Metaphor's Role in the Information Behavior of Humans Interacting with Computers

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Metaphors convey information, communicate abstractions, and help us understand new concepts. While the nascent field of information behavior (IB) has adopted common metaphors like "berry-picking" and "gap-bridging" for its models, the study of how people use metaphors is only now emerging in the subfield of human information organizing behavior (HIOB). Metaphors have been adopted in human–computer interaction (HCI) to facilitate the dialogue between user and system. Exploration of the literature on metaphors in the fields of linguistics and cognitive science as well as an examination of the history of use of metaphors in HCI as a case study of metaphor usage offers insight into the role of metaphor in human information behavior.

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Our world is growing increasingly digital; our entire lives—our interactions, our entertainment, even our personal memories—are mediated by technology. Humans have had thousands of years to learn to communicate with each other, largely employing metaphors and analogies to negotiate meaning. Our experience communicating with computers is both nascent yet broadening every day with increasing dependency. We must fully understand the role that metaphors play in the exchange of information to facilitate the communication between humans and computers.

Metaphors: a definition

Originally regarded as rhetorical devices, Plato abhorred the use of metaphors, arguing that they could convince a man to do the illogical. Schön explains that at that time metaphors were considered a "kind of anomaly of language, one which must be dispelled in order to clear the path for a general theory of reference or meaning."[1] Aristotle, on the other hand, saw that they provided insight into the items of comparison. "Ordinary words convey only what we know already; it is from metaphor that we can best get hold of something new."[2]

Traditionally the objects in the equation have been called the tenor and the vehicle, but more recently they are referred to as the target and source domains. In the metaphor, "Alex is a space cadet," Alex is the tenor or target domain (the abstract or undefined), and space cadet represents the vehicle or source domain (the known). If "the essence of metaphor is understanding and experiencing one thing in terms of another," then the vehicle or the source domain is responsible for elucidating the tenor or target domain.[3] One measures the relationship between these domains, the tenor and the vehicle, with "ground" and "tension." Ground concerns the similarities between the domains and tension represents the dissimilarities.[4]

Metaphors have been studied from multiple perspectives: from the creative use of metaphors in literature to the comprehension or appreciation of metaphors.[5] The research from other disciplines can offer insight into the effect of metaphors on human information behavior. I will first discuss the use of metaphors in language and then review some of the theories on how they work.

Metaphorically speaking: the role of metaphors in language

The work of Lakoff and Johnson has been fundamental to understanding the pervasive use of metaphors in our language. They propose that metaphors are an underlying structure forming and shaping the way we discuss and even think about the world. They argue that the "human conceptual system is metaphorically structured and defined."[6] Mapping from a source domain to a target domain is central to the semantics of language and communication. "Domains need structure so that one can reason about them. The major function of metaphor is thus to supply structure in terms of which reasoning can be done."[7]

In *Metaphors We Live By*, Lakoff and Johnson catalogue examples of underlying conceptual metaphors. They identify orientation metaphors that underlie how we speak about abstract concepts such as health, happiness, and success. Each of these states is associated with the direction up. One can be "up and at 'em" or in "high spirits" or of "high standing." Counter examples include "being under the weather," "feeling down," and "low comedy." Metaphors shape the way we think about the concepts we are describing. For instance, the metaphor "argument is war" ("defending your point of view," "attacking your opponent's stance," and "he shot me down") may define expectations for "winning" and "losing" and detrimentally shape our ability to negotiate and compromise.[8]

Lakoff and Johnson refer also to Michael Reddy's 1979 piece, "The Conduit Metaphor."[9] Reddy hypothesizes that linguistically and conceptually we see ideas or meanings as objects, linguistic expressions as containers, and communication as sending. The "receivers" of

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the communication are the information users or seekers. The designers "package their ideas," "put them down on paper," and "convey" them to the user who "gets" them or not. Reddy argues that this underlying metaphor influences the way we think about the communication process, making information and meaning an object rather than a process, which trivializes the function of the reader or listener.[10]

Metaphors are undeniably central to our ability to communicate and use language, and perhaps more fundamentally, to convey meaning or to infer meaning—to illustrate and explain as well as to identify and to catalog. The role of metaphors in human cognition is still a matter of great debate.

Thinking about metaphors: the cognitive role of metaphors

Information science is at its heart the study of information. If metaphors exist as a necessary component of language—a tool to convey meaning and to transfer information—then metaphors are by necessity a component of information science. Understanding how metaphors work provides insight into information itself.

Early propositions about how metaphors were understood stemmed from poetic and rhetorical research. That is, if a sentence cannot be interpreted literally, then it must be interpreted figuratively. To illustrate, the assertion "my child is a pig" is initially illogical, so the receiver would then move on to figurative interpretation. Once that determination is made, the mind sets about finding meaning from the expression. This theory argues that once the statement is deemed false, the statement is treated like a simile, or a comparison statement, by identifying traits or attributes in the source domain (the pig: sloppy, slovenly, fascinated with mud) that would be applicable to the target domain.[11]

One group of theorists questions this premise, pointing to sentences that can be interpreted literally and figuratively. One useful example is the statement "my dog is an animal."[12] While this expression is true literally, most would reject the literal interpretation in favor of one that depicts the dog as a ferocious or uncontrollable beast. Glucksberg and Keysar, among others, seek a model that focuses on the associations between the domains. They hypothesize that metaphors are not "implicit comparisons" but are class-inclusion statements or "assertions of categorization."[13] Research in cognitive processing of analogies has shifted from plain association of A is to B where A traits are matched to B traits to a hypothesis that maps from A to B and leads insight into a super-ordinate category that includes both A and B.

Gentner's work studying science metaphors in the 1980s is partially founded on this theory. She notes that through "analogical reasoning, learning can result in the generation of new categories and schemas."[14] She is particularly interested in creating ways for computers to interpret figurative expressions. She proposes a structure-mapping theory: a system of relations (not just traits) from the source domain to the target domain with a parallelism between the structures that allows for a one-to-one mapping of the domains and relationships. Weiner explores a similar tactic with human–computer interaction language processing by prototyping the shared framework. The prototype theory allows for a range of possible predicates and would accommodate greater tension (the differences in a metaphor) in the same way that we can categorize penguins and chickens under the prototype of bird.[15]

These theories of categorization remain popular today, but still struggle to account for certain things about the way metaphors are comprehended. Specifically, take the Shakespearean line, "Juliet is the sun." Categorization theory does not explain why some attributes like "glowing" and "center of the solar system" are transferred from the source while others such as "nuclear" and "huge" are not.[16] This theory also stumbles with novel poetic metaphors like e e cummings' "the voice of your eyes is deeper than all roses."[17] Alternative theorists argue that while the categorization-based theories accommodate the ground (commonality) in a metaphor, they fail to fully explain the effect and purpose of the tension (differences) in the equation.

Lakoff fervently contends that simplifying conceptual models to mere categorization ignores the unique nature of each specific mapping:

> Each mapping defines an open-ended class of potential correspondences across inference patterns. When activated, a mapping may apply to a novel source domain knowledge structure and characterize a corresponding target domain knowledge structure.[18]

In other words, each pairing creates new meaning or conceptual frameworks from which other metaphors and meanings can be instantiated. A is to B creates meaning C, rather than A and B are part of C. Looking at it from the perspective of Lanier, a vocabulary is created upon which we can define even more vocabulary.[19] Lakoff maintains that the theory of conceptual domains speaks to both the uni-directional nature of metaphors as well as the "systematicity" that allows the interpreter to selectively identify the aspects that are consistent and discard the aspects that are inconsistent with the metaphor.[20]

More recent work approaches the question from a connectivist point of view, seeking ways to identify an overarching model consistent with and encompassing of other theories. This premise rests on the foundation of metaphor as communication and examines the use of metaphors in conversational contexts. The necessary mutual cognitive environment of the communicators, the

working memory, and the common ground that they find are all of importance, but so are context and motivation as influencing factors. The context in which the statement is made, the place in which it is interpreted, and the motivation of the user to understand the statement combine to affect the meaning that is derived. For instance, the phrase, "I want you to sheepdog this project" could mean something different in the context of a chaotic group of workers than in the context of a core team threatened by competing entities.[21] Likewise, the relationship of the receiver to the sender could modify the motivation of the receiver to seek meaning beyond the first or easiest interpretation.

Classifying metaphors: metaphors in information science

These notions of context and user-motivation are not new to the field of information science. At the turn of the century the subfield of information behavior had begun to direct its attention to cognitive psychology, the nature of man–machine dialogue, and to a certain extent the role of metaphor in deciphering and creating meaning.

Spink investigates human information behavior (HIB) from an evolutionary perspective.[22] After exploring a wide variety of research in fields, Spink and Currier performed a qualitative analysis of the information behavior of historical figures. They postulated that modular cognitive architecture makes Homo sapiens rare in their ability to think of one thing in terms of another.[23] The resulting mapping allows for the creation of new cognitive structures in a similar fashion to Lanier's vocabulary development conjecture. Spink and Currier's work launched a new theory of information use, which has led to recent research into metaphor use. In an attempt to model an integrative approach to human information behavior incorporating the everyday life information-seeking and sense-making approach, the information-foraging approach, and the problem-solution view of information seeking, Spink and Cole recognized a gap in the research covering actual information use and proffered a fourth information approach to account for it. Their information-use theory "starts from an evolutionary psychology notion that humans are able to adapt to their environment and survive because of our modular cognitive architecture."[24] Development of this theory has birthed a sub-area within the field of human information behavior dubbed human information organizing behavior (HIOB) of which the use of metaphors or metaphor instantiation is a necessary component.

Cole and Leide explore the notion of modular cognitive architecture in an attempt to model a cognitive framework for metaphor use in HIOB. Similar to the categorization theory of metaphor use, they claim that "metaphor instantiation is similar to a form of superordinate category instantiation . . . along with the metaphor comes the structure of the metaphor."[25] Following in Belkin's footsteps, they address the problem of a "domain novice attempting to formulate his information need into an effective query to an information retrieval system."[26] They conducted three case studies with the purpose of developing a methodology that researchers can use to "ascertain the efficacy of metaphor instantiation as an information need structuring device."[27] They conclude that metaphor instantiation might help us create systems that more closely resemble the way that humans behave with information: interaction, organization, and retrieval.

Metaphors in human–computer interaction: a case study

Reality bytes

While theorists of various fields explored the nature of metaphors, the field of human–computer interaction (HCI) found itself thrust into the thick of it. Rarely does one intentionally adopt new ideas so whole-heartedly without first considering the ramifications, but the history of HCI shows that that is exactly what happened. It began with enthusiastic adoption to improve communication, then reeled in recognition of the drawbacks of metaphor mismatches, and finally has lurched to a standstill while new approaches to metaphor use are explored.

The first instances of metaphor and analogy in the field of computer science and HCI preceded images of windows, desktops, mice, scrollbars, and icons. The initial focus was on natural language processing to improve the communication between the user and the system.[28] Although the field of information science was on the periphery of metaphor research at the time, it certainly was interested in improving the dialogue between users and systems. Belkin proposed a model of information seeking that highlighted the user's anomalous state of knowledge. He argued for a better understanding of user's conceptual models in order to improve system communications.[29] Although he did not propose metaphors specifically, the advent of the graphical user interface (GUI) placed metaphors in a position to tackle Belkin's concerns.

HCI Gets GUI

Perhaps because of the difficulty of man–machine dialogue, GUIs emerged. By simplifying the "language" to "point and click," even an average user could make the system do what it was supposed to do.[30] With its more intuitive and memorable interface, the GUI was the

result of years of frustration trying to remember system functions and commands. Because illustrations of the abstract are necessarily grounded in something concrete, GUIs and metaphors were inexorably intertwined; in a sense, metaphors were "inescapable."[31] Metaphors enacted through the user interface would become the primary mechanism of communication between the user and the system.

GUI metaphors can be categorized several ways. A typical breakdown is to break out noun and verb metaphors into "organization metaphors" and "operations metaphors."[32] Alternatively, Fineman further divides the nouns and classifies various metaphors into three basic types: functionality metaphors, interface metaphors, and interaction metaphors.[33] Fineman describes an e-mail program. Functionality metaphors outline the expectations that a user should have for an application and generally guide the overall behavior of the tool. In the e-mail program the functionality metaphor would be "e-mail is postal mail." Interface metaphors are the mechanical metaphors that allow the user to accomplish the tasks within the functionality metaphor. The interface metaphors should be guided by the functionality metaphors, but not constrained by them. Examples would include the address book and printer metaphors. Interaction metaphors, or the verbs, are the underlying metaphors that define the form of the action, how things are performed; these metaphors span beyond a particular tool, but greatly affect the functionality metaphor.[34]

The effect of the selected metaphors cannot be underestimated. For instance, many feel that the direct manipulation metaphor (data is an object that can be manipulated) and GUI are synonymous.[35] And within the graphical user interface, the choice of desktop has affected all aspects of the interface with the user. One need only reflect upon the famous Englebart demonstration of the "mouse" most often viewed in Alan Kay's video presentation.[36] Englebart's mouse preceded the notion of a desktop and more closely resembled a pilot's controls than an office worker sitting at a typewriter keyboard. Imagine how different our computers would be today had the pilot metaphor ever got off the ground.[37]

The ground we walk on

Having adopted metaphors, the field of HCI wanted a better understanding of why and how they worked. Carroll and Thomas stressed the importance of psychology research and rallied for the use of metaphor for its grounding purposes, that is, bridging abstract concepts to concrete attributes. In a manner similar to Belkin, they brought forth the notion that the designer of the system creates a conceptual model of how it works. The metaphors used within the user interface serve as bridges to the user's mental model of the system. "People employ metaphors in learning about computing systems, the designers of those systems should anticipate and support likely metaphorical constructions to increase the ease of learning and using the system."[38] They encouraged designers to consider the limitations and consequences of metaphors; ideally, the metaphor should convey its limitations to the user. Their eagerness to adopt metaphors, which they considered "crucial" for motivating and facilitating understanding, was countered only by their warning that "for most computer systems there will come a point at which the metaphor or metaphors that initially helped the user understand the system will begin to hinder further learning."[39]

Case recognized the importance of assessing users' needs and expectations when designing metaphors for systems. His study of historians found that metaphors and analogies are commonly used in the information behavior of historians. He endorsed their use in interface development despite potential pitfalls. Concerned mostly with transitioning historians from physical to electronic format, Case argued that digital documents and files should more closely resemble physical files—not necessarily physically but in the manner of retrieval and storage.[40]

Espousing a slightly more conservative opinion, Marcus indicated that an "appropriate metaphor balances delicately expectation and surprise on part of the user/viewer."[41] Marcus repeated that the objective of the designer is to design a conceptual model that clearly indicates to users what their expectations of the system should be, the goal being that the conceptual model created by the designers will map as much as possible to an existing mental model that the user can bring to reference.[42]

Metaphors are not only useful for familiarizing users with the system, but also affect the system design as part of the design rationale. MacLean, Bellotti, Young, and Moran noted the usefulness of metaphors in the creative process, but expressed concern that designers should consider the effect of even implicit metaphors.[43] Some metaphors are inevitable because "new concepts and processes require new terminology. We can either coin new terms, borrow them from Greek, Latin, or other languages, create terms by adding prefixes or suffixes—or use metaphoric terms."[44] Many metaphors used by designers in their communications are simply embedded in the language of computer science. What makes computer science so unique among the sciences, especially when using metaphors, is that they not only talk about something in terms of metaphors, they implement them too. "We live with our metaphors."[45] This discourse may carry loads of inexplicable metaphors for common users, "heaps" and "stacks" and "parents" and "children," for instance, come readily to mind for anyone with computer science experience, but do

not necessarily convey meaning to users. We should stay aware of our metaphors so that we avoid seeing "platforms, engines and objects rather than 'platforms', 'engines' and 'objects.'"[46]

The tension builds

These caveats that metaphors must be constantly monitored and selected with care, coupled with a growing collection of mismatched and ill-fitting metaphors, began the initial protestations over the use of metaphors in HCI. The field of HCI started experiencing the effect of the tension in the metaphorical equation—those attributes that fail to match. Gentner and Nielson summarize three "classic drawbacks" of metaphors:

- The target domain has features not in the source domain (magic attributes).
- The source domain has features not in the target domain (misleading attributes).
- Some features exist in both domains but act differently (violation of expectations).[47]

Even proponents of metaphors readily admitted the limits of metaphors, specifically that they never match perfectly and that they can "limit meaning."[48]

Halasz and Moran cautioned that teaching new users through analogical models may be an easy way to introduce a user to a new system but that "analogical models can act as barriers preventing new users from developing an effective understanding of systems."[49] Halasz and Moran argued that computers are unique; we should abandon analogical models and rather seek to create a conceptual model of the system that would more accurately reflect the actual system. A system designer's conceptual model would represent the system to improve the user's ability to solve problems and apply reason within the system. They confess that moving away from analogical models leaves the user without the tool of "prior knowledge," so for teaching purposes (though not long-term reasoning purposes) they offer the use of smaller, simpler metaphors—those that they liken to literary metaphors used to "make a point in passing. Once the point is made, the metaphor can be discarded."[50]

Noting that there was room for error and rejection on behalf of the user, Marcus explained that some inappropriate metaphors simply become assimilated or evolve. For example, the original Apple trashcan icon more closely resembled a "kitchen garbage can" for scraps and rotting things than an office wastebasket for paper, but over the years it has evolved to its current office basket icon.[51] Also, as technology changes, the metaphors will change. "The paradigm shift, or change in metaphors, will be constant and swift as paradigms evolve from prototypes, become typed, evolve to archetypes, and eventually become stereotyped or obsolete."[52] Without stating it explicitly, he spoke of dead metaphors: metaphors that no longer bring new meaning to light, the "arm" of a chair or the "leg" of a table, for instance. These metaphors are accepted idiomatically with no need for explanation and exploration.

Aware of the ease with which users employ idiomatic icons in computing, Cooper adduced that idioms and meaningless symbols are preferable to new metaphors, claiming "metaphors offer a tiny boost in learnability to first time users at tremendous cost. The biggest problem is that by representing old technology, metaphors firmly nail our conceptual feet to the ground, forever limiting the power of our software."[53] He proposed that we move away from a metaphoric paradigm to an idiomatic paradigm where a word or symbol simply stands for something else and does not carry with it the weight of analogy. Many of the metaphors originally created in computing have become dead metaphors or idioms already. People do not think of their memory buffer where they store copied or cut items as an actual clipboard.

The Macintosh trashcan is ubiquitously cited as a perfect example of a mismatched metaphor and illustrates what may happen when a metaphor becomes idiomatic. For many years to the horror and confusion of many users, the trashcan both deleted files and was used to eject a diskette. A user would drag their diskette icon to the trashcan to eject it. Although this may seem like just a poor choice of metaphor, it does have a sensible origin. Historically, computers had no hard drive, but rather ran applications from diskettes. When you were entirely done with the application you would remove the application icon from the desktop by *placing it in the trash*. You would also need to eject the diskette. For expediency, Apple engineers incorporated ejection and desktop removal into one quick task. It was user tested and readily adopted.[54] The metaphor was a natural extension until the functionality changed.

The user is not the only potential victim of metaphors; the blinders of an adopted metaphor can curtail a system designers' vision.[55] Gentner and Nielson take great offense at the direct manipulation metaphor because it reduces us to "pointing" and "grunting" as if we were children barely able to communicate or patrons at a restaurant where we don't speak the language. When they state "computer interfaces must evolve to utilize more of the power of language,"[56] they are not speaking of voice control and natural language processing, but to creating a shared language understandable by both the user and the system. Only "power users" of a machine have breached the walls of the interface and have attempted to learn the language of the machine itself, but even they are inevitably dragged down by the restrictions of direct manipulation.[57]

Near the end of the millennium, user interface guidelines and handbooks backed off—afraid to support or spurn metaphor use in HCI. Blackwell's chronicle of the history of the desktop metaphor notes that 1990 "marked the middle of a decade (1985 to 1995) in which researchers anticipated problems with metaphor at the start and had experienced failure by the end."[58] The silence is most stunning in the *Handbook of Human Computer Interaction*, a 1,582 page volume in which only two of the sixty-two chapters even mention metaphors.[59] Hollan, Bederson, and Helfman caution against metaphors in their chapter on information visualization,[60] while Neale and Carroll cautiously return to Carroll's original thesis, stressing the importance of creating a conceptual model (the designer's model of the system's functions) that "should incorporate an accurate understanding of the user's task, requirements, experience, capabilities, and limitations."[61]

Metaphor ever after

By the year 2000, system designers found themselves stuck between a rock and hard drive. Investigations into the efficacy of metaphors find that metaphors are a mixed bag, unavoidable, useful, yet problematic.[62] While creating a taxonomy of HCI metaphors, Barr, Biddle, and Noble conclude that "the analysis present in the taxonomy should indicate that there are many benefits to user-interface metaphors if we choose them correctly and harness them properly."[63] Yet Blackwell's dissertation research finds that metaphors afford "surprisingly little benefit for cognitive tasks" and that the benefit is "largely restricted to mnemonic assistance."[64] Blackwell notes that the benefits were greatest when the user constructed his or her own metaphor rather than using the system-supplied metaphor. Interestingly, while studying students' understanding of search engines, Hendry identified a conceptual metaphor (not provided by the system) common to many of the students' visions of an information retrieval system. Although Hendry does not suggest that metaphors should be used when creating systems, he does question how existing conceptual metaphors might be identified through sketching and then incorporated to create mappings "between problem domains and programming notations."[65]

Endeavoring to incorporate the benefits of metaphors while dodging the drawbacks, recent variations on the use of metaphor have been tendered. Neale and Carroll lobby for composite metaphors—metaphors made up of multiple metaphors—to alleviate the tension between source and target domains.[66] Powell found composite metaphors useful for facilitating computer game play without unduly upsetting users. She explains that gamers have readily adopted the tool or inventory bag from which the user may equip their character with a mannequin style "dress-up" panel. The bag and mannequin metaphors have no real-world association but work effectively.[67] Hsu, investigating composite metaphors, confirmed Neale and Carroll's assertions and found that the "closer the mapping between designers' conceptual models and users' mental models, the greater the effect of interface metaphors."[68]

As an alternative to composite metaphors, Khoury and Simoff propose a new class of metaphors that they call "elastic." They explain that metaphors in language are unavoidable, and we must deal with them in information technology. Rather than focusing on concrete objects, however, metaphors should focus on social structures, such as relationships in game play. They conclude that "elastic metaphors can provide an optimal mapping from source to target domains."[69]

Conclusion

Historically, in HCI the designer of the system supplies metaphors to help the user understand the system better. Unfortunately, this format falls prey to Reddy's conduit metaphor: the receiver of the information is left out of the communication process. If HCI is to learn from human-to-human interaction, then the user of the system should be able to communicate his or her needs to the system. If the system does not have the capacity to understand the request, then the user and the system should be empowered to select mutually agreeable simple metaphors for communicating. The user should be given the option to choose his or her own metaphors, and the metaphors, vocabulary, and "language" created should be able to evolve as the boundaries of the comparison are reached. A common complaint from users is, "The computer just isn't listening to me." And they are, of course, right.

The field of information science, and particularly the subfield of human information behavior, are in a unique position to help resolve the long-standing debate over the use of metaphors in HCI. From Belkin's early stated objectives to improve information systems to Cole and Leide's pursuit of metaphor instantiation in human information organizing behavior, the study of information behavior attempts to better understand and ideally facilitate the user—assisting them in their acquisition and application of information. Metaphors are clearly utilized by humans as they communicate with each other, seek and conceptualize information, and solve problems. To improve the interaction between human and computer, we must first gain better insight into the role that metaphors play in our own interaction with information.

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