering and Operations Research, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061 (telephone number 703-231-3501). The research team consists of Steve Berube, a graduate student in Industrial Engineering and Operations Research, under the direction of Dr. Harold A. Kurstedt, Principal Investigator and Hal G. Prillaman Professor of Industrial Engineering and Operations Research (telephone number 703-231-3515).

In this study you'll be asked to perform two different management duties. While you perform each management duty, you'll speak aloud what you're doing and the data and information you use to perform the duty. An experimenter will give you the test documents and will make an audio tape recording of your voice as you perform the duties.

After reading this introductory material, you'll be given an informed consent form. If you understand what the experiment entails and agree to participate in it, you must sign this form. We'll also ask you to supply demographic data, such as your age, managerial experience, etc. Assuming you meet all of our standardization criteria, we'll schedule you for an experimental session, a brief outline of which follows.

Experimental Procedure

You'll first be seated at a table. The experimenter will be seated facing you across the table. The audio tape recorder will be started and placed on the table. You'll receive a set of test documents containing two procedures, worksheets, tasks, and data and information about the tasks. You'll be

asked to rank and schedule these tasks using the test documents, and speak aloud the data and information you use from the test documents and how you use the data and information. You can use as little or as much of the data and information on the test documents as you feel necessary.

You'll first be asked to look over and familiarize yourself with the test documents. You'll then receive the first procedure containing specific instructions on either ranking or scheduling the tasks. After you read the specific instructions outlined in the first procedure, you'll be asked to perform the procedure. After completing the first procedure, you'll be given a five-minute break. You'll then receive the second procedure, read the detailed instructions, and perform the procedure. After you complete the second procedure, you'll be asked several questions about the difficulty of the procedures, if you understood the directions, and the usefulness of the task data and information in completing the procedures. Answering the questions ends the experimental procedure.

There is no right way to perform the procedures. You'll complete the procedures based on your judgment and the data and information you use from the test documents. When speaking aloud during the procedures, just respond naturally, as if you were speaking to the experimenter. We're interested in what data and information you use, how often you use it, and how you combine it with other data and information in completing the procedures. If the data and units of information you use are numbered or lettered, referencing the data and information by number or letter may be more convenient for you. Speaking aloud the data and information you use and how you use it will slow down the completion of the procedures. This is normal. Time to complete the procedures is not an issue in this study.

Additional Information

At any time during the study, if you no longer wish to continue, you have the right to terminate your participation. While performing the study, you may ask questions that the experimenter may not be able to answer. If so, the experimenter will say so. You are encouraged to proceed on with the study as best you can. If you are unable to continue in any manner, you may terminate the study.

If you have any questions about the experiment or your rights as a participant after reading the attached informed consent form, please do not hesitate to ask. We'll answer your questions honestly and as openly as possible. We ask you not to discuss the details of this experiment with any person, particularly those who may participate, as prior knowledge of seemingly incidental facts might compromise the data. All data will be collected by May 1, 1990; you may feel free to discuss the study with any persons after that time. All data will be analyzed with anonymity, i.e., immediately upon completion of your experimental session, your data will be identified only by a randomly assigned serial number.

Participant's Informed Consent

1. You are being asked to volunteer to be a participant in a research project whose purpose and description are contained in the document entitled "Differences in Data and Information Makeup at Two Different Organizational Levels," which you have already read.
2. There are no potential risks involved in this experiment beyond those risks normally encountered in daily life.
3. A potential discomfort involved in this experiment includes fatigue due to the length of the experimental session, which will last no more than one hour total.
4. The data gathered in this experiment will be treated with anonymity. Immediately after your participation, your name will be separated from your data.
5. While there are no direct benefits to you from this research, you may find the experiment interesting. Your participation, along with that of other volunteers, should make possible the improved data and information support for managers.
6. You should not volunteer for this research if you are under 18 years of age or have no experience managing others.
7. Please note that the principal investigator of the research project will answer any questions that you may have about this project, and you should not sign this consent form unless you are certain that you understand all of the previous descriptions and conditions.

You may also contact Dr. E. R. Stout, Chairman of the University's Institutional Review Board (telephone number: 703-231-5281), if you have any questions or concerns about this experiment.

8. You may withdraw from participation at any time during the experiment without penalty.
9. Signature of the volunteer participant:

I have read and understand the details of this experiment, and I have no further questions. I hereby give my consent to participate. I understand that I may discontinue participation at any time.

Signature **Date**

10. Signature of a member of the research team:

Signature **Date**

Priority Sheet

For the Week of:

Month XX-XX, 1990

Priority A	Task Name B	Task Type C	Due Date D	Employee 1		Employee 2	
				Total Planned Hours E	Hours Completed To-Date F	Total Planned Hours G	Hours Completed To-Date H
—	Task Number 1	AA	X/XX/90	XX	XX	XX	XX
—	Task Number 2	BB	X/XX/90	XX	XX	XX	XX
—	Task Number 3	AA	X/XX/90	XX	XX	XX	XX
—	Task Number 4	BB	X/XX/90	XX	XX	XX	XX
—	Task Number 5	AA	X/XX/90	XX	XX	XX	XX
—	Task Number 6	BB	X/XX/90	XX	XX	XX	XX
—	Task Number 7	BB	X/XX/90	XX	XX	XX	XX
—	Task Number 8	BB	X/XX/90	XX	XX	XX	XX
—	Task Number 9	BB	X/XX/90	XX	XX	XX	XX
—	Task Number 10	BB	X/XX/90	XX	XX	XX	XX
—	Task Number 11	BB	X/XX/90	XX	XX	XX	XX
—	Task Number 12	BB	X/XX/90	XX	XX	XX	XX

WEEKLY SCHEDULE WORKSHEET

Employee Name: Employee 1

Week of: March 19-23, 1990

	MON	TUE	WED	THU	FRI
7:00					
7:30					
8:00	TASK 4	TASK 2	TASK 11	TASK 5	TASK 5
8:30	↓	↓	↓	↓	↓
9:00					
9:30		↓	↓		
10:00		TASK 11	TASK 3		
10:30		↓	↓		↓
11:00					TASK 3
11:30	↓	↓	↓	↓	↓
12:00	 	 	 	 	
12:30	 	 	 	 	
1:00	TASK 4	TASK 11	TASK 6		TASK 3
1:30	↓	↓	↓	↓	↓
2:00					
2:30	TASK 2		↓		
3:00	↓		TASK 5		
3:30			↓		
4:00					
4:30		↓	↓	↓	↓
5:00	↓				
5:30					

DEMOGRAPHIC DATA

1. Sex: _____ **Male** _____ **Female**

2. Age: _____

3. How many people [maximum at one time] work (worked) for you? _____

4. Number of years experience managing other employees: _____

For your employees, do (did) you

- | | | | | |
|----|-----------------------|--------------------------------|--------------------------|-------|
| 5. | Establish priorities? | _____ Yes ___ No | How Long [years]? | _____ |
| 6. | Rank tasks? | _____ Yes ___ No | How Long [years]? | _____ |
| 7. | Assign hours? | _____ Yes ___ No | How Long [years]? | _____ |
| 8. | Develop a schedule? | _____ Yes ___ No | How Long [years]? | _____ |

Name: _____

Note: Items in brackets were added to the form to reflect answers to questions asked by subjects during training.

Vita

D. Steven Berube was born June 5, 1958 in Nashville, Tennessee. He earned a bachelor's degree in Industrial Engineering from the University of Tennessee, Knoxville, in 1981. After receiving his degree, he worked for the Corporate Industrial Engineering Group at the Tennessee Valley Authority in Knoxville, Tennessee. He decided to return to school at Virginia Tech to earn an advanced degree in Industrial Engineering. After completing his course work, Steve went to work full time with Management Systems Laboratories (MSL), a research group within the Department of Industrial Engineering and Operations Research at Virginia Tech. After graduation, Steve plans to continue his work at MSL.