

with such an eloquent statement? Nonetheless, I worry that too many museums use such soothing words as excuses for the lack of follow-through with the hard work of providing opportunities to learn, to think, to reflect.

An interesting example of how one can combine experiential cognition as a motivator with tools for reflective learning is provided by the design of a game. The game shows the player how to practice the player's effective strategy. The motor model scenario hints at a particular situation. The manufacturer of the game at the museum d

games

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EXPERIENTIAL AND REFLECTIVE COGNITION

The essence of expertise is knowing what to do, rapidly and efficiently. The pilot pushes the throttles forward, controlling the nosewheel and rudder to keep the plane on the runway. "Rotate," says the copilot, and the pilot pulls back on the control wheel and, as the airplane climbs, adjusts the flaps, throttles, and gracefully banks the plane. All this is done with practiced ease and skill, continually integrating numerous sources of information—the scenes out the window, the spoken comments of the copilot, the readings of the flight director and engine instruments, the felt locations of the throttle and flaps, the sounds of the engines, and the previously memorized procedures for the particular airport and runway.

Similar stories can be told of any expert performance, whether in the airplane, on the playing field, or in front of an audience.

Consider how you can be captured by an exciting novel or television show—so engrossed that the rest of the world temporarily fades from existence. These are examples of experiential cognition: The patterns of information are perceived and assimilated and the appropriate responses generated without apparent effort or delay. Experiential thought is essential to skilled behavior. It appears to flow naturally, but years of experience or training may be required to make it possible. Although I call the mode "experiential" to emphasize the subjective aspect, an equally valid name for this mode of cognition would be "reactive," emphasizing the automatic nature of the reactions.

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All of us are expert in some domains, not in others. Once we are expert, the required responses appear to come effortlessly. A tremendous amount of processing is still required, but it is all done without conscious awareness. Subconscious processes match current experiences with our huge storehouse of experience and knowledge. Decisions that require considerable insight and information can thereby be made rapidly and without apparent effort. Experiential thought is reactive, automatic thought, driven by the patterns of information arriving at our senses, but dependent upon a large reservoir of experience.

Try it yourself: What is the sum of 2 and 4? The answer comes without conscious reflection, without any awareness. So it is with experiential cognition: The responses occur automatically, without any need for reflection, but as in this case, only if the required information has already been acquired, and this can often take considerable time and effort.

Reflective thought is very different from experiential thought, even when both are applied by the same people in similar situations. To see this, consider once again our pilots in their cockpit. We have already noted that routine, well-practiced flying is primarily experiential in nature: Encounter the situation, make the appropriate response. But suppose some decision making is required. Suppose the pilots have to plan. Now the situation calls for reflection. Thus suppose the airplane radar shows a large storm on the flight path, perhaps impeding the plane's ability to land at the scheduled destination. The crew has to decide how best to avoid

the storm. They could try to go above or detour around. Either choice is problematic, for the exact location of the storm is not known. Moreover, each will prolong the flight, use more fuel, and possibly make it impossible to get to the scheduled destination. The flight crew has to compute the likelihood of getting through to their destination and the estimated flying time and fuel usage for each possible alternative. Any alternative routing has to be cleared through the air traffic control system and, if a new destination is required, communicated to the airline company. This task involves considerable planning. The flight crew will discuss the alternatives with one another and perhaps do some numerical computations. The various alternatives will be compared until finally a decision is made.

The difference between the two modes is rooted in the technical details of the information-processing structures of the brain.

→ The one mode, experiential, involves data-driven processing: Something happens in the world, and the scene is transmitted through our sense organs to the appropriate centers of mental processing. But in experiential mode, the processing has to be reactive, somewhat analogous to the knee-jerk reflex. You know, tap the knee in just the right spot on the patellar tendon with a hammer and the lower leg jerks upward. In the case of the reflex, the stimulation of the hammer tap goes up to the spinal cord, makes the connection with the nerve fibers controlling the leg muscles, and zap, the leg jerks. No thought is involved. Experiential processing does involve some thought, but it is similar to the reflex in that the relevant information must already exist in our memory and the experience simply reactivates that information, much as the hammer tap activates the muscle movements.

Actually, some simple deductions are possible. Computer scientists Lokendra Shastri and Venkat Ajjanagadde have made an important first attempt to show just how much deduction is possible with experiential processing (which they call reflexive reasoning). They show that there are strict limits to how far a chain of reasoning can proceed. But, argue Shastri and Ajjanagadde, reflexive reasoning can make simple deductions. Thus if you read or are told that cats attempt to attack birds and if you already know that Sylvester is a cat and Tweety a bird, you can rapidly infer both that

Sylvester is likely to attack Tweety and that, as a result, Tweety is frightened of Sylvester, all reflexively, experientially. This type of rapid inference is essential to explain the ease with which we read books. After all, in most simple reading, we must make these kinds of inferences to understand the meaning, yet we do not continually stop and ponder each sentence as we read it, certainly not with everyday, nontechnical material.

Reflective reasoning does not have the same kind of limits on the depth of reasoning that apply to experiential cognition, but the price one pays is that the process is slow and laborious. Reflective thought requires the ability to store temporary results, to make inferences from stored knowledge, and to follow chains of reasoning backward and forward, sometimes backtracking when a promising line of thought proves to be unfruitful. This process takes time. Deep, substantive reflection therefore requires periods of quiet, of minimal distraction. Moreover, the use of external aids facilitates the reflective process by acting as external memory storage, allowing deeper chains of reasoning over longer periods of time than possible without the aids.

It would be wrong to try to determine which mode of cognition is superior, experiential or reflective. Both modes are needed, and neither is superior to the other—they simply differ in requirements and functions.

The reflective mode is that of concepts, of planning and reconsideration. It is slow and laborious. Reflective cognition tends to require both the aid of external support—writing, books, computational tools—and the aid of other people. The external representations have to be tuned to the task at hand if they are to be maximally supportive of cognition. Reflection is best done in a quiet environment, devoid of material save that relevant to the task. Rich, dynamic, continually present environments can interfere with reflection: These environments lead one toward the experiential mode, driving the cognition by the perceptions of event-driven processing, thereby not leaving sufficient mental resources for the concentration required for reflection. In the terms of cognitive science, reflective cognition is conceptually driven, top-down processing.

The experiential mode of performance is one of perceptual processing: what cognitive science calls pattern-driven or event-driven activity. The human perceptual system is well suited for the experiential mode, hence our excellent abilities at sports and other physical activities, our expert driving and piloting of aircraft. Experiential mode plays important roles in the routine aspects of otherwise reflective tasks, such as in some phases of chess games where the perceptual recognition of the game state can lead to a well-learned, pattern-driven response without deep reflection or planning.

From the scientific point of view, thought is a complex activity that involves multiple operations and components. It is important to remember that the dichotomy I have presented of two distinct modes is somewhat simplified. The two do not capture all of thought, nor are they completely independent of each other: It is possible to have a mixture, enjoying the experiential mode while simultaneously reflecting upon it. Most cognition involves components of both. Some kinds of cognition—daydreaming, for example—are difficult to classify as either.

From a practical point of view, the distinction between experiential and reflective thought is worth considering, in part because much of our technology seems to force us toward one extreme or the other. With proper artifacts, we can enhance each mode.

*Tools* Tools for experiential cognition should make available a wide range of sensory stimulation, with enough information provided to minimize the need for logical deduction. Similarly, tools for reflection must support the exploration of ideas. They must make it easy to compare and evaluate, to explore alternatives. They should not restrict behavior to the experiential mode. In both cases, reflective and experiential, the tools must be invisible: They must not get in the way. If tools are designed inappropriately, or for that matter, if appropriate tools are used in inappropriate ways and places, various dangers may arise:

- *Tools for experiential mode behavior that require reflection:* These tools turn simple tasks into problem-solving exercises, causing needless mental effort, taking needless

time. When taking pictures with a camera or driving an automobile, it is essential to be able to react quickly and effortlessly. If the camera or automobile controls require reflection, performance suffers: Consider the lapses of attention from driving when attempting to change the station with the typical automobile radio.

- *Tools for reflection that do not support comparisons, exploration, and problem solving:* In many cases, we need to be able to look over the situation and compare alternative courses of action or perhaps just ponder and reflect upon the variables involved. The most common tools for this purpose are writing and drawing. Many electronic decision aids tend to restrict the availability of information to small segments visible on the relatively limited display. This makes it difficult to integrate disparate sources of information, difficult to explore and to make comparisons.
- *Experiencing when one should be reflecting:* The experiential mode leads to responses without thought, without contemplation. This is essential when events move rapidly, but if the situation changes, experiential cognition may not be flexible enough to change appropriately.
- *Reflecting when one should be experiencing:* Too much reflection and the world will pass one by. See every point of view, consider every possible alternative. See the merits and perils of each alternative. Flutter in the breeze of public opinion, get caught in the trap of thought, never to decide and act.

Of all these dangers, the one I think poses the greatest peril today is that of experiencing when one should be reflecting. Here is where entertainment takes precedence over thought. Worse, one can believe that the experiential mode has substituted for independent, constructive thought, for reason and reflection.

Reflective thought is the critical component of modern civilization: It is where new ideas come from. Trashy novels are more popular than serious, philosophical ones. Comic books more popu-

## THINGS THAT MAKE US SMART

lar than novels. Films of fantasy and horror are more popular than films of content. Even informative news programs—documentary and discussion shows—are framed in the experiential mode, never allowing time for reflection, never allowing time for viewers to have their own thoughts. Unfilled time on the broadcast stations is thought to be nonproductive time. Why, the viewers might have their own ideas! Horrid thought. Worse, the viewers might get bored and do something else.

All work and no play makes for a nonrewarding life. All play and no work does not promise well for human survival and advancement. In the mental world, the correlates of entertainment and work are the two forms of cognition: experiential and reflective. Just as both entertainment and work are essential for a full physical life, both experiential and reflective thought are essential for a full mental life. The difficult intellectual challenge for modern society is to strike the correct balance.

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