Four Conceptual Knowledge Levels

Our use of knowledge varies with how it is organized and perceived. In particular, we arrange knowledge on four conceptual levels. Our perspectives of where these levels fit into our daily work are very important as we provide ourselves and our associates with the necessary knowledge to perform with the high quality, creativity, and consistency we desire. The four levels are also important when we try to understand what happens around us when people use knowledge and when we evaluate how much they know and which kind of knowledge is required for different tasks.

We ask: "What do you have to know, and how do you need to know it, to make decisions and do your work?" These issues are separable. ***What*** we have to know is a direct function of the tasks we perform. ***How*** we need to know it pertains more to the workstyle we adopt to use the knowledge. Do we wish to reason explicitly and vigilantly with our knowledge? Do we wish to make quick decisions based on well-developed judgments? Do we need to handle the situations automatically without discernible decisions as part of our normal workflow? There are many options for how we may wish to use knowledge and, therefore, the degree we need to know it or have it at our fingertips.

From a cognitive perspective, we use selected, often partly understood knowledge to represent the extreme in ideals and sophisticated concepts to form our goals and beliefs. To guide our insight into "how things work" we use other knowledge that may be more theoretical and general and often better understood. Explicit knowledge that pertains directly to the tasks we perform is used to reason with and to make deliberate decisions. Finally, we have some knowledge with which we are so familiar that we have automated it and are able to use it without thinking. Thus, we use knowledge on four conceptual levels:

Goal-Setting or Idealistic Knowledge or **Vision and Paradigm knowledge**. Part of this knowledge is well known to us and explicit -- we work consciously with it. Most of it, our visions, is not well known; instead, it is tacit and only accessible nonconsciously. *We use this knowledge to identify what is possible and to create our goals and values.* ("Knowledge of WHY" the ideal is desirable and obtainable.)

Systematic Knowledge or **System, Schema, and Reference Methodology Knowledge**. Our theoretical knowledge of underlying systems, general principles, and related problem-solving strategies is to a large extent explicit and well known to us. *We use this knowledge to analyze and reason in-depth and to synthesize new approaches and alternatives.* ("Knowledge THAT" it is possible, methodologies exist, and it can be achieved.)

Pragmatic Knowledge or **Decision-Making and Factual Knowledge (Know-How)**. Decision-Making knowledge is practical and mostly explicit; it is often based on scripts that we know well. *We use this knowledge to perform our daily work and make explicit decisions.* ("Knowledge HOW" it can be achieved.)

Automatic Knowledge or **Routine Working Knowledge**. We know this knowledge so well that we have automated it -- most has become tacit. *We use it to perform tasks automatically without conscious reasoning.*

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We can illustrate the nature and use of the different conceptual knowledge levels using examples as indicated in Table 4-1. In these examples, we have suggested what a junior and a senior control engineer may know on the different levels. Much of the knowledge that the junior engineer holds as higher, less familiar and accessible level knowledge is moved to lower, more practical and familiar knowledge levels in the mind of the more expert senior engineer. This evolution is normal as people gain expertise.

GOAL-SETTING or IDEALISTIC KNOWLEDGE -- Vision and Paradigm Knowledge

Top-level *goal-setting* or *idealistic* knowledge guides our thinking and motivation, helps us to generate our goals and ideals, and provides us with insights that enable us to observe situations from several perspectives. To a large extent, such knowledge governs "what we think is possible and desirable" and "what we think is the very best that could be achieved." Goal-setting knowledge is the knowledge that fires the imagination! When we reason or solve problems, when we choose tactical approaches, when we explore to find new strategies, we are usually driven by our idealistic knowledge. Examples of this highly influential knowledge include:

- Vision of how the business can be structured and organized -- which products, competitive strategies, operational practices, personnel practices, corporate culture features are required -- to become the undisputed business leader.
- Paradigm for pursuing total quality management -- new perspectives, new values, new judgments required, old judgments invalidated, new practices, new incentives, etc.
- Knowledge of how office and knowledge work should ideally be performed and how that goal might be achieved by gradually introducing new work practices and support tools.
- Knowledge of which expectations, advantages, and disadvantages can result from pursuing various advanced risk-management strategies when trading specific commodities.

We use *idealistic* knowledge extensively in two ways: (a) direct our motivation and actions towards the ideal that we perceive is possible and that we would like to pursue; and (b) provide a gestalt of the situation with broad perspectives that allow us to reframe it (i.e., to change the terms of reference). We also base most of our beliefs on our *idealistic* knowledge. Further, in a "generate-and-test" situation, we use this knowledge to provide us with both the goals for generating new alternatives and higher-level (nontechnical) criteria for judging performance of the alternative.

Table 4-1. Examples of Knowledge at Different Conceptual Knowledge Levels.

Conceptual Knowledge Levels	Junior Control Engineer	Senior Control Engineer
IDEALISTIC Knowledge Vision, Goal, & Paradigm Knowledge Provides basis for goals & values to guide & decision-making. Produces beliefs, values, & some nonconscious judgments. Sketchily known & partly accessible **Often associative, primed, & episodic** Mostly Nonconscious	*Knowledge of:* • Possibilities for applying Optimization Theory in combination with process models • Potentials for advanced Human-Computer interfaces • Ideals for plant performance	*Knowledge of:* • Advanced ideals for plant performance • Performance achievable with fuzzy, intelligent computer control • Vision for enterprise-wide integration of control/ information/ management • Neural Net Theory & Applications
SYSTEMATIC Knowledge System, Schema, Methodology Knowledge Complex background knowledge. Used for in-depth analysis of specific situations & synthesis of new solutions. Requires cognitive effort & concentration, used elaborately **Often associative as large chunked semantic nets** Mostly Conscious	*Knowledge of:* • Analyzing multivariable control system dynamics • Optimization Theory. • Stability Theory. • Basic Sciences • Applied Mathematics • Control Engineering Principles	*Knowledge of:* • Advanced Optimization Theory applied to very complex plants • Advanced Stability Theory • Cognitive Engineering for Human-Computer interfaces • Basic Sciences • Advanced Applied Mathematics
PRAGMATIC Knowledge Decision-Making & Factual Knowledge Used to reason explicitly with when making decisions. Provides the basis for explicit knowledge work. Well known & easily used **Often scripts, rules, judgments & procedures** Mostly Conscious	*Knowledge of:* • Tuning 3 mode controller • Diagnosing single loop behavior • Identifying correct control loop wiring & hook-up • Selection of correct sensors • Programming programmed controllers	*Knowledge of:* • Diagnosing multi-loop behavior • Stability theory rules • Identifying correct control loop wiring & hook-up • Control engineering principles • Automatic analyzer selection • Designing analyzer sampling systems
AUTOMATIC Knowledge Routine Working Knowledge Used automatically without explicit reasoning to recognize	*Knowledge of:* • Determining stability of single loop controllers	*Knowledge of:* • Tuning 3 mode controller. • Diagnosing single loop

situations & conditions, analyze them, & make decisions (by handling them automatically) **Often automated routines, procedures, & "reactions"** Mostly Nonconscious	• Laying out components in control loop design	behavior • Selection of correct sensors • Programming programmed controllers • Determining stability of a loop • Laying out control components

We obtain *idealistic* knowledge from many different sources. On the personal level we read, discuss, see what others have done, and may generate visions and paradigms when we speculate on what is possible. On the corporate level we obtain *idealistic* knowledge through benchmarking and internal development, and from the visions of knowledgeable individuals. One important aspect of *idealistic* knowledge is an understanding of the organization's goals and objectives and their derivatives that should guide everyone's actions and decisions.

When we explore or create, we synthesize and to be effective, synthesis must always be goal driven. More to the point, to be creative and really valuable, synthesis must be based on a vision -- a view of what ideally should be sought. Therefore, it becomes very important to facilitate development of such visions as part of any problem-solving, design, or Decision-Making process. However, since we always are presented with new problems and decision challenges, it is often impossible to develop corresponding visions after the challenge has materialized. As a result, in any intelligent-acting person or organization, it is very important to pre-establish a broad inventory of goal-setting *idealistic* knowledge to facilitate *ad-hoc* development of opinions and judgments on what might be sought in a variety of situations. The broader a field these perspectives cover, the more valuable they are.

SYSTEMATIC KNOWLEDGE -- System, Schema, and Reference Methodology Knowledge

Systematic knowledge provides general models and organized understanding of, and theoretical background for, the situations and conditions that we deal with, particularly the complex ones. It includes our understanding of how all kinds of systems work, that is, what their internal mechanisms are and what their behavior are likely to be when manipulated or "perturbed." This knowledge also provides us with methodologies and guides us with principles for how we handle situations. Selected examples of *systematic* knowledge include:

- Knowledge of how organizational systems work and behave, how people interact, how cultural changes can be implemented, and how effectiveness can be affected by particular changes, etc.
- Knowledge of basic sciences, specific sciences, scientific principles, mathematics, categorization systems, etc.

- Schemas and scripts for how friendly social conversations normally are conducted and are likely to develop.
- Schemas and scripts for achieving modern management practices such as total quality or business process reengineering.
- Methodologies for how to implement risk management strategies.
- Methodologies for how to proceed with investigations or other kinds of task.
- Schemas and scripts for various kinds of reasoning, problem-solving, and decision-making.

We use *Systematic* knowledge as background and reference knowledge for in-depth analyses to investigate particular aspects of situations under consideration. As implied in the above examples, our *systematic* knowledge spans our whole body of knowledge and is used for all kinds of reasoning and problem-solving purposes. For example, in "generate and test" reasoning situations, we use *systematic* knowledge both to develop the details of the generated solutions and to estimate expected behavior to test their validity.

Systematic knowledge is obtained in many ways. Normally, we think of education as the standard mode of obtaining this kind of knowledge. However, it is also developed extensively from self-study and from generalizing when we create scripts from observations and later when we generate schemas from scripts.

PRAGMATIC KNOWLEDGE -- Decision-Making and Factual Knowledge

Knowledge on this level consists of the rules, facts, and explicit concepts that we use consciously when we reason and make decisions as part of our normal knowledge work. To a large extent, it is "how-to" knowledge and "know-how." Examples of *pragmatic* knowledge include:

- Knowledge of how to deal with normally occurring management situations within one's area of responsibility.
- An experienced team leader's expert knowledge of how to organize and supervise quality teams.
- Knowledge of how to perform the daily aspects of one's normal specialty, such as how to operate a computer and how to write inter-office memoranda to achieve the desired effects.
- Knowledge of how to deal with one's subordinates to provide them with directions, motivate them, monitor their work, etc.
- Knowledge of how to implement a particular risk hedging strategy step by step.

Pragmatic knowledge is used directly to make decisions that are based on conscious reasoning. We use this kind of knowledge all the time. Whenever we reason consciously to perform our knowledge work, or in any other situation, we are likely to draw on our *pragmatic* knowledge. In a "generate and test" situation, we use *pragmatic* knowledge to reason explicitly

about such things as what the features should be of the next alternative that we generate, what its strengths and weaknesses might be, and so on.

We obtain *pragmatic* knowledge from a number of sources. We receive it from training, some education, and when our coworkers tells us how things work and are to be done. We also develop *pragmatic* knowledge when we figure out how things work and how we need to deal with them.

AUTOMATIC KNOWLEDGE -- Routine Working Knowledge

Knowledge on this level is fully internalized and we use it without thinking. We handle situations automatically using this knowledge. Examples of *automatic* knowledge include:

- Knowledge of actions to take on routine management issues that "happen all the time" and, therefore, do not need special consideration.
- Knowledge of handling interactions and group leadership in quality circles.
- Knowledge of placing orders for a commodity contract once the size and contract source are decided.

Automatic knowledge is used to guide highly routinized actions. When we codify and document knowledge or embed it in systems and procedures, technology, and organizations, or in active, knowledge-based systems, it may represent different levels. In fact, however, different knowledge repositories tend to favor particular levels selectively.

Some Conceptual Levels Have More Explicit Knowledge Than Others

Knowledge on the different conceptual knowledge levels varies in explicitness. While some is well known and quite explicit, some is tacit, either because it is not well known or because we have compiled it to where it has become automatic. The approximate amount of tacit and explicit knowledge that we have is shown qualitatively in Figure 4-9.

As we become more expert in a subject matter, we tend to shift knowledge from one level to the next in the direction of the arrows illustrated in Figure 4-10. When beginners first are introduced to a subject matter (as shown to the left in the figure), they normally possess very limited *idealistic* knowledge. Depending on the type of education or training they will have a little *systematic* knowledge, beginning *pragmatic* knowledge, but no *automatic* knowledge.

As they become more accomplished (moving to the right in the figure), people add knowledge items (on all levels, not only on the top level as indicated in the figure). In the process of becoming better acquainted with and internalizing the knowledge, they integrate and build associations for some of the *idealistic* knowledge whereby it becomes *systematic* knowledge.

Figure 4-9. Approximate Amounts of Tacit and Explicit Knowledge for the Four Conceptual Knowledge Levels.

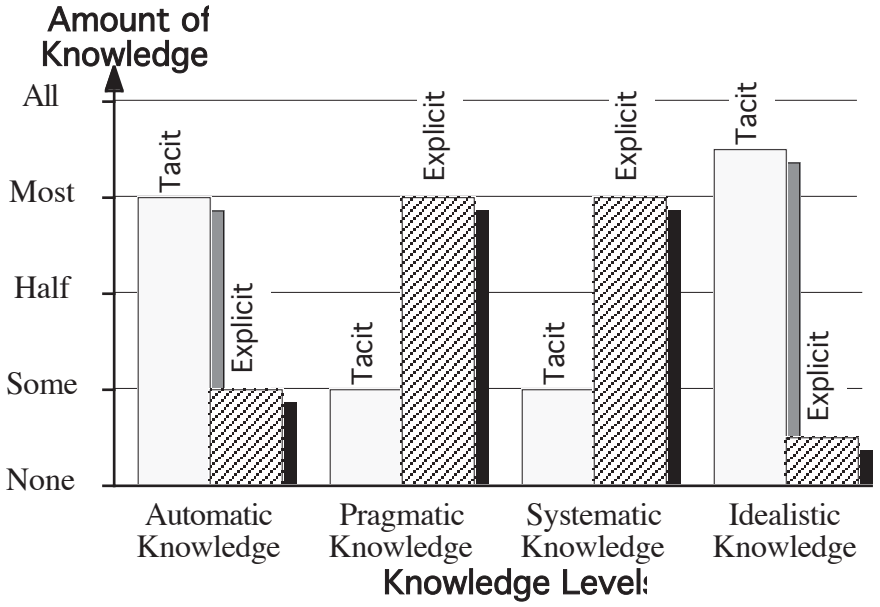
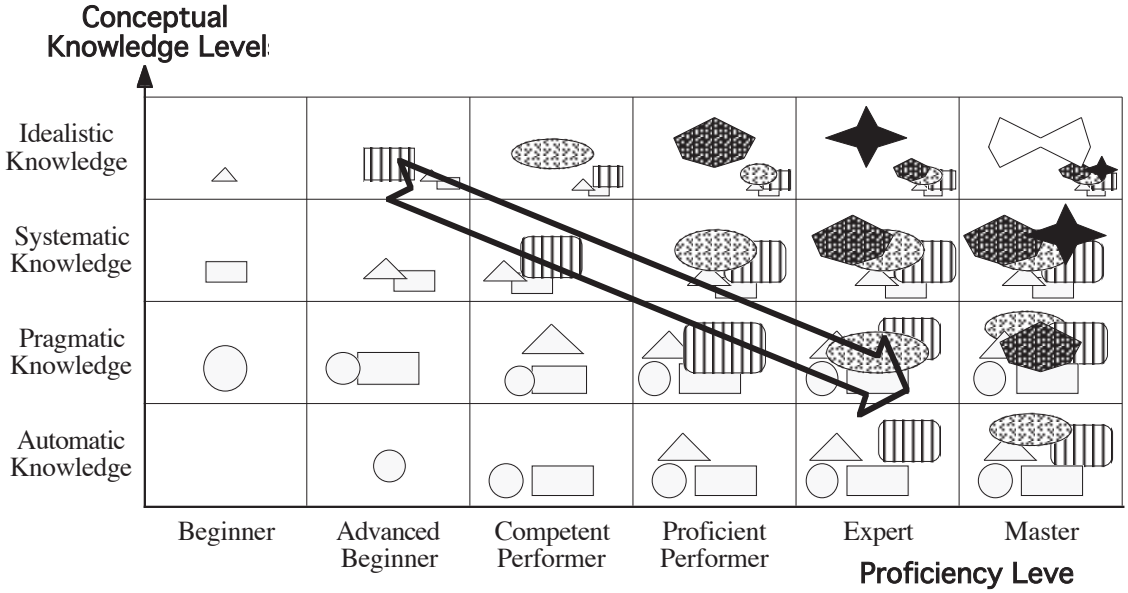


Figure 4-10. Schematic Illustration of How Knowledge Shifts Between Cognitive Levels as Expertise Increases.



Note: Each symbol represents a different area of knowledge. The size of the symbols indicate the amount of knowledge commanded by the individual at the different levels of expertise.

Some of the *systematic* knowledge is built into rules, judgments, and concepts for direct work and is migrated to become *pragmatic* knowledge. Furthermore, people are able to automate some of the *pragmatic* knowledge to make it *automatic* knowledge as they become thoroughly familiar with the subject matter and it becomes routine.

What is not illustrated in Figure 4-10 is that as we learn and understand more some decision-making knowledge is generalized and becomes higher-level *systematic* knowledge and may gradually also become *idealistic* knowledge. From our understanding of these processes, we can see that people often hold the same general knowledge quite differently. For example, what is *idealistic* knowledge for a beginner or performer may be well-known *pragmatic* knowledge for a master -- and may even be *automatic* knowledge for a grandmaster.

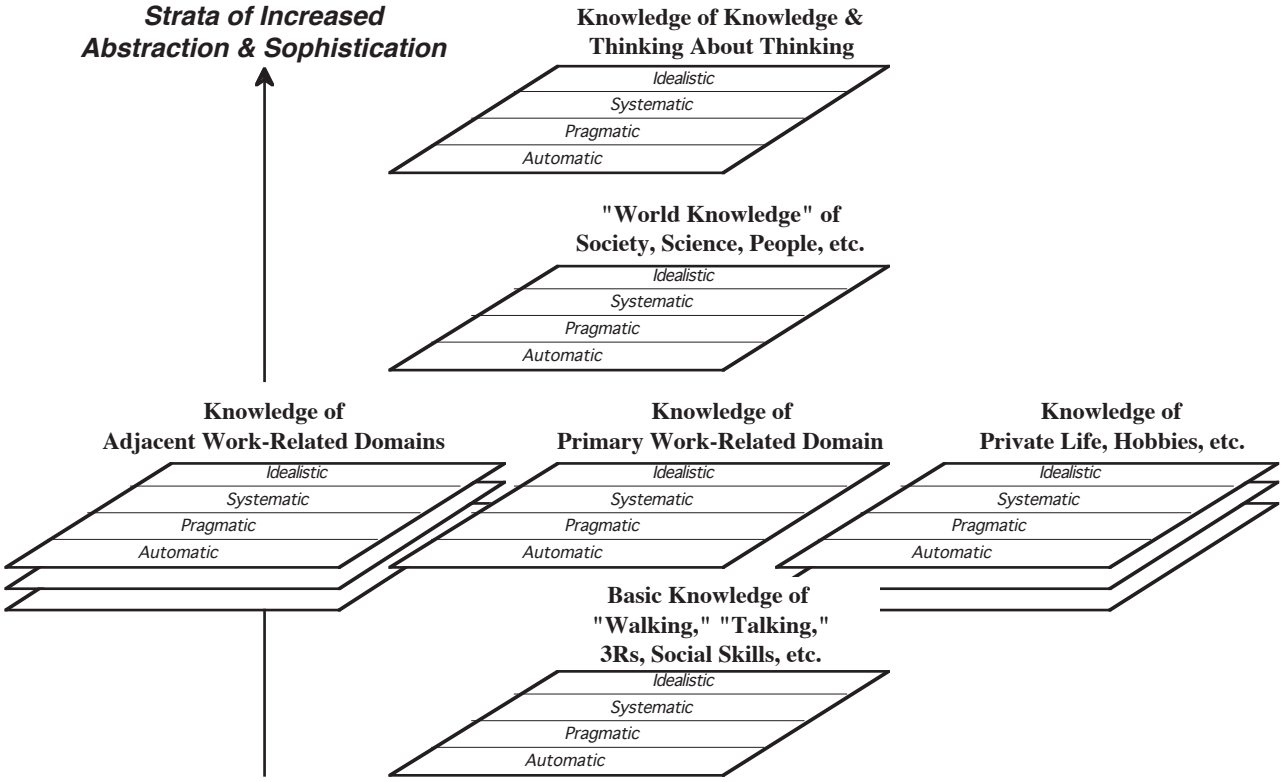
The Four Conceptual Levels Can Be Found At All Abstraction Strata

Knowledge workers have broad understandings of many knowledge domains. Some of these are relatively concrete while others are sophisticated and abstract. Figure 4-11 illustrates six typical knowledge domains that knowledge workers and most of us know with different abstraction and sophistication. The six most common knowledge areas are:

- Knowledge about Knowledge and Thinking about Thinking
- "World Knowledge" of Society, Science, People, etc.
- Knowledge of Adjacent Work-Related Domains
- Knowledge of Primary Work-Related Domains
- Knowledge of Private Life, Hobbies, etc.
- Basic Knowledge of "Walking," "Talking," 3 Rs, Social Skills, etc.

A person's most unsophisticated and concrete knowledge may be associated with basic physical and social skills, including basic communication and reasoning skills. On a higher abstraction stratum, we can find knowledge of both principal and adjacent professional domains. On yet a higher stratum is general "world knowledge" and knowledge of basic principles in the world around us -- whether social or scientific. Finally, on the highest stratum, we may find knowledge about knowledge and thinking about thinking. This domain also encompasses religion, reasoning behind basic beliefs, and philosophy. Our knowledge at all strata is held at all conceptual knowledge levels as also indicated in Figure 4-11. On closer inspection, we will find that *idealistic* knowledge typically is held with greater abstraction than *systematic* knowledge, and so on.

Figure 4-11. Hierarchy of Six Typical Knowledge Domains That Knowledge Workers Command to Different Extents.



A MEASURE OF THE **AMOUNT** OF KNOWLEDGE -- THE SEMESTER HOUR EQUIVALENT

We often require to express the amount of knowledge present or needed. A convenient (rather qualitative) measure is the amount of ***knowledge retained*** by a B+ student in one semester hour -- the semester hour equivalent, or SHE. That means that the knowledge retained in a one-semester course equivalent is 3 SHE, and in a full college education over 100 SHE, and so on.

Theoretically, if a person used twelve hours, seven days in every one of 52 weeks to learn, it would be possible to obtain 273 SHE in a year.[1] Similarly, learning on the job with 100% efficiency and constantly being confronted with new learning situations could lead to an annual knowledge accumulation of 125 SHE. Such learning efficiencies are clearly not practically

[1] Assuming that one semester hour represents the knowledge retained during 16 contact hours with no homework required.

attainable but may be considered extreme upper limits of the new knowledge a person can obtain.

As we have discussed, knowledge is obtained with different efficiency by different individuals. Some learn very quickly and internalize and retain with great ease. Others are not as quick. As a result, individual differences play a great role in the amount of the knowledge a person obtains. The exposure to learning situations and material is equally important and even an avid learner may obtain little new knowledge if forced to perform routine work in an unchanging environment for long periods.

People obtain new knowledge from many domains and at different conceptual knowledge levels. Early in life, we struggle to learn very basic knowledge for basic life functions -- how to walk, talk, interpret and handle the world around us, and so on. Later, as we enter school, we learn the "3 Rs" and similar basic knowledge. However, during this period, we also start to form abstract mental models of all the events that we observe and learn about. We form judgments and expectations for how the physical world functions and create complex models that stay with us for the rest of our life. Later, we then become exposed to more advanced learning in high school and college, until we start learning on the job or in specialized training programs that focus on our work environment. All this knowledge provides us with perspectives and ideals that later become more concrete as it becomes *systematic* until, with more learning and familiarity, it becomes *pragmatic* or *automatic*.

It is possible to illustrate qualitatively the approximate knowledge held by a person at different conceptual knowledge levels and in different domains, thereby obtaining an overview of that individual's "knowledge inventory." This is illustrated hypothetically in Figure 4-12 for a competent performer with four-year college education after three years on the job. In addition to knowledge of the primary work-related domain, this individual has a little exposure to adjacent domains, but has much to learn in that area, in the area of "world knowledge," and in the primary area to become a versatile expert.

Knowledge Holders and Cognitive Styles

People have different cognitive styles. Some are wizards at remembering and using numbers. Others are good at solving puzzles. There are people who are very good at explaining complex concepts and intricate relationships. Some people are verbal with excellent commands of language. Others, also very intelligent, are not very verbal but instead, they see things in terms of pictures or images and think in terms of concepts without labels.

To some extent, we can understand some of these differences from our models of memory and the ways we organize knowledge. For example, as individuals, we may favor episodic memory over semantic memory; nonconscious reasoning over explicit, conscious reasoning;