Planning and Information Foraging Theories and Their Value to the Novice Technical Communicator

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Abstract

Two complementary cognitive theories help to explain how novice technical communicators learn effective search methods: information foraging theory, a model of information-seeking behavior that combines human-computer interaction with anthropological constructs; and strategic planning theory, a communication model of how humans plan and achieve social goals. The paper includes an extended example of how a new communicator might learn to use both models on the job.

I.7.2 Document Preparation—*information foraging*
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Introduction

Seasoned technical communicators are experts at getting what they need. Their expertise stems partly from professional education and partly from practical experience. Over the years they have learned to identify precisely what data they need, where to look for them, and how to work productively with colleagues to obtain them. By contrast, many novice communicators approach projects unsystematically. Lacking efficient search methods and a knowledge base of their own, they often depend on their organizations' engineers, product developers, and other experts to supply them with technical content ready-made. Only with experience do they learn to locate data and develop documents effectively.

Two complementary cognitive theories help to account for the process by which the novice communicator learns to search productively. This paper first discusses information foraging theory, a relatively new model of information-seeking behavior that combines elements of human-computer interaction with anthropological concepts of foraging for food. The model helps to explain how communicators identify search goals and allocate expenditures of time and energy for maximum gain. The paper then examines strategic planning theory, a communication model that describes how humans achieve social goals—in this context, interacting successfully with co-workers to obtain needed data. Following the two theoretical descriptions, the paper provides an extended example of how a novice technical communicator might modify her behavior in accordance with both models to identify data needs and collaborate with subject-matter experts to acquire those data. The paper concludes with a brief discussion of the value of comple-

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mentary cognitive theories.

Information foraging theory

The theorists credited with developing information foraging theory are Pirolli and Card of the Xerox Palo Alto Research Group, whose models build on foraging constructs within human behavioral ecology that anthropologists have studied since the mid-1970s (1995, 1999; Card et al., 2001). Food foraging models integrate several features: a range of resource options, a goal for acquiring the most resources for the least expenditure of energy; a method of evaluating costs and benefits; and a set of social and environmental constraints (Winterhalder and Smith, 2000). These concepts are also useful in describing the process by which a human decides which information problems to analyze, what criteria to use in evaluating decisions, and how to assess environmental or contextual limitations. Whereas food foraging models measure the gains realized from a search in terms of energy, data foraging models measure gains in terms of value (Pirolli and Card, 1995).

Research findings in library and other information services indicate that the foraging model has already become a useful heuristic for investigating scholarly research and communication behaviors. Sandstrom suggests that "[s]cholars and subsistence foragers face similar constraints and conform to the same set of principles in how they make decisions to allocate scarce resources, such as time and energy, among alternative ends in the game of survival" (1994, p. 415). Although conceding that researchers cannot yet quantify the outcomes of scholarly activity in terms as precise as a food forager's caloric intake, Sandstrom believes that the foraging model is more than a metaphor for information-seeking behavior. She finds that, within their own environments, scholars and subsistence hunters and gatherers face the same decisions about where, how, how long, and with whom to search for resources, and with parallel consequences (2001, p. 598).

Constructs from human behavioral ecology

Information foraging theorists have adopted several anthropological constructs to conceptualize data-seeking activities. In human behavioral ecology, *diet* refers to resource choices made for maximum benefit from among several alternatives. Where more than one food source is available, predators must determine the "profitability" of prey by weighing the effort of hunting various species against differences in their size, speed, abundance, and levels of stored energy (Pirolli and Card, 1999, p. 646). In choosing one diet over another, the predator must also consider the opportunities lost as a result of that choice. The decision to pursue a single large prey, for example, may mean that the predator gives up the option of hunting several smaller ones. For communicators and other information seekers, diet refers to the specific types of data they select from the universe of all possible data sources. In most cases data vary in quality and availability, but the information foragers have only limited metadata in advance of their searches. Inevitably, the choice to invest time and energy in one document or data collection will leave fewer resources available for gathering data from other sources, resulting in missed opportunities. Foragers must therefore weigh the estimated costs of procurement against the potential value of particular sources.

Another information foraging concept adopted from human behavioral ecology is that of patches, or discrete clusters of resources situated about the landscape (Pirolli and Card, 1999, pp. 645-646). When a food forager first enters a patch, the resources may be plentiful and easily accessible. The forager's initial energy costs will be fairly low in proportion to the benefits gained. With continued foraging, however, the quantity and quality of resources in the patch may diminish. As this occurs, the forager must decide whether the benefits of remaining in the patch outweigh the risks and costs of seeking a new patch elsewhere, and whether the time is right to move on. Similarly, data-seeking communicators are likely to encounter material in patches or concentrations such as library collections, special journal issues, subject-matter experts, and online query results. At first, the patches' resources may seem to satisfy the foragers' data needs. As the foragers examine the material more closely, however, they may conclude that some sources are less than optimal. The foragers must then decide whether to invest additional time in the sources they have, abandon one patch to seek others, or allocate their efforts among several patches.

If predators go in search of new resource patches, they are likely to exploit scent, which is a way of characterizing the partial perceptions of environmental cues that may affect pathway choice (Card et al. 2001). Scent provides the forager with at least some basis, however incomplete, for assessing the nature

and location of a particular prey. Depending on the relative strength of the scent, the predator can decide whether to expend time and energy in pursuit of that prey or to make better use of resources elsewhere.

If the scent is sufficiently strong, the forager will be able to make the correct choice at each decision point. If there is no scent, the forager will perform a random walk, either literally in physical space or metaphorically in abstract search space. These two extreme search regimes have different characteristic cost functions (Pirolli and Card, 1999, pp. 646-647).

In information searching, the forager may catch the scent of useful data by means of bibliographic references, in-text citations, online links, and personal referrals.

The literature of behavioral ecology also distinguishes between predators who pursue prey aggressively ("widely foraging predators") and those who build webs or lay other traps ("sit-and-wait foragers") (Pirolli and Card, 1999, p. 670). Among information seekers, scent may be more critical to communicators who must actively pursue data leads to meet workplace deadlines, for example, than to those who can afford to accumulate material more passively.

Adaptability of foragers

Information foraging theory assumes that people modify their information-seeking behavior in accordance with the yields they realize and, if possible, will also modify the information environment for greater productivity. In personal work spaces, for example, people often keep frequently consulted materials close at hand, while storing other, less important information at some distance (Pirolli and Card, 1999, p. 644). This principle of behavioral adaptation within environmental contexts provides an important link between foraging theory and the second cognitive model to be discussed in this paper, strategic planning theory, because the adaptability principle suggests that social interaction can affect an individual's information-seeking behavior. If foragers make decisions based on perceived tradeoffs between resources and opportunities but can improve those decisions by interacting with other humans, then the result may be more profitable. Put another way, information foraging theory and strategic planning theory provide complementary explanations of human search behavior. In order to carry out social goals, the communicator often gathers data, but the data-gathering process itself adapts to social interaction. The following section reviews briefly some of the important features of strategic planning theory, the complement of information foraging.

Strategic planning theory

Current planning theory relies heavily on the work of communication scholar Charles Berger, who has examined planning as one of several strategies within uncertainty reduction theory, a broader cognitive model that seeks to explain how individuals lower their levels of uncertainty in social interaction. Berger sees planning as a goal-directed activity in that it focuses on the strategies individuals use to minimize the negative consequences of their messages and thereby achieve social goals. A communicator whose social goal is to maintain credibility within an organization, for example, would devise a strategy for learning each staff engineer's areas of expertise to avoid the embarrassment of misdirecting technical questions. Insofar as the social goals in planning theory "involve the induction of some desired state in other people" (Berger, 1997b, p. 19), planning theory shares some elements with compliance-gaining theory.

The planning process

Berger defines plans as "hierarchical cognitive representations of goal-directed action sequences" (1997b, p. 25). Individuals may rely on plans they have constructed previously and stored in long-term memory, making few changes if the fit between plan and current situation is good. As Berger points out, however, individuals tend to overgeneralize about circumstances and may therefore miss subtle but important differences among situations (1997b, p. 27). If the goals have high priority, individuals may formulate plans from current information, a strategy that requires greater effort than using stored plans. They may also formulate plans online, as a situation unfolds.

Cognitive theorists differ on exactly how planning occurs. Berger posits a "top-down" planning process, which "begins with an abstract plan from which progressively more detailed actions are deduced" (Berger, 1995, pp. 145-146) until the plan's lower level contains a set of extremely specific tasks.

Other researchers suggest that planning is multidirectional and involves both top-down and bottom-up planning, an approach sometimes referred to as opportunistic (Hayes-Roth and Hayes-Roth, 1979). That is, individuals sometimes begin with high-level, abstract plans, and at other times they formulate relatively low-level plans in response to environmental cues and other opportunities, which they then use to shape planning at higher levels. A communicator engaged in top-down planning might begin a project by scheduling interviews with subject-matter experts, for example, whereas a more opportunistic planner might turn first to other data sources, setting up interviews only as needed.

Berger believes, however, that no human is capable of devising a completely new plan for every interaction and that all plans involve at least some abstraction, even if the plans accommodate opportunistic adjustments along the way (Berger, 1995, p. 146). Empirical research into the relationship between goal-directed actions and memory (Lichtenstein and Brewer, 1980) supports Berger's claim that individuals organize plans hierarchically, "with abstract action representations at the top of the hierarchy and progressively more concrete representations toward the bottom" (Berger, 1997a, p. 39). According to the hierarchy hypothesis, when external events or internal interactions block progress toward a goal, individuals tend to conserve cognitive energy by first attempting to repair their plans at the lower, concrete levels instead of the abstract levels at the top. If that initial strategy fails, only then will individuals invest energy in changing their plans in more abstract ways, particularly if their desire to achieve a certain goal is high. For example, a communicator who tries unsuccessfully to obtain important data from a subject-matter expert by sending repeated e-mail messages—a low-level response to goal frustration—may finally adjust the plan at a higher level of abstraction and make an appointment to gather data from the expert in person. Although individuals may abandon goals altogether if thwarted too often, goal blockage can provide important insights into their planning ability, for the process of formulating alternative plans may actually stimulate learning (Berger, 1997b, p. 35).

Planning and metagoals

While planning theory itself does not address goal selection, the theory assumes that individuals do choose goals, possibly in a cognitive process related to foraging. Moreover, humans seem to organize their planning processes around metagoals, of which Berger identifies two: efficiency and social appropriateness (1997b). Although individuals usually want to develop the most effective plans possible for the least expenditure of energy, most people are likely to subordinate their efficiency goals to the constraints of social acceptability. A communicator under a deadline, for example, may decide that the efficiency metagoal of gathering data quickly is less important than the social appropriateness metagoal of interacting courteously with subject-matter experts in order to keep the lines of communication open. Conversely, social appropriateness may become less important than efficiency if the clock is ticking and the communicator is encountering significant resistance from others.

Under the broad metagoals of efficiency and social appropriateness are hierarchical, nested arrangements of subgoals. People may pursue several goals simultaneously, set one primary goal and several secondary goals, or change goals altogether. "The specific actions necessary to realize these subgoals. . .constitute plans, that is, the means for achieving goals" (1997b, p. 21). An individual's skill and experience in identifying and executing the specific tasks necessary for achieving subgoals will largely determine a plan's success.

Plan complexity

The complexity of a plan may refer to the number of steps it contains, or the number of contingencies for which it provides. According to Berger, plans may become increasingly complex as pressures mount on one or both of the metagoals, as the planner's desire to achieve a social goal becomes stronger, or as the planner's knowledge of issues and strategies increases (1997b). Although the existence of multiple contingency plans in case of plan failure may appear to be an advantage, the opposite can sometimes be true. When individuals develop plans so complex that they can no longer articulate those plans effectively, their overall credibility or fluency may suffer, regardless of the plan's actual effectiveness. By contrast, individuals whose plans contain fewer alternatives but who can communicate those plans persuasively may expend less cognitive effort and thus appear more fluent (1997b, pp. 40-41). A communicator trying to elicit data from subject-mat-

ter experts by means of a form, for example, will probably have more success with a few well-chosen questions than with a lengthy, detailed list of requests.

Foraging and planning theories in action: an illustration

Information foraging theory and planning theory provide complementary explanations of human search behavior. The foraging model accounts for how individuals choose data sources, while the planning model focuses on the strategies they use to obtain the data from those sources, once identified. While executing a plan, individuals may discover new data sources; at that point, the foraging model helps individuals optimize their choices, which may in turn call for a new plan in response to changed circumstances.

In the extended example that follows, a communicator in her first professional position learns to adapt her behavior in accordance with both models in order to produce a technical manual. Her overall goals are to produce a document of high quality that represents the organization well and to establish her own professional credibility. When she receives the assignment and a deadline, the communicator asks herself several basic questions: What data should I include in this manual, and where do I find them? What should the document look like? How do I actually produce the document? These questions, which ultimately evolve into the project's subgoals, provide the communicator with a structure for organizing her data search. Although in practice these subgoals overlap, the following discussion focuses on each area separately.

Foraging and planning in content development

Upon receiving the assignment, the communicator, a recent college graduate, turns to the foraging model that usually sufficed in her undergraduate work. If she could locate previous versions of the manual, she thinks, she would know what data such documents contained in the past. Because her office is full of her predecessor's papers, publications, and files, the information scent there is strong. As she sorts the materials in the office, she begins to formulate a basic notion of diet, or the specific types of data she needs to gather for the manual. She rejects files that contain irrelevant diet samples but sets aside more promising files as possible data patches worthy of further investigation. She also finds the old manuals that prompted her search. At the end of her initial foraging efforts, she believes that she has most of the data she needs. Her gains have been high in exchange for relatively low expenditures of time and energy.

As she analyzes the materials in her diet sample more closely, however, she realizes that her first impressions were wrong. Many of the data she has gathered in this patch are incomplete. Although she finds progress reports on product development, the files contain little on final versions, new features, and known errors. Still operating on the information foraging model, the communicator works alone to identify the missing data. She knows only a handful of other employees, but she considers whether they might know of other files or data patches, and whether the value of the data would be worth the energy she would have to expend to locate them. Given the constraints of the deadline, she also wonders how particular she can afford to be about diet quality. How should she quantify the tradeoff between data of marginal quality and a document published on time, or a document that is late but complete? Worried about failure and conceding that she needs help, she finally asks for advice from the department's longtime administrative assistant, who suggests that she consult specific researchers for additional data. In response to the environmental cue of low diet yields, the communicator decides to adapt her behavior for greater productivity, and she begins to consider strategic social interaction as a complement to solitary foraging.

The communicator now begins to behave in accordance with planning theory. To address her first subgoal of content development, she formulates a high-level, abstract plan for determining which data are most important for the manual and how best to obtain those data from other people. Within the hierarchy of that plan, she identifies the concrete actions she must take to contact the appropriate subject-matter experts. She realizes that their time, like her own, is a valuable resource for which she must compete and that beyond a certain point, the advantage afforded by an interview with a particular subject-matter expert may not be worth the resource expenditure involved in waiting for an appointment. Armed

with additional advice from the administrative assistant on how best to reach specific people, the communicator sets her priorities and arranges interviews with the specialists.

The communicator's first interview is less than successful, because she arrives unprepared, with inadequate background information. To avoid sending additional negative messages and to get what she needs in the next interview, she allocates time for solitary research so that she can ask better questions, an example of using information foraging to complement hierarchical planning. That is, instead of repeating a concrete action with only marginal results, she uses new data to modify her plan at a higher level. The communicator is much more effective in her interview with the second researcher, who offers her an unexpected lead. On the basis of this strong information scent, the communicator adjusts her schedule to include an additional person—an expert (analogous to a new data patch) with valuable samples of a high-energy diet. This strategy proves quite successful, and throughout content development, the communicator learns to blend strategic planning and information foraging theories in complementary ways.

Foraging and planning in document design.

The communicator next focuses on the design of the manual she is developing. The older manuals she located in the office, tersely written with poor production values, conform poorly to the design principles she studied in school. She wonders what approach is appropriate for her manual's audience, but she is uncertain about who the audience is. In the organization's library she forages in the data patch of technical manuals from other organizations, analyzing them to determine why some communicate more effectively than others.

The communicator now has a better idea of what the completed manual should look like, but she still is unsure about how to integrate all elements in a unified design. She considers foraging in professional listserv archives and other internet data patches but concludes that the gain would probably be low in proportion to the time invested. She seems to have exhausted all readily available data sources. Should she turn to strategic social interaction and seek advice from someone with more experience?

Consulting the office's organizational chart, she catches a faint information scent upon noticing a person in another division with a job title similar to hers. Following this lead, she discovers that her counterpart is indeed a subject-matter expert who offers a rich diet of production and design suggestions. Energized by the yields of the social interaction, our communicator is now able to develop a plan for meeting her second subgoal. The plan incorporates content she is already developing with ideas for visual design elements. From this abstract, high-level plan she develops a list of tasks, including drafting a layout for the report. She also works out a contingency plan for graphics in case she cannot obtain them from her department's subject-matter experts. After reviewing the plan with her new design mentor, she is able to prepare a satisfactory final layout for the manual.

Foraging and planning in tool mastery

With content development underway and the layout complete, the communicator's final subgoal concerns getting the project into production. She locates work orders for previous printing jobs in the files but wonders how last year's costs relate to this year's budget. Some of the terms on the work orders are unfamiliar to her. Should she follow them as written? In addition, she is uncertain which software applications for document design the print shop will accept. The application on her office computer is new to her. Although the instruction manual offers the specific data diet she needs in this situation, the time and energy expenditures for learning the application seem unacceptably high. Still, she sees no alternatives. How can she find out what to do?

If the communicator behaved solely in accordance with information foraging theory, she would probably concentrate on the data in the instruction manual. Instead, learning from experience, she decides to make strategic interaction with the print shop her first priority, given that constraints in that area are likely to be critical. On the previous work orders she finds a contact name; following the scent of that lead, she meets a helpful subject-matter expert in the print shop who educates her about printing requirements, standards, and options. The print shop contact also alerts her to two other data patches: a training video on the design software, available for checkout; and an upcoming two-hour class for clients, also offered through the shop. The communicator calculates that she probably has time to pursue only one training option. She must decide how to get the maximum return on any investment of resources

in another data patch. On the basis of her interaction with the shop contact, she modifies her original goal of learning the software on her own and formulates a high-level plan with concrete actions for meeting her third subgoal. She decides to take the class and supplement that data source by foraging in the manual and consulting the print shop as additional production questions arise.

By learning to behave in accordance with two cognitive models—the information foraging model, with its solitary research patterns and use of information scent to determine pathway choice, and the planning model, in which social interaction guides strategy development—our novice technical communicator is finally able to achieve her three subgoals. She learns how to develop appropriate content, design a document that meets audience expectations, and achieve competence in production tools. In the process, she also reaches her overall goals for the project: to produce a document that presents the organization positively, and to establish her credentials as a technical communicator. In addition, by having to integrate input from others with her own research, she learns something about balancing the competing claims of the social appropriateness and efficiency metagoals. Her experience illustrates how the two cognitive theories complement one another and may explain better than either theory alone how individuals learn to draw conclusions from social and contextual cues and discern promising informational leads.

Conclusion

Information foraging theory has developed fairly recently, driven largely by the expanding Internet, which has increased exponentially not only the volume of available data but also the difficulties of locating and navigating to data sources efficiently. Because of its newness, theorists are only beginning to evaluate information foraging theory critically. In the view of at least one behavioral psychologist, the foraging model offers several benefits over positivist information theory, all related to the model's being situated contextually or environmentally (Mantovani, 2001). Although the model implies, however, that knowledge is not an objective collection of facts but "a set of complex activities such as seeking relevant information, gathering it in appropriate ways, and making sense of it," it still stops short of a true social constructivist perspective, in Mantovani's view (p. 49). That is, by failing to incorporate cooperation and communication into its explanation of behavior, the model's theoretical information seeker discovers, rather than constructs, reality, unlike the true subsistence forager, who must employ a host of creative coping strategies in an unpredictable environment. The advantage of a model that incorporates both foraging theory and planning theory, however, is that cooperation among humans becomes an integral part of the explanation. Such a model accounts for both facets of cognitive processing—the activities associated with solitary information gathering and those that depend on social interaction as well. It describes a way of working that is well known to experienced technical communicators, and one that new hires who hope to succeed must learn.

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