Science of Memory: Concepts

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OXFORD
UNIVERSITY PRESS

48

Integrative comments
Transfer: The ubiquitous concept

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Transfer refers to the effect of practice on one task to learning another task performed at a later time. Every case of new learning in any organism represents an instance of transfer, in the sense that past experiences may make the new learning easier or harder. No act of learning and memory occurs in a vacuum; new learning always reflects transfer of past habits and knowledge already acquired.

The simplest measure of transfer involves a criterial task of some type (called task B here for convenience). At issue is how some prior task might affect later performance on the criterial task, relative to a control group that has been given no training or training thought to be irrelevant to B (to control for general practice effects). One group of subjects might initially practice task A, a second group task C, and a third group may either receive no training or training on an irrelevant task. The results might show that, relative to learning of task B by the control group, subjects who had practiced task A performed better on task B, whereas those who had practiced task C performed worse. These outcomes would then represent cases of positive and negative transfer from tasks A and C, respectively. Of course, the logic of transfer of training designs, as they are called, hinges critically on the control group accurately representing a neutral point.

These elementary definitions in the preceding paragraph (and more complex variations) were once well known to every student of experimental psychology, even at the undergraduate level. Textbooks devoted both to experimental psychology and to human learning and memory routinely had at least one chapter devoted solely to transfer, or to transfer and the related concept of retroaction (e.g. Woodworth 1938). However, some time during the 1970s the topic of transfer fell out, both out of textbooks and, to some degree, out of the research literature. In retrospect, this seems quite surprising because all studies of learning and memory can be considered studies of transfer, as all the authors of chapters in this section note in one way or another.

Unlike other fundamental concepts considered in this volume (e.g. forgetting), the definition of transfer and designs to study the topic are not the subject of hot debate. Rather, the issue at hand is more the application of the concept across wide ranges of the field. As Dudai (Chapter 44, this volume) notes, transfer is never explicitly discussed by contemporary neurobiologists, although they implicitly use the logic of transfer designs in their research. Students of animal learning and behavior avowedly study transfer, and Capaldi (Chapter 45, this volume) notes that one of the great discoveries in animal learning behavior—that behavior persists during extinction training (with no rewards given) much longer if prior training had occurred with a partial schedule of reinforcement than with a continuous schedule of reinforcement—is based on a transfer design. Stated differently, the partial reinforcement extinction effect refers to the fact that partial schedules of reinforcement transfer better to extinction schedules than do continuous schedules of reinforcement. Of course, the study of many other central topics discovered in studies of animal learning, such as stimulus generalization, also depend explicitly upon transfer designs.

Healy (Chapter 47, this volume) is concerned with another critical dimension of transfer, its generality or specificity. Her new research reviewed here shows cases of remarkable specificity of transfer, agreeing with other findings in various literatures on the topic, from studies of reading and memory (see Kolers and Roediger 1984) to those of problem solving and reasoning (e.g. Gick and Holyoak 1980). The aim of education is to train for broad transfer, where students will leave their classes and go into the world able to apply their training to many different classes of problem. However, anecdotal complaints from the business world about students who cannot apply what they know, as well as considerable laboratory evidence (Chapter 47, this volume), shows that transfer is often narrow rather than broad. This specificity of transfer is a critical issue in psychology, in education and in many other domains (e.g. training for tasks in the military and in industry). McDaniel (Chapter 46, this volume) is not being overly exuberant when he writes that 'Transfer is the most central concept in learning and memory'. All research on learning and memory involves transfer; all tasks we perform every day are transfer tasks; all acts of retrieval are the transfer of learning from one situation to a new situation in which retrieval is provoked by cues and the subject's retrieval set (or mode), often induced through instructions.

Transfer effects have always been considered critical to education, and the explicit study of transfer of learning can be traced to educational issues debated at the turn of the twentieth century (and beliefs held long before that). Many educators believed in the concept of formal discipline, the idea that learning to memorize sets of material in one domain would practice some general skill and make learning of other types of material easier. Formal discipline was once a firmly held principle of educational practice and encouraged an emphasis on memorization as a skill. The concept has waxed and waned in popularity over the years, but never seems to quite lose its grip, despite largely negative evidence for its efficacy. I memorized Edgar Allan Poe's *The Raven* as a freshman in high school so that I could both write it and recite it, assured by my English teacher that this exercise would help me learn other subjects such as Latin and algebra more easily. Although one can point to studies here and there showing positive effects (e.g. Winch 1908), the literature mostly shows that such ideas are wrong. William James (1890) reported experiments in his famous textbook that led him to call formal discipline into question (Volume I, p. 666), and Thorndike and Woodworth (1901*a,b,c*) conducted numerous studies of transfer that called the concept into question. In *Educational Psychology: Briefer Course*, Thorndike thundered against the accepted idea of formal discipline: 'By doubling a boy's reasoning power in arithmetical problems we do not double it for formal grammar or chess or economic history or theories of evolution' (1914, p. 268).

One absolutely secure phenomenon somewhat related to that of formal discipline is learning-to-learn, shown in many tasks. If people are given the same experimental task (e.g. learning successive lists of paired associates with different pairs in each list), they get better over lists. Because the content across lists does not overlap, the subjects are learning general skills in how to learn the list (e.g. Postman and Schwartz 1964). However, learning-to-learn differs from formal discipline in that subjects become better on practicing the same task, not in transferring the general skill to other, dissimilar tasks (as would be required for a strict form of formal discipline). As Healy (Chapter 47, this volume) notes, even one task that seems to have great *a priori* similarity to another task can fail to provide positive transfer to that task.

Can any theoretical approaches account for positive and negative transfer across a variety of domains? At some broad level, almost all theories of transfer have something in common with Thorndike's theory of identical elements, which was advanced in his works already cited (Thorndike and Woodworth 1901*a,b,c*; Thorndike 1914). The general form of Thorndike's argument is that tasks can be considered as composed of elements (either its contents or processes) and that positive transfer will occur if elements from a first task (A) overlap with those in a second task (B). (The control task used is designed to have no elements in common.) If a first task (C) has elements that conflict with those of the second (B) task, then negative transfer results, because subjects must overcome the competition between elements.

Critics pounced on Thorndike's ideas for two basic reasons: elements of tasks are hard to define, and the relationship between elements of two tasks need not be one of literal identity; similarity of task components can lead to positive transfer. Both criticisms are accurate, although they differ in their severity. The second can be overcome by changing *identity* to *similarity* of elements, but the first—defining elements—is most difficult. Within the context of a particular task, such as paired-associate learning, it is possible to use task analysis to define components. McGuire (1961) argued (and showed) that paired-associate learning involved three component processes (response learning; stimulus discrimination; and associative hook-up, or associating stimuli to responses appropriately). Osgood (1949) proposed his 'transfer and retroaction surface' as a means to account for paradoxical findings of positive and negative transfer, but wholly in the domain of paired-associate learning. No one has attempted to generalize his arguments to more complex forms of transfer, such as those reported by Healy (Chapter 47, this volume) or Kolers and Perkins (1975), to take but two examples.

The idea of transfer-appropriate processing (a phrase coined by Morris *et al.* 1977) and advocated by McDaniel (Chapter 46, this volume), among many others, put the emphasis on types of processing instead of (or in addition to) the contents of memory traces (considered as elements or features). Briefly, according to the transfer-appropriate processing approach, performance on a test of memory (of whatever sort) will be enhanced when processing operations required during the test phase recapitulate those required during an encoding or study phase. This idea encompasses mental operations as well as mental contents as determinants of transfer, and is illustrated by findings in tasks such as rereading transformed text (Kolers 1975) or naming fragmented pictures or words (Roediger *et al.* 1989), tasks that measure retention indirectly.

The transfer-appropriate processing approach is able to encompass many findings in the cognitive memory literature in a general way, but suffers from certain difficulties. A major one is that there is no generally accepted catalog of types of processing [although Roediger *et al.* (1989) argued that perceptual and conceptual processing could be considered two important types]. A related difficulty, because of the inability to define features or processing crisply, is that all these approaches run the risk of circularity. When an experimental result fails to show the expected form of transfer, the theorist can appeal to having misidentified the relevant elements, features or type of processing (for discussion of this issue, see Roediger *et al.* 2002). Clearly much theoretical work remains in order to understand transfer effects properly. Osgood's (1949) theory is perhaps the most heroic, but is applicable to a limited domain (and debated even within that domain; see Hall 1971, pp. 375–385).

Transfer studies make another important point that might be called 'the relativity of remembering', using the term *remembering* in its generic, nontechnical sense (of 'memory performance'). Many different tests and assessments of memory are possible, even in laboratory settings; there is no acid 'test of memory'. When multiple valid measures of memory are examined as a function of various independent variables, they often reveal that performance across measures is uncorrelated. *Relativity of remembering* refers to this fact that the outcome of an experiment is relative, depending on the particular memory test used and the relationship between the study or encoding conditions and the test conditions. For example, studying words (e.g. *eagle*) in one study condition (e.g. judging whether a word belongs to a semantic category such as birds) may have a large positive effect relative to another encoding condition (making rhyme judgments about words; does the word rhyme with *legal*?) on a later recall or recognition test for the words. This outcome constitutes the standard levels-of-processing effect (Craik and Tulving 1975). However, after the same study conditions, the opposite outcome may occur on a memory test that measures recognition of rhyming words from the study list (did a word that rhymed with *beagle* occur in the list?), because the test requiring knowledge of rhymes overlaps more with the information encoded in the rhyming condition at study (Morris *et al.* 1977). Finally, on other tests that use phonemic retrieval cues, no effects of encoding condition have been observed (Fisher and Craik 1977). The same generally null results from varying phonemic and semantic processing during study occur on perceptual implicit memory tests such as identification of briefly presented words (Jacoby and Dallas 1981) or completion of word-stems or word-fragments with the first word coming to mind (Roediger *et al.* 1992).

The bottom line is that several different tests, all of which indubitably assess some form of memory, show completely different patterns of performance as a function of the type of study processing. Such dissociations are of interest to those studying memory, but often seem to be considered as exceptions to some general rule (of parallel results across tests). However, Kolers and Roediger (1984) argued that such dissociations are really the rule, not the exception, in transfer designs. The reason much research rarely uncovers such differences is that most experiments examine a single measure of retention. Whole careers are built on studying one measure (whether fear conditioning, or free recall, or the Morris water maze, or passive step-down avoidance) and assuming that the principles emerging from these studies are general ones, applying to all forms of memory. For example, what is known about episodic memory from neuroimaging experiments is almost entirely derived from studies of yes/no recognition memory.

The assumption that underlies such single measure experiments—that all memory measures correlate and measure some quantity such as 'strength of memory—is surely wrong. Perhaps the most systematic study illuminating the relativity of remembering was conducted by Challis *et al.* (1996), who crossed five encoding conditions in which words were studied with various tasks and instructions with six different conditions employing a variety of memory tests (with a different group of subjects receiving each test). The details of the study (using a 5 × 6 design!) are rather complex. However, the tests involved a variety of standard memory tests (both explicit and implicit) used in many laboratory paradigms. The fascinating results from the experiment showed radically different patterns of performance across tests, i.e. the tests differed markedly among themselves in revealing effects of past experiences afforded by the prior encoding conditions. Although the results of Challis *et al.* used many tests, practically every experiment using just two or three rather different memory tasks shows the same complexity between encoding and testing conditions. The standard outcome is an interaction, and this fact severely undermines the common assumption that memories vary in some straightforward quantitative fashion, often referred to as 'memory strength', because such strength theories predict a uniformity of results across tests. Tests may be differentially sensitive to strength, by this view, but the ordering of conditions should not change. Yet clearly it does.

To conclude, if a researcher claims that 'variable X has a positive effect on memory', you can be almost certain the claim is untrue. The claimant really means 'Our study has shown that variable X has a positive effect on a particular measure of memory'. We can be almost certain that if some other perfectly valid measure were used, either no effect, a different effect or even the opposite effect would have been obtained. Transfer studies clearly undercut the idea of unitary notions of memory by revealing dissociations among tests and, consequently, the multiplicity of forms of retention. Ideas such as transfer-appropriate processing provide some understanding of these puzzling facts, although clearly much theoretical work to expand these ideas is needed. Transfer is the fundamental concept for understanding the science of memory.