



Analogical Reasoning: When a Non-Expert Reasons Like an Expert

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Abstract

Current thinking suggests that fast, comprehensive decision-making is a characteristic of certain decision-makers. Expert models explain much of this behavior; however, they cannot explain the success of some entrepreneurs and transferring executives. This work uses theories of expertise, similarity, and analogy to explain how some non-experts can perform like experts.

A popular topic in cognitive science has been the discussion of expertise; more specifically, differences in information-processing capability within a task domain and how these differences can impact individual and organizational performance (e.g., Klein & Calderwood, 1988). Expert models differ from other information-processing models (e.g., limited-capacity model, rational model, and cybernetic model) by their focus on the role of domain-specific knowledge structures during information processing. While the study of expertise has a long history, it is only recently that this micro-level theory has been used to explain and develop more macro-level theories and outcomes. Recent work on strategic decision-making in high-velocity environments, for example, helped concluded that human-information processing capabilities of top management executives (i.e., expertise) can explain differences in firm performance (Eisenhardt, 1989; Lord & Maher, 1990). In a theoretical extension of Eisenhardt's work Eveleth and Reed (1995) have suggested that the extant model of the environment and firm performance should incorporate the concept of expertise to account for differences in executive information-processing capabilities and resulting differences in firm performance. In this work, and others, expertise has been defined as the knowledge and skills that differentiate individuals in their ability to define problem situations, make decisions, and perform tasks within a stated domain (Klein & Hoffman, 1993).

While these conclusions extended our thinking about the impact of expertise in changing environments they failed to explain those instances when an executive is brought in from another industry to save a company in a downward slide or those instances when an entrepreneur successfully moves from one industry to another. Using only theory on expertise, the transferring executive or the entrepreneur would, by definition, be classified as a non-expert and would be expected to perform poorly. The knowledge and skill, developed in a different domain from the one in which they must now operate, would provide little advantage in the new domain. Then, how is it that an occasional 'non-expert' will perform like an expert? It is clear that some transferring executives and entrepreneurs have performed at high levels. The question is why. Responding to this question requires an extension to the previous line of thinking; specifically, we must consider three categories of individuals when thinking about information-processing differences: experts, non-experts, and non-experts-who-perform-like-experts. Understanding the differences and similarities among these three may be useful in selection, training, and development of executive talent.



The literature on analogical reasoning has the potential to help explain differences and similarities among experts, non-experts, and non-experts-who-perform-like-experts (e.g., Gentner & Markman, 1997; Kolodner, 1997; Sternberg, 1988). This literature categorizes various knowledge-situation combinations as either near analogies, far analogies, mere appearances, or anomalies. Incorporating this concept into the literature on expertise allows us to describe an expert as a person who relies on 'near' analogies for drawing inferences and making decisions (Klein & Calderwood, 1988; Kolodner, 1997). A non-expert who performs like an expert may be skilled at using 'far' analogies as a basis for judging a given situation and making inferences. A poor performing non-expert has neither the domain-specific knowledge for forming near analogies nor the skill needed to see the connection between a given situation and a 'far' analogy and thus, may be prone to 'false matches' between knowledge in memory and situational cues. This paper brings together the literatures on the environment, expertise and analogical reasoning as an extension of existing theory of executive decision-making in high velocity situations.

The remaining discussion is organized into three sections. The first section summarizes the literature on expertise. In the second section we introduce the concept of analogical reasoning and discuss how this skill extends models of expertise and explains instances when apparent non-experts perform at expert-like levels. Finally, the third section explores the implications of the extended model for research and practice.

Expertise

Glaser and Chi (1988) and others (e.g., Lord & Maher, 1990, 1991b) have identified a number of characteristics that define the information-processing advantages experts possess over their non-expert counterparts. These characteristics directly relate to experts' superior performance on decision-making and problem solving within their domain. One characteristic is experts' superior domain-specific knowledge that allows them to represent problems at a deep level, while non-experts are limited to representing problems using surface-level features. Additionally, the elaborate knowledge-structures allow experts to perform many tasks automatically that a non-expert would perform in a controlled fashion. The result is that experts are relatively fast, error-free decision-makers, even when satisficing behavior is required (Klein, 1989). They exhibit superior memory for domain-specific information, they can perceive large meaningful patterns between variables in their domain, and they possess strong self-regulation skills for tasks performed within their domain. These characteristics are particularly useful when information load is high, comprehensiveness is needed, and when the time frame for making decisions is short. The key feature of each of these characteristics is their domain-specific nature.

The literature on cognitive psychology and artificial intelligence suggests that domain-specific knowledge is the primary source of an expert's task performance advantages (Chi, Glaser, & Farr, 1988; Gordon, 1992). Knowledge refers to both the content and the form of a domain-specific structure held in long-term memory. While 'content' refers to the facts or concepts in memory, 'form' refers to the relationships, categorization, or linkages between the various concepts. In a symbolic view of information processing, domain-specific knowledge is conceptualized as pieces of information held in long-term memory storage, each bit of



information connected to the others through their common characteristics or associations. A connectionist perspective conceptualizes knowledge as the various connection weights held in a network of interconnected neurons. As such, knowledge is implicit in the architecture, rather than something located in it, and knowledge may only be present in the presence of an activating cue (Lord & Maher, 1990). Though we may speak of information storage and retrieval, this view suggests that the acquisition of knowledge involves a process of learning and conditioning that fine-tunes the weights over time, and the retrieval of information involves the activation of the network through internal or external cues. With experience the weights are strengthened and the number of pathways through which specific knowledge can be activated increases.

A connectionist view of knowledge also suggests that the ability to recall this information depends in part on the ability to activate relevant information in memory. If information is stored in the connection weights between nodes in a neural network, retrieval of any specific information requires external or internal cues to prime the proper neurons. Individuals low in expertise may have some relevant information in memory, but be limited in their ability to activate it. Through experience and deliberate practice the number of cues or pathways to any given piece of information increases, making the information easier to activate. Expertise also depends upon the ability of the cognitive architecture to inhibit non-relevant pathways. Information processing is described as a process of "settling in." That is, environmentally or internally generated cues are used to activate information in memory. As subsequent cues become available the system inhibits pathways that no longer appear to be relevant. Eventually, through a process of facilitation and inhibition, the neural network reaches a specific state of activation (i.e., information currently in working memory). Without the ability to inhibit activated information, increases in knowledge would lead to information "overload."

An important aspect of an expert information-processing model is that it can explain differences in performance over and above those explained by more general characteristics. In a study of word-processing tasks (Eveleth, 1996), expertise explained significant variance in performance even when general cognitive ability and motivational factors were statistically controlled. These findings are consistent with others (e.g., Sternberg, 1997) who have suggested that there is more to understanding managerial performance than indicators of general cognitive ability.

While a person's characteristics such as personality or intelligence do not change according to the domain, expertise does. An individual may be an expert in one domain (e.g., web-page design) and a non-expert in another (e.g., firefighting), regardless of any physical or intellectual traits. Thus, holding all else equal, expertise in one domain differentiates a person's performance in that domain from that of a non-expert, and it provides no advantage in other unrelated domains. The extent to which a person's knowledge and skill are a source of superior performance will be based on the salient domain (e.g., the environment or industry) and the individual's degree of expertise within that domain. For example, an executive may be an expert with a specific company, a specific industry, and a specific functional area (e.g., accounting), gained through experience and practice, but lack sufficient knowledge and skill to be considered an expert in another setting (e.g., same functional area, different company or industry). While



two experts (e.g., two accountants) may have similar training and years of experience, the fact that their experience was acquired in a particular setting limits the extent to which expertise is transferable across settings. In this example, the domains are obviously related, so some amount of transfer is expected. However, the key point is that expertise reflects domain-specific cognitive characteristics, and moving to another domain requires a person to develop specific skills relative to the new domain. Even if the person has high domain-specific abilities in a related domain some amount of practice, general ability, and motivation to learn will be required to develop similar skills in the new domain.

It is also important to note that expertise is more than industry, functional, job, or task experience shared by all participants with similar tenure in an industry, profession, or job (Ericsson & Charness, 1994). Expertise is a set of developed cognitive characteristics, and as such, is contingent upon the specific type of experience a person receives, as well as motivational and dispositional characteristics related to skill acquisition and learning processes. This may be one reason why individual characteristics, such as experience, often explain only a small amount of variance in task performance (e.g., Camerer, 1981; Dawes, 1979; Johnson, 1988). Lord and Maher (1991a), for example, have suggested that the weak support for the impact of leadership succession on firm performance may be attributed to a failure to control for ability. If expertise is a set of domain-specific cognitive characteristics, then experience, job titles, or years of schooling may not sufficiently tap the construct. Domain-specific knowledge and skill may be an important key.

Similarity and Analogical Reasoning

While expert information-processing models are useful in explaining many differences in decision-making within a stated domain (Lord & Maher, 1991b), they do not explain those instances when apparent non-experts perform at high levels. In the particular case of strategic decision-making, there may be times when transferring executives perform successfully without the requisite level of expertise. Thus, while models of expertise are helpful for understanding many acts of decision-making, they are not sufficient to explain all such behaviors. In this way, such models are "descriptively limited" (Lord & Maher, 1991b, p.23). In many ways this conclusion is comforting; for the development of expertise is a long and difficult process. The road to expert levels of skill and knowledge is paved with countless hours of practice (Anderson, 1987, 1990; Ericsson & Charness, 1994). To a transferring executive or to strategic decision-makers facing a revolutionary change, such advice maybe daunting. Fortunately, there may be another way to approach the problem. The literatures on similarity and analogy provide promise for explaining situations when non-experts perform like experts. For the transferring executive, the development of analogical reasoning may be one method of compensating for lack of expertise.

Models of similarity and analogy operate on the assumption that individuals perform comparison processes when evaluating cues from the environment. The process of comparison helps individuals represent these cues according to information stored in long-term memory. Analogical reasoning appears to be a fundamental process that all people employ (Glick & Holyoak, 1980; Keane, 1988; Read & Cesa, 1991), some more successfully than others do.



When a comparison results in the alignment of a current situation with a *similar* situation from memory the matching situations share both *attributes* and *relations* between attributes (Gentner & Markman, 1997). For example, if an executive in the DRAM industry sees a similarity between the downturn in the industry during the mid-1990's and a downturn experienced in the late 1980's, that executive is drawing a literal similarity between the current situation and the previous one. The matching scenarios will share similar attributes (e.g., competitors, industry conditions, global economic factors) and similar relations between the attributes (i.e., cause-and-effect relationships among the attributes).

On the other hand, the primary characteristic of an *analogy* is the alignment of *relations* between the current situation and the one retrieved from memory. Unlike a literal similarity the attributes of the analogy and the current situation are not the same. Sports analogies, for example, are very common ways to represent situations of competition. The link between two strong competitors in the business environment and two competitors on a football field lies in the relations between the various elements in the scenarios. It is not necessary for the elements of the analogy (e.g., football players, a grass playing field, and coaches) to be identical to those of the current situation (e.g., the firm, industry, and competitors). The focus is on the commonality between the relations (Gentner & Markman, 1997). Not all matches will be relevant or successful. It is possible for an individual to identify a false analogy (one that is not appropriate for the situation) or to overlook a relevant analogy (Read & Cesa, 1991).

Within the similarity and analogy literatures additional concepts have been identified that describe other potential comparison-matching outcomes. An *anomaly* is a match between two scenarios that share neither relations nor attributes. A *mere-appearance* match is one that shares attributes but not relations (e.g., a ball and the moon). A fifth concept that is commonly discussed is that of a *metaphor*. The conceptualization of a metaphor is somewhat fuzzy, though it has been widely used. The literatures on similarity and analogy tend to place metaphors in a category that cuts across the analogy, anomaly, and mere-appearance categories; that is, depending upon the nature of any specific metaphor (e.g., family tree) it may share some attributes or relations with the target or it may share none. Discussions of these various concepts can be found elsewhere (Gentner & Markman, 1997) and are organized in Table 1.

	No Shared Attributes	Many Shared Attributes
Many Shared Relations	(Near) Analogy metaphor	Literal Similarity (Far analogy)
No Shared Relations	metaphor Anomaly	metaphor Mere Appearance



Table 1
Matching Situational Characteristics with Knowledge Structures

From the perspective of an individual who works in the area of expertise these literatures provide an opportunity to extend models of expertise through a syllogism, and provide the opportunity to describe situations when non-experts might process information like an expert. While the literatures (i.e., similarity, expertise, and analogy) are largely separate, they are analogous, and some value can be added through integrating their conclusions. Recently, Gentner and Markman (1997) began this integration by suggesting that the process of similarity comparison is like analogical reasoning. Others (Kolodner, 1997) have referred to the distinction between similarity and analogy as the difference between "near analogies" (i.e., literal similarity) and "far analogies" (i.e., shared relations, no shared attributes). These authors have effectively positioned similarity and analogy concepts as separate ends of a single spectrum. All comparison matches along the continuum share relational properties with their target; but as one moves from literal similarity (near analogy) toward (far) analogy the number of matching elements or attributes decreases. Both are seen as sets of information stored in long-term memory that can help in organizing environmental cues and making causal inferences. While this link between similarity and analogy is largely being discussed within the field of analogical reasoning, it is also possible to make the connection between expert information processing and similarity matching (e.g., Kolodner, 1997). As discussed earlier in this work the process of expert information-processing deals with representing cues from the environment according to existing *domain-specific* knowledge-structures (i.e., there is literal similarity between the present situation and domain-specific knowledge). Thus, the following syllogism can be made: 1) Models of expertise are similar to models of literal similarity (Kolodner, 1997); 2) Models of similarity are like models of analogy (Gentner & Markman, 1997); thus, 3) Models of expertise are like models of analogy (this work).

Another way to view this relationship is to accept the assumption that analogical thinking is a fundamental process that all humans perform (Keane, 1988). Research findings help us conclude that humans perform analogical processes (using far analogies) when they face situations that are perceived as unstructured or when a situation provides incomplete information (Keane, 1988). Holding constant the absolute level of uncertainty within a given situation, non-experts will tend to perceive a situation to be more uncertain or more unstructured than will an expert. Thus, we can conclude that individuals are more likely to attempt matches with far analogies (rather than literal similarities) when they are non-experts in a given domain. While experts will most often use near analogies when representing problems, non-experts will turn to far analogies because they lack the requisite knowledge needed to form near analogies. The process of analogical reasoning, performed by the non-expert, is much like the process of expert information processing; both involve representing environmental cues according to existing knowledge; one is across domains (far analogies) and one is within a single domain (Glick & Holyoak, 1980). The difference lies the extent to which the source of analogies (near or far) contains attributes that are literally similar to the target.



To this point we can conclude that experts possess superior domain-specific knowledge and skill, and that non-experts must rely on far analogies when attempting to represent current problems or environmental cues in an unfamiliar domain. From this stage the next question becomes "why do some non-experts perform better analogical reasoning than other non-experts?" A review of analogy literature provides a somewhat surprising answer; the answer seems to bring us back to the nature of expertise and opens up the potential for expertise in one domain to help performance in another domain. The reason for this is that successful matching of far analogies to a current situation apparently requires a well-developed knowledge structure, not necessarily from the domain of interest.

Successful Analogical Matching

When faced with an ill-defined problem, non-experts will first attempt to align actors and objects from previous situations with the actors and objects in the current situation (Read & Cesa, 1991). Next, they will attempt to map the relational structure between the elements of the previous situations with the relational structure between the elements in the current problem. Of particular importance is the identification of a match between the causal structures of the two instances. Given most strategic decision-making processes are goal directed (e.g., what should our strategy be if we wish to maintain our current share of the market?) understanding the current situation according to cause-and-effect relationships is critical. Another property of this process is that it can be performed quickly; a bonus in situations where fast decision-making is necessary. Unfortunately, the matching process is not always successful. Failure to notice a relevant analogy or accepting a false analogy are common outcomes of this 'natural' process (Glick & Holyoak, 1980). Understanding the conditions when this occurs may give us some insight into the difference between non-experts and non-experts-who-perform-like-experts.

Problem representation abilities for domain-specific information appear to be a major performance differentiator between non-experts and experts, and are largely the result of an elaborate, domain-specific knowledge structure. This problem representing skill is also a characteristic of successful mapping between a current situation and an analogous one (Gentner & Markman, 1997); and as with expertise, this skill appears to result from the existence of an elaborate knowledge structure from which to draw analogies. In a study of tank platoon leaders, for example, Brezovic, Klein, and Thordsen (Klein & Hoffman, 1993) found that non-experts and experts did not differ in the explicit information cues each extracted from the situation. The difference was in the ability of experts to 'see' the information that was not explicitly available. In general, Klein and Hoffman (1993) say that while "novices see only what is there; experts can see what is not there" (p. 203). In addition to the explicit cues, experts understand the relationships between the cues (i.e., they can note subtle similarities between different looking situations, and make distinctions between similar looking, but very different situations). Experts also perceive the antecedents and consequences that relate to the explicit situation at a given point in time. All of these abilities are helpful in the task of strategic decision-making.

Similarly, in the process of successfully matching a target with a far analogy it is important to note both typicality and differences (between the target and a potential analogy), and to understand the relationships between various attributes in each. To this end, Holyoak and



Thagard (1989) describe the process of analogical thinking as a constraint satisfaction process. According to this view, the absence of clear typicality between a source and a target analogy (i.e., the inability to see typicality) can lead to overlooking a potentially useful analogy. Likewise, a focus only on surface-level similarities can lead to the acceptance of a false match. Being able to note typicality and differences, and understanding the relationships between elements are crucial to successful matching.

The ability to note typicality and to make distinctions (for experts and analogical thinking) appears to have a similar origin - i.e., a well-developed knowledge-structure. Extending this logic, the tendency to select false analogies, mere appearance matches, or anomalies seems to be related an individual's inability to draw analogies from *any* well-developed knowledge structure. Returning to the discussion of expertise and the connectionist perspective of knowledge, we can recall that experts possess well-developed knowledge structures, represented as a network of neurons with multiple, strong pathways between nodes in the network. Through the use of internal and external cues an expert can quickly and automatically activate information in memory. Individuals with less-developed knowledge-structures may have some relevant information in memory, but be limited in their ability to activate it. The more developed is the knowledge structure, the greater are the number of cues or pathways available to activate information in memory. Thus, a person with a well-developed knowledge-structure in one domain (e.g., knowledge of teaching children gained through many years of teaching first and second grade students) may be able to identify analogies from that domain that match situations in a new domain (e.g., a teacher who takes a position as a school administrator and then notices that the behavior of a specific teacher reminds him or her of a child having a tantrum). A cue or set of cues in the current situation activate knowledge from a domain in which the person possesses extensive knowledge.

This conclusion is supported by the methodology and findings of many analogy studies (e.g., Read & Cesa, 1991; Glick & Holyoak, 1980). In these studies subjects are often given information to read, study, and repeat. This information acts as potential sources for analogical inferences later in the study. The analogy information is often presented in the form of a story and typically possesses content that is new to the subjects. Later, subjects are asked to read a story from an unrelated domain, and then to make inferences between the current story and the previous stories. In most cases, subjects have difficulty identifying the correct analogy without first receiving a hint from the researcher (Glick & Holyoak, 1980) or without being reminded of the original stories (Read & Cesa, 1991). By design, subjects in these studies are non-experts in both domains (i.e., the source domain and the target domain). Rather than a well-developed knowledge structure that is primed by cues from the current story, subjects must be primed by the researcher. The absence of an elaborate knowledge structure inhibits activation of the information from memory. Theorists have concluded that for a successful match to occur the subject must understand the source information at an abstract or deeper-level (Keane, 1988). Thus, it would appear that a deep level of knowledge in the source domain is essential for matching both near and far analogies. Therefore, we can conclude that: 1) experts utilize their superior domain-specific knowledge and skills to match current environmental cues with those of near analogies or literal similarities; 2) non-experts will utilize their knowledge from other



domains to match current environmental cues with far analogies; and 3) successful matching of current environmental cues to far analogies requires a well-developed knowledge structure from which to draw analogies.

Discussion

One explanation for the difference in decision-making performance is a difference in expertise. Experts are able to capitalize on their well-developed knowledge structures and perform successfully on decision-making, problem-solving, and motor-skill tasks within their domain. While this conclusion can be drawn from the extensive literatures on expertise it doesn't explain those situations when apparent non-experts perform like experts. The literature on analogical thinking provides one explanation for such behavior. While all non-experts will attempt analogical reasoning, only those with a well-developed knowledge structure from which to draw analogies will be successful. Others will fail to identify relevant analogies or will accept false analogies because of their surface similarity with the current situation. While there is much that we do not know about the ability of humans to identify relevant far analogies (for example, there are a number of competing hypotheses about how analogues are retrieved), the fact that some non-experts can perform like experts provides some support for studying these processes in decision-making situations.

Other issues that are less clear at this point include the exact nature of a knowledge structure that is necessary for identifying relevant far analogies and whether any attention behaviors are necessary to activate a search for a far analogy. In the discussion above we infer that a person needs to be an expert in "some" domain. If it is in the domain of interest they are able to make successful near analogy matches. If it is in another domain they are better able to make successful far analogy matches than a person with no expertise. Concluding with these inferences is not entirely comforting. For a non-expert, possessing an elaborate knowledge structure for information and relationships within one domain may be better than being a non-expert in any domain, but one wonders if, for the purpose of forming far analogies, it is better to have a deep level of knowledge in a single area or a broad level of knowledge in multiple areas. From a cognitive science perspective the ability to activate information in memory increases as a knowledge structure becomes more elaborate; but it is less clear whether breadth or depth is more critical for successful matching of far analogies to situations in unfamiliar domains.

Let us imagine two individuals. One is an executive in the U.S. timber industry who possesses 30 years of experience and a successful record managing a single company. Using theory on expertise it would seem reasonable to classify this person as an expert in his domain. The second person is an entrepreneur. Throughout her career she has started and managed businesses in numerous industries. When riding on a plane or taking a break from her busy life she reads anything (e.g., newspapers, fiction, non-fiction). She listens to National Public Radio on her drive to and from work each day, and she has actively participated in the raising of her two, now adult, children. By definition she may not be considered an expert in a single domain. Rather, she would be a person with a general (though well-developed) knowledge-structure. Both of these individuals possess elaborate knowledge structures, and given our earlier discussion on analogical reasoning may be candidates for performing like experts in an unrelated domain.



Moved to a new domain (e.g., industry) which one of these individuals would more likely identify successful matches between new situations they face and source information contained in their memory? Intuition, and some research findings, would suggest that they are not equally suited, even though they both possess elaborate knowledge structures.

First, research suggests that people turn to far analogies when they perceive a situation to be uncertain (i.e., you must say "I don't know everything" or "This situation is new to me"). This suggests that a certain level of awareness about what you know and what you don't know is necessary. Given the entrepreneur in our example shifts and changes environments constantly she may be more likely to view a new industry as uncertain (i.e., "This is a new environment"). This level of awareness (i.e., a perception of uncertainty) would trigger a search for far analogies ("Do the things I see here remind me of anything from my other experiences?"). Given her well-developed knowledge structure the likelihood of a successful match with a far analogy is high (as compared to someone with a less-developed knowledge structure).

Turning to the transferring timber executive one can imagine an instance when an expert from a single domain moves to a new domain and perceives the new situation to be well structured and highly certain. Given the lack of breadth to the executives knowledge there may be a tendency to view the new situation as "just like" the previous one. Failure to note that the situation is new, and somewhat ill-structured may lead the individual to search for literal similarities, focusing primarily on the matching attributes and not the relations among attributes. The result may be the identification of a false analogy or a mere appearance match. At this stage these are both empirical questions.

Implications

The expertise literature provides a rich set of findings to support the claim that observable differences in decision quality, and thus, individual and organization performance, can be attributed to differences in expertise. The research findings drawn from the areas of similarity and analogy provide some explanation for non-experts who perform like experts in these environmental conditions. As noted in the discussion section, there are still many descriptive questions to be answered. Then, how do we turn these descriptions into prescriptions? There are numerous avenues open for answering this call. One particularly promising area of study is case-based reasoning (Kolodner, 1997; Klein & Calderwood, 1988). The focus of these tasks is on developing individuals' skills at performing successful analogy matches in real-world problem-solving situations. The descriptive computational models developed in this line of inquiry provide implications for learning and skill building and are aimed at improving individuals' abilities to retrieve or recall relevant information from memory. Others have suggested that exposure to multiple analogies for the same situation can lead to the development of more abstract schema in memory (Read & Cesa, 1991). One explanation for subjects' inability to identify links between analogous stories has been their lack of expertise in the source domain. Because the elements of a far analogy are not identical to those of the target problem it is necessary to understand the source information at an abstract or deeper level. From a connectionist perspective a learning environment that promotes the identification of multiple analogies for a single situation is one that would promote more and stronger connections



between nodes in a neural network. The result would be an increase in the probability that subsequent cues in the environment will activate analogies in memory. Unfortunately, the development of multiple and strong pathways in memory is a gradual process that is a function of a person's interaction with environmental cues from the domain of interest. Thus, while there may be innate traits that predispose certain people toward different domains and different success in a domain (Gardner, 1995) the key to developing analogy skill appears to be practice and more practice (Ericsson & Charness, 1995). An empirical question that remains is whether this practice should be directed at breadth of knowledge or depth of knowledge.

Finally, some insights from the field of critical thinking suggest that training efforts that make the "structure" of information salient should increase individuals' analogical reasoning-skill (e.g., Halpern, 1998). A quick review of Table 1 points out that the characteristic shared by near analogies and far analogies is the number of relationships among the attributes of a source and a target situation. While a person who is skilled at the use of far analogies or near analogies will identify source information that contains many common relationships, those less skilled will identify source information that contains few relationships. The result is false analogies.



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