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An investigation of factors affecting how engineers and scientists seek information

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Abstract

This study investigated how 872 US aerospace scientists and engineers select information carriers. When considering oral and written information carriers, the principle of least effort was supported with a strong preference for oral communication over written communication. In examining how the respondents select written carriers, the decision to use or not to use a written carrier was found to be primarily a function of the perceived importance of the carrier's information to a person's work. Task uncertainty and task complexity were found to be significant, but not the primary nor a totally consistent criteria. The perceived quality and accessibility of written carriers were not found significant. The findings reinforce the need for firms to hire knowledgeable employees, to provide them with comprehensive training programs, and to develop formal and informal communication networks.

Keywords: Information seeking; Task; User; Carrier

1. Introduction

Information seeking behavior is the "purposive acquisition of information from selected information carriers (e.g. messages, sources and channels)" (Johnson et al., 1995a, p. 275). Clearly, how one selects an information carrier is an important issue, since the quality of decisions is a function of the information used. If one has poor or incomplete information, the resulting decisions will more than likely be poor and may lead to serious consequences to the organization (Culnan, 1983; Inman et al., 1986; Strobel, 1980). Cohen and Levinthal (1990) noted that the most innovative firms appear to be those that are best at recognizing

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the relevance of new, external information, importing and assimilating it, and then applying the information.

Information seeking behavior has been studied for several decades. This research has taken place in differing settings and has focused on a large number of topics. Some general conclusions that may be drawn from over three decades of research are: (1) there is a linkage between a firm's performance and its communications' effectiveness (O'Reilly, 1982); (2) internal technical communication is an important source of innovation (e.g. Allen et al., 1980; Goldhar et al., 1979); (3) organizations use business and technical information, largely from the external environment, to reduce technical uncertainty and complexity (Miller, 1971) and (4) a preference exists for face-to-face communication when dealing with non-routine, ambiguous, difficult messages, and for print carriers when dealing with routine, clear, simple messages (Daft and Lengel, 1984; Lengel and Daft, 1988; Dirsmith and Covaleski, 1985).

The aerospace industry is an ideal place to examine information seeking behavior due to its strategic importance to the US and, because it is the source of considerable scientific activity. The industry has been described as having a high degree of complexity embodied in the design and development of its products (Mowery, 1985; Tyson, 1992) as well as high technical and market uncertainty (Utterback, 1974). This paper examines how aerospace scientists and engineers seek information and the variables that affect such choices.

2. Theoretical framework and research hypotheses

The literature on information seeking behavior has examined a wide variety of variables such as the accessibility of the carrier, task characteristics, carrier characteristics, user characteristics, and demographics. The following sections briefly describe each of the major factors thought to influence the selection of information carriers.

2.1. Accessibility

One consistent empirical finding in the literature has been that information seekers follow the "principle of least effort" of Zipf (1949). This principle holds that people strive to solve their problems in such a way as to minimize the total work that must be expended. More specifically, it is defined as the degree to which "people strive to minimize the probable rate of work expenditure (over time)" (Zipf, p. 1). Early work by Mintzberg (1973) established that managers preferred personal interactions rather than written carriers. Hardy (1982) applied Zipf's principle suggesting that people take a path of least resistance when seeking information rather than focusing primarily on quality. Several other studies (e.g. Badawy, 1988; Allen, 1977; Blandin and Brown, 1977; Culnan, 1983; Gertsberger and Allen, 1968; Hardy, 1982; O'Reilly, 1982; Rosenberg, 1967; Swanson, 1987) have supported this conclusion. In fact, Gerstberger and Allen found that an information carrier's technical quality was unrelated to its use. These findings help to explain the number of studies that have found heavy reliance on the more accessible oral communication for transfer of information (Allen and Cohen, 1969; Jain and Triandis, 1990, p. 29).

More recent work has upheld the premise of ease of use. Von Seggern (1995), in her review of information seeking among scientists, found a heavy reliance on personal collections, informal communication and physically accessible sources, and far less usage of library sources and formal literature search processes. In a review of information seeking behavior of engineers, Leckie et al. (1996) reported that studies have shown that professionals tend to rely on their own personal knowledge and experience first, when faced with a work-related decision or problem. They also noted that, "[r]epeatedly, studies of information seeking in engineers have revealed that oral communication is predominant, just as is the reliance on coworkers' and supervisors' knowledge" (p. 165). Finally, the authors found that, "[l]ibraries are little used and, instead, engineers rely on personal files, personal knowledge, and personal experience". And, "this practice held for engineers who are active in universities, R&D industries and who are professional practitioners" (p. 165). Similarly, Ellis and Haugan (1997) studied the information seeking patterns of engineers and scientists in an international oil and gas company. They found that engineers made heavy use of internal communications inside the company. And, when confronted with an unfamiliar field, they tended to look at contacts within their own personal networks, and only then employed library personnel as intermediaries for literature searches.

O'Reilly (1982) argued these least effort practices occurred, because of the ambiguity inherent in available information and pressures to produce results. On the other hand, Swanson (1987) contended that the principle of least effort may be situational. He pointed out that researchers need to seek those contingencies under which the statement may be true and situations where information value, rather than accessibility, explains carrier usage.

While the principle of least effort may be difficult to operationalize, a number of similarities are found in the literature. These include a preference for seeking information from one's own store of information as opposed to seeking information from others, oral communication as opposed to written communication, communication with sources inside the organization as opposed to communication with sources outside the organization, and direct communication with a source as opposed to through mediating carriers such as those provided by library personnel, who are not authorities in the discipline under study.

Hypothesis 1. Among US aerospace scientists and engineers, information carrier choice will follow the principle of least effort, i.e. one's storehouse of information will be preferred to other information sources, oral communication will be preferred to written communication, communication within the organization will be preferred to communication external to the organization, and direct communication will be preferred to communication that goes through an intermediary.

2.2. *Task characteristics*

Task characteristics, as determinants of information seeking behavior, have been studied from two perspectives. The first focuses on task classification such as that used in the study of R&D laboratories by Katz and Tushman (1979). They classified tasks on a scale from high to low complexity, i.e. basic research, applied research, development, and technical service. The second classification uses broader measures such as task uncertainty and task complexity. Technical uncertainty and complexity are major issues in the aerospace industry

(Katz and Kahn, 1966), because of the innovative nature of its tasks (Rogers, 1983a). And, as technical task uncertainty increases and environments become more complex, requirements for information also increase (Bystrom and Jarvelin, 1995; Culnan, 1983; Gifford et al., 1979; Katz and Tushman, 1979).

There are as many definitions of uncertainty as there are treatments of the subject (Argote, 1982). Rogers (1983b) viewed uncertainty as the degree to which several alternatives are perceived with respect to the occurrence of an event and the relative probability of these alternatives. Thus, uncertainty implies a lack of predictability, of structure, and of information. Jain and Triandis (1997, p. xiv) characterized R&D organizations as having considerable uncertainty since the output can never be predicted perfectly from the various inputs used. Galbraith (1977, pp. 6–7) succinctly viewed uncertainty as, "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization". Duncan (1972) identified five organizational sources of uncertainty that engineers and scientists encounter in the aerospace industry: customers, suppliers, competitors, socio-political issues, and technological uncertainty.

Rogers (1983a) held that individuals faced with uncertainty typically seek information. This was supported by Brown and Utterback (1985), who studied six R&D groups in the food, computer, and paper industries. They concluded that technical people who saw the world (competitors, suppliers, customers, technology, and regulation) as more uncertain also sought greater contact outside their firms. Blandin and Brown (1977) found significant positive correlations between perceived uncertainty by managers and their reliance on external sources of information and their use of informal sources of information.

Complexity has been defined as the extent to which a unit must coordinate and joint problem solve with others (Tushman, 1978), thus generating greater information processing requirements (Galbraith, 1977; Hackman and Vidmar, 1970). Tushman (1978) and Picot et al. (1983) (cited in Johnson et al., 1995b) found interpersonal channels to be more useful in transmitting highly complex subject matter. Culnan (1983) concluded that the decision to use a carrier was positively related to both perceived accessibility and environmental complexity. On the other hand, O'Reilly (1982) found no relationship between complexity, uncertainty, and information use for those employed in the same job in a county welfare agency.

More recently, Bystrom and Jarvelin (1995), in a study of civil service workers in Finland, developed a qualitative model that posited that as task complexity increases, the complexity of the information needed increases, the internality of the channels decreases, and the number of sources increases. Vakkari and Kuokkanen (1997) concluded, based on their empirical analysis, that several general statements apply to task complexity. Among these are the conclusions that as task complexity increases (a) the use of internal channels decreases and (b) the number of sources increases.

Other investigations of uncertainty and complexity were based on the work of Daft and Lengel (1984) and Lengel and Daft (1988), which posited an information processing model. This model held that the choice of a communications carrier was based on the information carrying capacity of a medium to convey information, with face-to-face communication constituting the 'richest' medium and print media the least. Thus, Daft and his associates attributed carrier choices not to ease of use or availability, but to information needs of a manager and the ability of a medium to fulfill these needs. Gales and Mansour-Cole (1995), using the information processing approach, found that the frequency of user involvement and the number of users contacted increased as projects progressed from idea generation to commercialization and that specific measures of uncertainty were related to involvement. They also found significant interaction between known uncertainty and frequency of user involvement with respect to performance.

Despite differences in definitions and theoretical approaches over time, the literature provides considerable evidence that increased task complexity and task uncertainty lead to greater use of multiple carriers.

Hypothesis 2. The greater the (a) task complexity and (b) task uncertainty increase, the greater the use of multiple carriers among US aerospace scientists and engineers.

2.3. Information carrier characteristics

A substantial amount of literature has investigated characteristics of written information carriers that affect information seeking behavior. Various authors have investigated carrier characteristics such as accessibility (Allen, 1977; Culnan, 1983, 1985; Gertsberger and Allen, 1968; O'Reilly, 1982); quality (Allen, 1977; Gertsberger and Allen, 1968; O'Reilly, 1982); ease of use (Gertsberger and Allen, 1968; Hardy, 1982; Rosenberg, 1967); usefulness (Swanson, 1987); promptness or the time it takes to deliver the information (Hardy, 1982); and cost (Mick et al., 1980; Swanson, 1987). Despite differences in measures used and characteristics studied, the literature provides evidence of two competing written carrier characteristics, i.e. accessibility and quality.

2.4. User characteristics

A substantial amount of literature has investigated the role of the characteristics of information users. Several researchers have investigated carriers in terms of a person's prior use. Early work by March and Simon (1958) and Allen (1977) noted that information seekers are more likely to obtain information from carriers familiar to them rather than seek new carriers and that this practice becomes self-reinforcing. Wilson (1977) proposed that non-users of a particular carrier are likely to underestimate the existence of the carrier's potentially useful information and to overestimate the difficulty of obtaining the desired information. The concept of successful prior use of a carrier as a factor in information seeking behavior was also upheld by Culnan (1985), Hardy (1982), Johnson et al. (1995a), Johnson (1996), and Swanson (1987). A recent review by Leckie et al. (1996), concluded that accessibility and familiarity are more important than perceived quality.

A second stream of work has focused on the user's perception of the relevance or utility of the information to the task at hand. Swanson (1987) factor analyzed 38 carrier characteristics and identified a factor he termed 'value', which included the attributes of importance, relevance, meaningfulness, usefulness and value. In Swanson's work, the value dimension was found significant, but not the primary determinant of the use of a source. More recently, Johnson et al. (1995a) adopted the Evans and Clarke (1983, p. 239) concept of 'salience' or "the perceived applicability of information to a problem that he or she faces". In a multivariate analysis, these authors found that 'importance' was one of several factors included in their comprehensive model.

2.5. Demographics

Some early studies suggested that demographic factors such as tenure, experience, and education affect information seeking behavior (Keller and Holland, 1978; O'Reilly, 1982). Not only are these demographic variables obviously interrelated but significant findings, which were tested independent of other factors, were found to account for little variance. Johnson et al. (1995a) argued that an information seeker's education level probably has the most important consequences for information seeking. However, when these variables were cast into a multivariate model, their impact was found to be very low or non-significant. Vakkari and Kuokkanen (1997) also considered the impact of education and experience. However, they concluded that task complexity reflects a worker's experience with a task, and accordingly, "the more acquainted the enquirers are with a task the less complex they perceive it" (p. 511). Thus, these authors decided to exclude demographics from their analysis.

The literature has, for the most part, examined demographic variables in isolation. Some attempts have been made to develop more comprehensive models. For example, Johnson et al. (1995a) and Johnson (1996) proposed a comprehensive approach that identified five antecedents to information seeking: (1) demographics; (2) direct experience; (3) salience; (4) individual beliefs about the outcomes of information and (5) carrier characteristics. Johnson and his associates studied a large state government agency providing engineering and technical services and found that direct experience, salience, and carrier characteristics were the primary determinants of choice. The evidence suggested that demographic considerations were not major factors in information seeking and, thus, were not considered for analysis in this paper.

2.6. Summary of proposed hypotheses

The research study presented here considers the combined impact of six variables in carrier selection: (1) perceived importance of a carrier; (2) an individual's prior experience with a carrier; (3) task characteristics of uncertainty; (4) and complexity; (5) carrier characteristics of quality; (6) and availability.

In addition to the two hypotheses stated above, the third hypothesis takes a multivariate approach to the selection of written information carriers. The hypothesis holds that written carrier choice may be predicted by the six previously discussed variables. Thus, six subhypotheses are proposed.

Hypothesis 3a. The more positively, a person views a written carrier as being important to the task at hand, the more likely that person will opt to use the carrier.

Hypothesis 3b. The more successful one's past experience with a given written carrier, the greater the likelihood that the person will use that carrier in the future.

Hypothesis 3c. The higher one's perceived level of the task attribute of complexity, the more likely the person will be to use a written carrier.

Hypothesis 3d. The higher one's perceived level of task uncertainty, the more likely the person will be to use a written carrier.

Hypothesis 3e. The higher one's perceived level of the task attribute of complexity, the more likely the person will be to use a written carrier.

Hypothesis 3f. The higher one's perceived level of the task attribute of complexity, the more likely the person will be to use a written carrier.

3. Research design and measures

3.1. Sample

Data were drawn from a larger survey of information-related behaviors among US aerospace engineers and scientists. A pre-tested questionnaire was sent to a random sample of 2000 members of the aerospace division of the society of automotive engineers consisting of engineers and scientists performing professional duties in design, development, manufacturing and production. A toll-free telephone number was provided to the participants, so they could inform the researchers if the survey was not relevant. One month later, follow-up postcards were sent to those who had not yet responded. To control for external factors (such as accessibility to government restricted information), only responses from private sector organizations were used. The final sample consisted of 872 usable surveys from private sector organizations. After accounting for surveys returned undeliverable or non-relevant, an adjusted response rate of 67% was achieved.

The survey was worded to ask participants to focus on, "the most important job-related project, task, or problem you have worked on in the past 6 months". The rationale of this event oriented technique was that, it is easier for people to recall accurately what they did on a specific task than remember what they do in general (Lancaster, 1978). This approach has been used in a variety of situations, e.g. DeWhirst (1971) and more recently by Smith et al. (1996) and Johnson et al. (1995b). In the balance of this paper, the term 'project' will be used to describe technical project, task, or problem described by the respondents.

3.2. Survey instruments and data collection procedure

A perceptual measure of task complexity and uncertainty was adopted and was measured on a scale of 1 (little) to 5 (great). While, a number of writers (e.g. Downey et al., 1975) criticized work that relied on perceptions rather than objective indicators, others (e.g. Duncan, 1972; Dutton and Jackson, 1987; Gioia and Ford, 1991) argued that perceptions concerning uncertainty and complexity shaped decision choice. As used in this paper, the terms uncertainty and complexity refer to technical task uncertainty and complexity.

First, respondents were asked to rank order their use of five different carriers identified in previous studies as being salient to engineers and scientists (AAES, 1986; Shuchman, 1981; Pinelli et al., 1989). These are: (1) consulting my personal store of knowledge including sources I keep in my office; (2) speaking with coworkers or other people inside my organization; (3) speaking with colleagues outside my organization; (4) speaking with a librarian or technical information specialist; (5) using literature sources (e.g. conference papers, journals, technical reports).

Respondents were also asked about nine considerations they used in choosing written carriers: (1) easy to obtain; (2) easy to use; (3) technical quality; (4) comprehensiveness; (5) relevance; (6) obtainable from nearby source; (7) good prior experience; (8) importance and (9) cost. Five written carriers commonly used in aerospace R&D were investigated: journal articles, conference papers, in-house technical reports, DoD technical reports and NASA technical reports. Respondents were asked to rate each of the five written carriers on the nine characteristics on a scale of 1 (very unimportant) to 5 (very important) in deciding whether to use the carrier.

4. Results

4.1. Research findings

Of the 872 respondents, over 90% worked as engineers. Average experience in aerospace was 18.7 years. Slightly more than half had undergraduate degrees, 34% held master's degrees, and 5% had post master's education. Slightly over 90% were trained and educated as engineers, 7% as scientists and 3% in other categories.

Katz and Tushman (1979) developed a general paradigm of levels of task complexity and uncertainty. An analysis using this prototype revealed that both complexity and uncertainty are reasonable approximations of task characteristics, ranging from high to low (see Table 1).

To reduce the number of written carrier characteristics, principal component factor analysis was employed using an eigen value equal to or greater than unity as the criterion for inclusion. Analysis of each of the five carriers separately revealed a consistent factor structure implying a consensus among the respondents as to elements considered in the decision to use a specific characteristic. Using 0.50 as criterion for loading, the analysis reduced the number of reasons for use or non-use from nine to four factors (Table 2), which accounted for 67% of the variance. Factor 1 (TECH) consisted of technical dimensions such as

Table 1
Reported levels of complexity and uncertainty by project type

Type of project[a]	Complexity	Uncertainty
Research	3.88	3.52
Development	3.85	3.43
Management	3.69	3.06
Production	3.68	3.24
Design	3.60	3.01
Education	3.15	2.69
F	3.87*	7.15**

[a] Listed in descending order of routineness.
* $P < 0.05$.
** $P < 0.01$.

Table 2
Factor analysis of elements in the decision to use written communications carriers[a]

Media	Factors (decimal points omitted)			
	1	2	3	4
	TECH	ACC	PRI	IMP
Journal articles				
Comprehensive data and information	**88**	15	9	0
Relevant to my work	**78**	10	12	0
Good technical quality	**81**	19	17	2
Easy to use or read	**64**	39	9	−5
Inexpensive	10	**70**	70	7
Obtainable nearby	30	**63**	14	−2
Easy to obtain	52	**55**	4	−2
Good prior experience in using	25	22	**67**	−12
Importance to my work	3	8	3	**76**
Conference or meeting papers				
Comprehensive data and information	**80**	18	14	1
Relevant to my work	**79**	12	14	14
Good technical quality	**81**	19	12	3
Easy to use or read	**62**	47	13	0
Inexpensive	4	**71**	17	0
Obtainable at nearby source	33	**67**	19	4
Easy to obtain	47	**61**	8	13
Good prior experience in using	28	24	**72**	6
Importance to my work	11	6	17	**61**
In-house technical reports				
Comprehensive data and information	**82**	13	14	−2
Relevant to my work	**80**	6	15	−3
Good technical quality	**84**	15	25	1
Easy to use or read	**68**	39	16	−5
Inexpensive	12	**72**	15	4
Obtainable at nearby source	30	**58**	19	0
Easy to obtain	52	**58**	10	−5
Good prior experience in using	23	21	**78**	6
Important to my work	−2	4	−7	**74**
DoD technical reports				
Comprehensive data and information	**73**	19	8	5
Relevant to my work	**71**	12	9	3
Good technical quality	**74**	20	7	5
Easy to use or read	**56**	48	9	−0
Easy to obtain	40	**67**	6	4
Inexpensive	2	**75**	9	9
Obtainable at nearby source	21	**69**	15	5
Good prior experience in using	15	28	**73**	12
Importance to my work	−4	−6	12	**65**
NASA technical reports				
Comprehensive data and information	**73**	17	9	7
Relevant to my work	**71**	13	9	5
Good technical quality	**74**	20	7	5

Table 2 (*Continued*)

Media	Factors (decimal points omitted)			
	1	2	3	4
	TECH	ACC	PRI	IMP
Easy to use or read	**56**	49	9	4
Easy to obtain	39	**67**	6	6
Inexpensive	2	**76**	9	9
Obtainable at nearby source	21	**69**	15	5
Good prior experience in using	15	28	**73**	12
Importance to my work	2	6	4	**72**

[a] Bold coefficients indicate $P < 0.001$.

accuracy, comprehensiveness, relevance, and ease of use. Factor 2 (ACC) addressed issues of accessibility in terms of cost and ease of obtaining the information. Factors 1 and 2 are consistent with the analysis of Swanson (1987) although the instruments differed.

Two factors not found by Swanson, but upheld by Johnson et al. (1995a) were factor 3, good prior experience in using the source (PRI) and factor 4, the importance (IMP) of the source to one's work. Factor scores were derived by summing the appropriate components for each factor. Reliability analysis yielded satisfactory Cronbach alphas for the additive variables ranging from 0.77 to 0.95 for TECH and 0.80 to 0.85 for ACC (see Table 3). The consistency of the factor analysis strongly suggested consensus among the respondents in their evaluation of the characteristics of each written carrier.

Table 4 contains means, standard deviations, and correlations of the variables under study. Analysis of technical task uncertainty and complexity measured on a scale of 1 (little) to 5 (great) yielded means of 3.18 (S.D. = 1.04) for uncertainty and 3.70 (S.D. = 0.87) for complexity. Both variables had approximately normal distributions suggesting that respondents were able to make a determination about the levels of uncertainty and complexity they faced. It also implied that answers were not contaminated by desirability or similarity biases. If these biases were present, one might expect less variance and higher levels of

Table 3
Reliability for additive variables using Cronbach alpha

Variable (*n* number of items in the scale) (carrier)	Alpha
Technical quality (TECH) ($n = 4$)	
Journals	0.92
Conference papers	0.93
In-house technical reports	0.95
DoD in-house reports	0.94
NASA in-house reports	0.77
Accessibility (ACC) ($n = 3$)	
Journals	0.80
Conference papers	0.83
In-house technical reports	0.84
DoD in-house reports	0.84
NASA in-house reports	0.85

Table 4
Mean, S.D., and correlation

Variables	Mean	S.D.	Correlation[b] (decimal points omitted)															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Task																		
Complexity	3.70	0.87		**47**	2	5	**13**	11	**15**	**18**	**23**	**18**	11	**17**	3	2	6	**25**
Uncertainty	3.18	1.04			−0	7	17	11	**15**	**12**	**21**	**12**	4	**14**	3	4	−0	**17**
Carriers[a]																		
PER	0.91	0.28				45	16	−2	**17**	0	0	5	4	1	−1	0	5	2
COI	0.90	0.30					26	1	**18**	−2	−1	7	1	−2	−4	2	0	−7
COO	0.73	0.45						**23**	**21**	13	**18**	11	8	8	3	3	7	8
LIT	0.63	0.48							**41**	**18**	**17**	**13**	**18**	13	2	−5	4	**19**
LIB	0.42	0.49								**32**	**22**	**22**	**18**	**24**	−6	−5	5	**26**
Print medium[a]																		
Journals	0.63	0.48									**44**	**22**	**23**	**30**	1	1	**14**	**47**
Conference papers	0.58	0.49										**23**	**28**	**28**	0	−4	2	**36**
Technical reports																		
In-house	0.83	0.38											**19**	**17**	−4	−0	5	**18**
DoD	0.43	0.49												**32**	−1	−4	5	**23**
NASA	0.43	0.49													−3	−0	5	**30**
Medium characteristics journals																		
ACC	3.35	1.03														**63**	**41**	**11**
TECH	4.01	1.11															**41**	6
PRI	3.14	1.07																**18**
IMP	2.61	1.09																
Conference papers																		
ACC	3.29	1.03																
TECH	3.98	1.11																
PRI	3.11	1.07																
IMP	2.49	1.08																
Technical reports in-house																		
ACC	3.23	1.15																
TECH	3.98	1.15																
PRI	3.25	1.16																
IMP	3.28	1.20																
DoD																		
ACC	3.12	1.05																
TECH	3.73	1.19																
PRI	3.06	1.05																
IMP	2.63	1.13																
NASA																		
ACC	3.36	1.18																
TECH	3.81	1.15																
PRI	3.08	3.08																
IMP	2.53	2.54																
			17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

Table 4 (*Continued*)

Variables	Mean	S.D.	Correlation[b] (decimal points omitted)															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Task																		
Complexity			3	4	5	**24**	7	6	5	10	4	7	4	**14**	5	10	**12**	**17**
Uncertainty			2	5	1	**19**	2	9	1	12	3	9	−1	**12**	3	11	2	**14**
Carriers[a]																		
PER			2	5	9	5	5	3	7	−3	3	3	6	1	2	2	5	2
COI			−5	0	−3	−1	−2	1	0	3	1	1	−3	−3	0	2	−2	−0
COO			−0	1	4	**13**	3	4	7	8	6	6	10	3	6	8	9	5
LIT			1	−3	3	**18**	8	1	9	9	4	0	11	**14**	2	0	5	**16**
LIB			−5	−4	3	**21**	−0	−1	5	11	0	0	6	**16**	−1	−1	6	**20**
Print medium[a]																		
Journals			1	1	9	**32**	−1	2	8	11	5	6	11	**18**	3	6	10	**25**
Conference papers			1	−3	0	**49**	3	−2	−0	**12**	6	6	6	**20**	4	4	5	22
Technical reports																		
In-house			−5	−3	2	**17**	−3	1	9	**44**	−1	5	2	12	−2	4	5	**12**
DoD			−3	−3	6	**24**	−3	−2	5	**15**	7	**16**	**20**	**55**	4	8	10	**22**
NASA			−5	−1	0	**28**	−4	−0	−2	**14**	1	8	3	**18**	3	9	8	**53**
Medium characteristics journals																		
ACC			**78**	**47**	**31**	3	**64**	**45**	**33**	11	**60**	**41**	**32**	9	**63**	**44**	**35**	7
TECH			**48**	**77**	**30**	−2	**36**	**69**	**32**	10	**34**	**60**	**26**	−0	**44**	**61**	**28**	4
PRI			**36**	**32**	**66**	8	**33**	**28**	**51**	**14**	**31**	**27**	**52**	**15**	**31**	**26**	**52**	12
IMP			10	3	13	**59**	9	6	9	**24**	**15**	**11**	**15**	**33**	**13**	10	**18**	**42**
Conference papers																		
ACC				**61**	**45**	3	**71**	**51**	**40**	10	**64**	**43**	**34**	7	**67**	**45**	**36**	**5**
TECH					**42**	−2	**39**	**76**	**37**	10	**34**	**65**	**28**	2	**46**	**65**	**29**	**2**
PRI						5	**36**	**33**	**62**	**16**	**31**	**26**	**56**	11	**33**	**28**	**59**	**11**
IMP							6	−2	2	**22**	10	8	8	**35**	8	4	8	**40**
Technical reports in-house																		
ACC								**56**	**51**	**16**	**63**	**36**	**35**	10	**60**	**38**	38	9
TECH									**51**	**14**	**39**	**65**	**29**	4	**49**	**68**	**30**	**2**
PRI										**28**	**34**	**33**	**58**	12	**34**	**34**	**59**	6
IMP											**13**	**16**	**16**	**20**	**12**	11	**15**	**22**
DoD																		
ACC												**60**	**52**	**14**	**79**	**53**	**46**	**13**
TECH													**48**	11	**61**	**85**	**40**	8
PRI														**26**	**42**	**40**	**73**	**14**
IMP															10	8	**16**	**41**
NASA																		
ACC																**70**	**50**	**12**
TECH																	**48**	7
PRI																		**18**
IMP																		

[a] Users: 1; non-users: 0.

[b] Bold coefficients indicate $P < 0.001$.

Table 5
Results of the Friedman two-way ANOVA of carrier preference[a]

Variable	Mean rank
Used my personal store of technical information (including sources I keep in my office) (PER)	1.75
Spoke with coworkers inside organization (COI)	2.16
Spoke with colleagues outside my organization (COO)	3.31
Used literature sources found in my organization's library (LIT)	3.60
Spoke with a librarian/technical information specialist (LIB)	4.19

[a] $\chi^2 = 1550.2827$; d.f. $= 4$; $P < 0.000$.

uncertainty. Correlation between the two variables was 0.47 ($P < 0.01$) or approximately 21% of the variance in one variable was accounted for by variance of the other. This suggests that while a statistically significant relationship existed, the two variables do not tap the same dimension, and hence, are not substitute measures of the same construct.

4.2. Hypotheses testing

4.2.1. Hypothesis 1

Hypothesis 1 held that among US aerospace scientists and engineers, information carrier choice will follow the principle of least effort. Respondents were asked to indicate whether each of the five carriers was used on the project and, if so, the rank order with which each was used. As an initial step, the data were tested for ranking consistency using Friedman's two way ANOVA (Table 5). The results demonstrated a high degree of consistency among the respondents ($P < 0.000$) and that the respondents followed the hypothesized path of least effort.

Table 6 contains the respondents' rank ordering of the information carriers they used to obtain the information they needed for the project. Reading across the diagonal (bold numbers provided) one may easily detect a steady decrease in the use of a carrier as the carrier

Table 6
Carriers used to obtain needed information concerning the technical project ($N = 872$)[a]

Carrier	Reporting (%)					
	Used first	Used second	Used third	Used fourth	Used fifth	Not used
Used my personal store of technical information (including information in my office) (PER)	**60.0**	17.7	10.2	2.3	1.1	8.7
Spoke with coworkers inside my organization (COI)	26.9	**45.3**	11.5	5.6	0.6	10.1
Spoke with colleagues outside my organization (COO)	5.4	15.5	**32.0**	13.1	6.2	27.9
Used literature resources found in my organization's library (LIT)	4.6	11.1	19.6	**20.0**	7.7	37.0
Spoke with a librarian/technical information specialist (LIB)	3.1	3.8	7.5	11.8	**15.8**	58.0

[a] See text for bold diagonal supplied.

Table 7
T-tests of use of carriers and project complexity and uncertainty

	Users (%)	Complexity scores		Uncertainty scores		Non-users
		Non-users (%)	Users	Non-users	Users	
PER	91.3	8.7	3.76	3.64	3.18	3.19
COO	89.9	10.1	3.71	3.56	3.20	2.96*
COI	73.1	27.9	3.77	3.51	3.30	2.89**
LIT	63.0	37.0	3.81	3.61*	3.32	3.08***
LIB	42.0	58.0	3.80	3.52	3.80	2.97***

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

becomes more external (to the organization) and involves written as opposed to personal contacts. The last column of Table 6 shows a similar trend. Overall usage decreases as carriers become more remote and move from verbal to written.

As suggested by the first hypothesis, the respondents first used their personal store of technical information. This was followed by oral consultation with coworkers within the organization and then by oral interactions with outsiders. Finally, respondents relied upon literature available within the organization and, then, consulted a librarian or technical information specialist. The findings were supportive of Hypothesis 1 and consistent with prior work (e.g. Allen, 1977; Katz and Tushman, 1979; Leckie et al., 1996; Katz and Tushman, 1979; Shuchman, 1981; Pinelli et al., 1991) all of which found preference for personal contacts.

4.2.2. Hypothesis 2

Hypothesis 2 held that the greater the (a) task complexity and (b) task uncertainty increase, the greater the use of multiple carriers among US aerospace scientists and engineers. To test these hypotheses, respondents were classified as users or non-users of each carrier. Table 7 contains the results of the analysis of the impact of complexity and uncertainty separately. The findings indicated that task complexity had no effect on use except in the case of the use of literature (LIT). However, increasing task uncertainty was associated with increasingly more contact with organizational colleagues (COI) and colleagues outside the organization (COO). At the two highest levels of reported uncertainty, literature found in the organization's library (LIT) was used and at the second highest level uncertainty. And, at the highest level of uncertainty, library resources such as librarians or technical information specialists (LIB) were employed. This suggests that as uncertainty increases, respondents increase their use of less accessible carriers. The results only marginally supported Hypothesis 2a, but strongly supported Hypothesis 2b.

Given the relationship ($r = 0.47$) between reported uncertainty and complexity, it was necessary to consider task complexity and uncertainty simultaneously. As the independent (predictor) variables were metric and the dependent (criterion) variables were dichotomous, discriminant analysis was employed using a step-wise inclusion of variables. To derive the discriminant function, a 50% subset was used to insure a sufficiently large number to attain

Table 8
Results of the discriminant analyses of factors affecting use of a communications carrier

Carriers (variables)	Wilks' lambda	χ^2 (d.f.)	Standardized canonical coefficients	Correctly classified (%)	
				Discriminant function (hit ratio)	Proportional chance criterion
PER					
Uncertainty	–[a]				
Complexity	–[a]				
COI		4.26* (1)		43	82
Uncertainty	0.99*		1.00		
Complexity	–[a]				
COO		26.42** (1)	1.00	62	59
Uncertainty	0.97*				
Complexity	–[a]				
LIB		11.34** (1)	1.00	57	53
Uncertainty	0.98*				
Complexity	–[a]				
LIT		27.97** (2)		62	53
Uncertainty	0.98*		0.57		
Complexity	0.97*		0.60		

[a] F-level insufficient for further computation.
* $P < 0.05$.
** $P < 0.01$.

stability of the coefficients. Otherwise, the test may be flawed from the start. A 50% hold out sample was used to cross-validate the derived discriminant function, because an upward bias occurs in the prediction accuracy of the discriminant function, if the sample used to develop the classification matrix is the same as that used to compute the function (Hair et al., 1987, pp. 82–83).

Table 8 contains the results of the discriminant analysis. The χ^2 statistic is a measure of the statistical significance of the function (Hair et al., 1987, pp. 84–85). The analysis revealed significant χ^2 statistics for COI ($P < 0.05$) and for COO, LIB and LIT ($P < 0.001$). The standardized discriminant function coefficients indicate the degree of contribution of each predictor (within a function) to the separation of groups (Borden and Abbott, 1995, p. 467). The percentage correctly classified (hit ratio) is analogous to regression's R^2 (Hair et al., 1987, p. 85). The proportional chance criterion, shown in the table, serves as a bench mark for comparing the effectiveness of the individual discriminant functions and should be used when group sizes are unequal (Hair et al., 1987, pp. 89–90). Proportional chance measures the percentage of individuals that would be correctly classified by chance. This is calculated using the formula $\alpha^2 + (1 - \alpha)^2$, where α represents the prior probability of one category (Hair et al., 1987, pp. 99–100).

As the search for information spread beyond the consulting of personal resources, the cross validated discriminant functions correctly classified communications carriers in a manner better than that of the proportional chance criterion. The results were identical to the

Table 9
Results of the discriminant analyses of factors affecting use of a print carrier

Carriers (variables)	Wilks' lambda	χ^2 (d.f.)	Standardized canonical coefficients	Correctly classified (%)	
				Discriminant function (hit ratio)	Proportional chance criterion
Journals		219* (2)		70	67
Importance	0.78*		0.95		
Prior use	0.77*		0.20		
Conference papers		259* (3)		72	51
Importance	0.76*		0.90		
Complexity	0.75*		0.19		
Uncertainty	0.74*		0.17		
In-house technical reports		224* (3)		79	71
Importance	0.80*		0.95		
Uncertainty	0.78*		0.35		
Accessibility		0.77*	−0.27		
DoD		329* (3)		76	52
Importance	0.76*		0.98		
Technical quality		0.69*	0.33		
Accessibility		0.68*	−0.21		
NASA		299* (2)		75	52
Importance	0.71*		0.96		
Complexity	0.71*		0.17		

* $P < 0.05$.

individual analyses, which considered uncertainty and complexity separately. The analyses indicated that in the sequential choice of carriers, complexity was a factor in carrier choice only when the user had exhausted all personal contacts and resorted to written sources. Accordingly, Hypothesis 2a had only weak support and is rejected, while Hypothesis 2b was upheld.

4.2.3. Hypothesis 3

Hypothesis 3 held that the choice of written carriers is related to (a) a user's perception of the importance of the information to the work at hand; (b) one's past experience with a given carrier; (c) carrier characteristics and the task attributes of (d) complexity and (e) uncertainty. To test the third set of hypotheses, discriminant analysis was used for each of five written carriers commonly used in the aerospace industry. The same procedures were employed as outlined in Hypothesis 2. Table 9 contains the results of the discriminant analyses. For all five carriers, the discriminant analyses revealed statistically significant χ^2 values ($P < 0.001$) and classified the respondents in a manner superior to the proportional chance criterion.

Hypothesis 3a held that the more positively a person views a written carrier as being important to the task at hand, the more likely that person will opt to use the carrier. The discriminant analyses revealed that the primary and only completely consistent predictor of the use of a print medium was that of importance, having standardized canonical coefficients of 0.95, 0.90, 0.95, 0.98 and 0.96 for journals, conference papers, in-house technical reports, DoD technical and NASA technical reports, respectively (see Table 9). Average correlation (r) between importance (IMP) and the three variables of prior use (PRI), accessibility (ACC), and technical quality (TECH), were 0.12 (journals), 0.00 (conference papers), 0.19 (in-house technical reports), 0.17 (DoD technical reports), and 0.12 (NASA technical reports) (see Table 4). The results showed that importance was perceived by the respondents independent of other factors such as technical quality, accessibility, and prior experience. The hypothesis was upheld.

Hypothesis 3b held that the more successful one's past experience with a given written carrier, the greater the likelihood that the person will use that carrier in the future. Despite the literature, which proposed that prior successful use of a written carrier serves as a self-reinforcing factor and limits search, prior experience was a factor in the use of only one carrier, journal articles, and the standardized canonical coefficient was only 0.20 (Table 9). Thus, the hypothesis was rejected.

Hypothesis 3c proposed that the higher one's perceived level of the task attribute of complexity, the more likely the person will be to use a written carrier. Task complexity was found to be a statistically significant factor for two of the five carriers, viz. conference papers and NASA technical reports yielding standardized canonical coefficients of 0.19 and 0.17. Thus, the support for the hypothesis was marginal.

Hypothesis 3d submitted that the higher one's perceived level of task uncertainty, the more likely the person will be to use a written carrier. Task uncertainty was a statistically significant predictor of the use of only two carriers-conference papers and in-house technical reports, yielding standardized canonical coefficients of 0.17 and 0.35, respectively. Again, the support for the hypothesis was marginal.

Hypothesis 3e contends that the higher one's perceived level of the task attribute of complexity, the more likely the person will be to use a written carrier. The data indicate that accessibility was not a factor. In fact, in two cases (in-house and DoD technical reports), the analysis revealed significant (though low) negative relationships (−0.27 and −0.21, respectively). The hypothesis was rejected.

Hypothesis 3f addressed the technical quality of a carrier. The hypothesis predicted that the higher one's perceived level of the task attribute of complexity, the more likely the person will be to use a written carrier. The hypothesis was upheld for only one carrier, DoD technical reports, where the standardized canonical coefficient was 0.33. The hypothesis was rejected.

5. Summary

For all written carriers, perceived importance to one's work is the primary factor in the decision to use the carrier, telling us that although a written carrier may be considered of high quality, the importance of the data is the overriding issue. Technical task uncertainty and complexity played only a secondary role in the use of a written carrier. The accessibility of a carrier as a predictor in selection of a carrier was not upheld, implying that once an individual resorted to written media, the least effort principle no longer held.

6. Discussion

This study investigated the information seeking behavior of US aerospace scientists and engineers. In summary, the findings concerning choice of information carriers were the following.

- In sequential choice, users followed a pattern consistent with the principle of least effort. That is, respondents preferred personal collections and oral communications within the organization; the next choice was to confer with others outside the organization. A lesser used choice was to refer to the literature, and the last choice was to consult with library intermediaries.
- As task uncertainty increased, the search widened from oral contacts to literature searches and, then, to consulting with library personnel.
- Task complexity was not a factor in sequential choice.
- Task complexity and task uncertainty were not major factors in written carrier selection.
- Accessibility and quality were not factors in written carrier use.
- The primary determinant of written carrier use was perceived importance of the carrier to the user's work.

While most of the issues have been previously examined in the literature, this study offers the additional benefit of considering the determinants of information seeking behavior employing multiple antecedents of choice simultaneously in a multivariate analysis. It also points out that despite advances in technology, the principle of least effort still obtains at least in sequential selection.

The initial line of inquiry addressed sequential choice of carriers. The results showed that the first choice overwhelmingly was the search of one's personal store of information. This most likely arises from the fact that personal collections typically reflect areas of specialized expertise (Von Seggern, 1995). The next most used information source was personal contacts or networks within the organization and, then contacts outside the organization. The inclination to favor oral over print carriers may be explained to some extent by Jain and Triandis (1997, p. 30), who noted that, "many new ideas are obtained by talking with people who do similar work. Sometimes talking with one person on Monday and another on Tuesday allows two apparently unrelated fields of research to merge in one's mind and leads to new insight".

Further, this informal give-and-take of communication allows a means to, "absorb new information, connect with experts in their field, and float ideas and hypotheses" (Von Seggern, 1995, p. 97). Price (1970) suggested that oral (non-documentary) communication networks, sometimes referred to as 'invisible colleges', are sustained by personal contacts such as conversations in the workplace, meetings at conferences, and telephone conversations among specialists who have closely related interests. And, Von Seggern concluded that these networks of collaboration and exchange of new ideas appear to be critical to productivity.

An argument may be made that oral communication may be less than optimal. Gales and Mansour-Cole (1995) suggested that there is a cost associated with using rich communication. And, Jain and Triandis (1997, p. 70) proposed that, "oral communication may be dysfunctional if the actors who exchange communication do not share a common language ...”. However, they also pointed out that, “oral communication permits rapid feedback, decoding and synthesis of complex information which fit well in settings where most research ideas are yet unformed and difficult to articulate” (Katz and Tushman, 1979, cited in Jain and Triandis, 1997, p. 31). Nevertheless, despite reservations, the evidence appears to the contrary. Tushman (1982, p. 350) noted that, “[r]esearch has consistently demonstrated a linkage between high-performing individuals and projects and an extensive pattern of verbal communication”.

The findings of this study confirm earlier research that shows that information gatherers, in searching for carriers, prefer those that are easily accessible, and they preferred interpersonal over print carriers. After exhausting personal contacts, the next step involved consulting the literature in the organization’s library and the least preferred option was to consult with a librarian or technical information specialist. Four reasons for not contacting library personnel potentially include: (1) classification systems which may or may not fit the user’s needs; (2) time constraints, i.e. the idea that information carriers are chosen on the basis of return on the investment of limited time (Von Seggern, 1995); (3) rational behavior based on estimates of cost and probability of success (Orr, 1970) and (4) the intermediary role of library personnel. The relegation of librarians and technical library personnel to the lowest priority may be at least partially explained by Folster (1995), who observed that libraries and librarians are perhaps best classified as intermediaries and not viewed as primary or even important sources of information.

The findings of sequential preferences confirmed the observation of Tushman and Scanlan (1981) that recognition and assimilation of new, external information are more chaotic and informal than one might expect. Instead of relying on written carriers such as journal articles, technical reports, and internal memoranda, technical people are more likely to gain knowledge of new ideas through informal oral communication networks.

Thus, at a macro level of analysis, the principle of least effort appears to apply. However, when one looks at how engineers and scientists select among print carriers, a different pattern emerges. Here, the perceived importance of the carrier to one’s task was the primary determinant. This variable was the most consistent and primary reason for choice, more so than accessibility, prior use of a source, source quality, and task characteristics of complexity and uncertainty.

The use of refereed literature was not totally consistent, but agreed with prior analyses. As far as journals were concerned, in addition to the factor of importance, prior use of a source appeared as a significant, but very weak factor in choice (standardized canonical coefficients = 0.95 and 0.20 for importance and prior use, respectively). This confirmed early work by Allen et al. (1980) that only a small percentage of all idea generation comes from scientific literature. The use of conference papers was strongly associated with the variable of importance (standardized canonical coefficient = 0.90) and only a very weak association with task complexity and task uncertainty (standardized canonical coefficients of 0.19 and 0.17, respectively; see Table 9). Part of this may rest in the multi-month and even multi-year (for journals) process of submission peer-review, acceptance, publication, etc. Also, new knowledge in these sources may be too delayed in a competitive environment, the information needs to be original. These reasons possibly explain the tendency of engineers and scientists in applied technology industries to consider journal literature irrelevant (Von Seggern, 1995).

Technical reports have enjoyed little examination in the literature. One piece of research (AAES, 1986) addressed the use of internal technical reports. This survey of 3106 engineers reported that 81% of the respondents used internal technical reports in the past year in their current project or job. While the study at hand asked respondents to consider how they obtained the information for only one project, the findings compared favorably, with 83% of the 872 respondents indicating use of internal technical reports ($z = 1.34$, $P =$ n.s.). No data were available for outside technical reports such as DoD and NASA. For all three types of technical reports, only the importance factor was a consistent determinant.

The results of the analyses of the choice of written carriers were not totally uniform, but provided some insights into written carrier use. First, the importance of the source to the task at hand becomes the overriding issue. Task characteristics were a lesser factor. The analyses of written carrier characteristics indicated, to some extent, that accessibility may be, at this point in information search, no longer an obstacle. Further, the characteristics of task complexity and uncertainty are not consistent factors in written carrier choice. And, the differences in factors other than importance in selection of a written carrier may be partially rooted in differing organizational needs and demands. The findings also suggest that, at the outset, sequential carrier selection may be a satisfying solution. However, once personal contacts are exhausted, written carrier selection appears to follow an optimizing solution.

7. Implications and directions for future research

7.1. Study limitations

The study has several limitations. First, the study was limited by variable measures that came from using a survey that had been designed for other purposes and that had not been replicated in the literature. However, the variables have face validity.

Second, the design was cross-sectional and thus could not accommodate more than one source for judgments such as project importance and task complexity and uncertainty. On the other hand, the design allowed a wide sample of organizations and work settings in a single industry. This allows generalizability within the industry and should eliminate company effects such as organizational culture.

Third, the study did not take into account the impact of the availability of computerized data bases; yet, more recent literature suggested that the use of intermediaries such as data bases or library personnel have yet to make a significant change in information seeking (Leckie et al., 1996).

Finally, this work focused on a specific group in an applied high technology industry. Differences in the selection of written carriers may be a function of the sample studied (i.e. engineers and scientists in the aerospace industry) and may not be generalizable to other groups or industries.

7.2. Implications

There are several practical implications of this study. First, the propensity of engineers and scientists to eschew print carriers points to the need to hire curious, well-educated and knowledgeable employees in the first place and to provide them with a high level of training, so that they remain knowledgeable and can act as sources of information for others.

A second consideration involves organizational members, who act in the role of technological gatekeepers — those who perform the important and crucial function of providing the connection between the organization and the external world of scientific and technological knowledge. As such, gatekeepers should keep themselves informed of related developments outside the organization via journals, professional conferences, and seeking out and fostering personal contacts. Much controversy exists about the extent to which gatekeepers should be identified and rewarded (Jain and Triandis, 1997, p. 27). Some hold that formalizing the role will undermine it.

The issue of reward is also problematic. For example, the question of promotion may be moot as over 15 years ago, Katz and Tushman (1981) found that almost all gatekeeping project leaders had been promoted up the managerial ladder; whereas, for non-gatekeeping project leaders, only one-half of the promotions were up the managerial ladder. Thus, it may be that encouraging and rewarding this key function could be augmented by means other than promotion such as generous allowances for subscriptions, telephone use, and database access as well as travel allowances for seminars and professional meetings (Johns, 1996, p. 588).

A third issue is the structure of the organization. Jain and Triandis (1997, p. 28) made the argument that effective gatekeeping will be enhanced within organic structures and that even the best gatekeepers will fail in bureaucratic organizations. They also caution managers that organic organizational forms are no panacea having potential problems of the neglect of routine functions and wasted time in meetings. Thus, any moves toward organic organizational forms should be done with caution, so that routine functions and other organization needs are not neglected.

Fourth, the finding that scientists and engineers prefer to gain information from colleagues, particularly those within their organization, suggests that firms need to develop formal and informal communication networks and techniques for employees to give and share information. This may not assure that these are the best sources of information, but the probability of this occurring may be enhanced. Relying solely on chance meetings among employees or personal ties may not be sufficient. Jain and Triandis (1990) addressed the commonly heard stories of how a scientist thought of an idea while having tea or coffee with a colleague. The authors observed:

> Americans joke about the sanctity of the British tea breaks. Maybe there is something to their tradition. Sir William Hawthorne of Cambridge University once remarked that institutionalizing (or encouraging) tea breaks or similar social interaction in an R&D organization is quite beneficial; such activities are not common in the US, but they should be fostered (p. 32).

While tea breaks or even scheduled coffee breaks are not necessarily transferable to US settings, management might consider other settings that would facilitate interactions such as office architecture and non-territorial office communications (Allen, 1977). Some organizations have encouraged the creation of bulletin boards, discussion groups, and open forums organized around subjects.

7.3. Directions for future research

One issue for future research is the question of what determines a scientist's or engineer's perception of the importance of a written carrier. In the present work, importance was not found to be equivalent to quality, nor related to ease of use or prior experience with the carrier. The study of Swanson (1987) found a 'value' dimension that consisted of value, usefulness, relevance, importance, and meaningfulness; whereas, in this study, importance was an independent factor and relevance loaded on another factor. Further, in this study, the respondents' judgments of the importance of a source were independent of perceptions of ease of use, technical quality, and prior experience with a medium.

Given this, it appears that the dimension of importance found in this study may refer to the perception of a written carrier's ability to help to, 'solve the problem' or its salience to an individual, which can be defined as "the perceived applicability of information to a problem that he or she faces" (Evans and Clarke, 1983, p. 239). Wilson (1977) (cited in Johnson et al., 1995a, p. 279) pointed out that "[s]alience provides the underlying motivating force to seek information; in work organizations, job requirements may substantially shape information seeking". Yet, this study found that importance was not a function of prior familiarity with a written carrier, thus failing to uphold the argument that prior experience leads to reinforcing behavior. Therefore, it is not unreasonable to assume that a high quality publication, one that is readily accessible, or one that had been used successfully before might not be important to addressing the task at hand.

Further research could also examine two other factors not addressed in this study. First, electronic media such as e-mail, video conferencing, computerized databases, and Internet access is changing the way individuals gather information and warrant consideration in future studies. Second, future research could examine the extent to which carrier selection is affected by organizational culture, because certain organizations may have preferred methods for uncertainty reduction. This includes issues such as pressure to use a carrier arising from management's experience or preferences, organizational policy, or because carriers were historically used in an organization.

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