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In *Mind and Its Evolution: A Dual Coding Theoretical Approach*, Allan Paivio has written a careful and thorough explication of his dual coding theory (DCT), updating prior descriptions with timely brain research and placing the entire theory within an evolutionary context. The book is aimed at a scholarly audience rather than the layperson and is divided into four sections, with the first part being a primer on DCT and classic experimental psychology. This is the part of the book most likely to be familiar to cognitive psychologists (although, as we describe below, even this section contains surprises). The second section is a primer on the brain and how DCT is implemented in the brain, with a focus on neuropsychology and neuroimaging. The third section speculates on the evolution of the dual coding mind, and the last section involves a DCT perspective on applications such as expertise, intelligence, genius, and nurturing the mind (e.g., psychotherapy). Although we wish the first two sections had been integrated rather than separated, the organization otherwise works reasonably well.
In today's age of specialists, it is refreshing to see someone with such a global perspective. The reader who expects to read 400+ pages on picture versus word stimuli will be surprised. Far from focusing on the results of a single laboratory paradigm, the book tackles a very difficult problem—the issue of representations across all of cognition—and how this evolved. Cognition is covered, from traditional components such as language and memory to the highest level of cognition—genius. The discussion is not limited to human participants; there are reports about the behaviors of paramecia, pigeons, and primates. In short, this is a wide-ranging book that goes well beyond traditional cognitive psychology in questions, content, and participants. It is DCT for all disciplines, including biology, philosophy, and the history of science.

The book is likely to surprise the cognitive psychologist who holds a passing familiarity with DCT as described in the typical cognitive psychology textbook. Of course the book contains descriptions of Paivio's classic work, such as the finding that, on average, pictures are better remembered than words (the picture superiority effect). So what is DCT, if not simply the idea that two codes or types of representations are possible? Paivio argues for two cognitive subsystems that interact to produce cognition—one verbal and one nonverbal. A key point is that both systems are modality-specific in their representations. Language can occur across modalities; it can be spoken, heard, written, and felt (as in the case of Braille). The nonverbal system also cuts across modalities; it can represent emotions, environmental sounds, tastes, smells, and textures, in addition to visual properties.

Multimodal representations are currently a hot topic, and researchers in this area would be well advised to think about the connections between their work and Paivio's. Of course one of the big questions surrounding multimodal representations involves binding: How are the different sensory features bound into a single representation? This question is discussed in a chapter aptly titled “Brain Teasers,” but it is not clear that DCT fares better than other approaches at solving this classic problem.

Returning to the issue of representations, it is important to note that *logogens* and *imagens* (the representations of the verbal and nonverbal systems, respectively) are not necessarily just two different ways of expressing the same information. Consider the example of a scientific theory; it might be expressed in words or in a diagram. Paivio points out that

> the term *expression* is misleading, however, because it implies that there is an underlying abstract theory that is simply expressed in the two forms. Not so according to dual coding metatheory. Instead [the theory consists] of interconnected verbal and nonverbal representations and their activation by the [diagrams], the verbal statements, or the evocative name of the theory. (p. 402)

The two systems might contain different information, even for the same concept. Some knowledge of a scientific theory, for example, might be

represented in only nonverbal representations, whereas other parts might be represented in both systems.

The relationship between the verbal and nonverbal systems is important, and Paivio's view is that "language never worked its magic alone and it cannot do so now. Instead, it was always depended [*sic*] on a silent partner that provides it with something to talk about…I see language as a benevolent, octopus-like parasite whose tentacles invaded the brain and was empowered by it to survive and thrive to the point where it could contribute something useful to its host" (p. 3). Paivio argues that the nonverbal system came first and that the verbal system evolved later as a mnemonic system. The argument is that language would not be necessary to communicate about copresent objects (because gestures such as pointing would suffice) but that language is ideal for communicating about past events and objects out of view. Despite the claim that "to avoid any misunderstanding, I repeat that the mnemonic hypothesis is about why language began and not how it began" (p. 282), the book does contain numerous speculations about *how* language began, and they are interesting ones.

We would have liked to have better understood exactly how the two systems interact, beyond the description of activation of connecting pathways. In several prominent places, the nonverbal system is described as "generally `stronger' than the verbal one" (p. 462); our question is how this more powerful system interacts with the less powerful one. This interaction is described as crucial in the discussions of genius and also comes up in the discussion of intelligence. The interaction is "probabilistic and optional rather than automatic and obligatory" (p. 45), which is consistent with the idea of two independent systems but begs the question of what guides them when the systems are interacting.

Consider the interaction of verbal and nonverbal systems in the memory phenomenon labeled verbal overshadowing. This is the finding that describing a face reduces ability to later identify it in a lineup, compared with a condition in which the face is not described (Schooler & Engstler-Schooler, 1990). Understanding the interaction between verbal and visual processing in this memory error has been quite complicated. Paivio discusses the idea

that describing the face in words effectively recodes it into a verbal representation, which then interferes with retrieval of the original nonverbal representation. However, it is difficult for a recoding interference account to explain why perceptual processing before the test reduces verbal overshadowing. For example, solving mazes or listening to music before the final test reduces the negative consequences of having described a face (Finger, 2002). This finding is more consistent with the idea that verbalization induces a processing shift at test. That is, because verbal descriptions of faces tend to emphasize individual features, the subject carries over this type of processing to test (which is problematic because faces tend to be recognized on the basis of configural information). Granted, we could probably use DCT language to capture this alternate mechanism as well, but it is not clear it was *predicted* by DCT.

As befits a leader in the field, Paivio does not shy away from controversial topics. Consider, for example, the issue of whether animals form mental images. Perhaps not surprisingly, given the role of imagery in DCT, Paivio believes that animals are capable of mental imagery. That may be the case, but it is certainly not a statement accepted by all researchers. Similarly, the issue of imagery in human infants is still controversial, as is the idea that this ability is innate (although trainable). Likewise, we are not sure all researchers would agree with the argument that in terms of "cognitive power" the nonverbal system is more powerful. The figure appearing on the cover of the book (and in the epilogue), however, makes Paivio's view clear: Language came in late, and although it has increased in power, it has not reached the same amount of power that the nonverbal system has.

DCT is applied to an astounding number of different problems—from intelligence to education, to psychotherapy. Such diverse skills as athletics, typing, and chess have all been linked to DCT. The strength of this approach is that these interesting connections may spark useful research. One weakness is that some of the strongest evidence supporting DCT is buried amid more speculative links, and at times the discussion strays away from clear ties to DCT. For example, the links to DCT feel forced in the section on expert knowledge of movies, literature, and sports. The least convincing are

the case studies of geniuses such as Beethoven and Skinner. It may very well be that these individuals relied heavily on both imagery and verbal codes, but the arguments are less satisfying when based on secondary sources or retrospective introspections. By contrast, Krueger's (1976, as cited by Paivio) interviews with scientists and his controlled study of their problem solving are compelling, yet they are discussed only briefly, compared with the case studies. In short, some of the diverse applications are more convincing than others, although one cannot help being impressed by Paivio's breadth in thinking about such different problems.

Given the breadth of the book, it may come as a surprise that there are a few omissions. We wondered, for example, what the DCT perspective on working memory would be. Working memory involves the short-term manipulation and maintenance of memories. Solving a multiplication problem (e.g., 237 × 311) without paper and pencil or calculator is an example of using working memory—you need to remember the problem and the interim products as you work toward your final solution. Many of the dominant approaches to working memory call for some kind of domain-general control processes (e.g., Baddeley's 1986 concept of a *central executive*), but Paivio seems to reject the idea of any amodal control processes, arguing that an executive is unnecessary because its functions arise from the interplay of verbal and nonverbal systems. It would be interesting to hear the DCT explanation of work by Engle on individual differences in working memory and how performance differences on simple working memory tasks predict performance in many domains, including reading and chess (e.g., Engle, 2002). In particular, we are interested in how executive processes "fall out of the operation of verbal and imagery processes on their own output in DCT. There is no separate, mysterious, metacomponent" (p. 364).

Even though the book has a historical perspective, today's readers will find much of interest. It is an interesting exercise to connect DCT to several findings published around the same time as this book. For example, Paivio speculates on the anticipatory function of imagery (p. 241), and within the last year several papers have been published on similarities and differences

between imagining the future and remembering the past (e.g., Addis, Wong, & Schacter, 2007; Szpunar, Watson, & McDermott, 2007). Similarly, we can see relationships between DCT and Rubin's basic systems brain-based approach to memory (Rubin, 2006), which rejects the computer metaphor of memory that is prominent in many textbooks.

In conclusion, in 464 pages, the reader will likely find some gems, some favorite citations missing, and points of disagreement with Paivio. In some ways that is the point. Donald Hebb "maintained that a good theory leads to its own destruction by making better theories possible" (p. 423), and Paivio challenges us to build from his.

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