2 Cognitive Psychology and Situated Learning: Foundational Research on Transfer of Learning

This volume begins with a review of the fields of cognitive psychology and situated learning—in part because they offer the earliest instances of empirical research into transfer of learning and more importantly because they establish the foundational arc followed in many other fields from behaviorist assumptions to cognitive investigations to a growing appreciation of the situated nature of learning. We will see the same arc in writing studies and in a number of other areas in the following chapters including industrial and organizational psychology (Chapter 3), and sports, medical, aviation, and military education (Chapter 4). Nonetheless, psychology remains focused primarily on individuals and is dominated by the so-called two-problem paradigm that establishes a baseline of initial learning, then tracks subsequent transfer of that learning to a novel context.

Cognitive studies of transfer are dominated by a few recurring questions.

- What level of abstract understanding best facilitates transfer of learning? How can individuals effectively build such abstract understandings? What is the influence of social and material contexts on those abstractions?
- What types of hints or cues might prompt individuals to recognize similarities between prior learning and new contexts?
- Are there general abilities that will facilitate transfer of learning?

Much of the cognitive research on transfer of learning focuses on analogical reasoning; it was conducted in labs and studies "isomorphic problems"—that is, problems that share a deep underlying structure despite superficial differences. Another tradition of cognitive research into learning—theories of dual processing—doesn't address transfer of learning directly but nevertheless has important implications for understanding how individuals draw on their earlier learning when they approach new contexts. Subsequent research from the situated learning perspective, however, often moved out of the lab, studying, for example, how individuals repurposed their classroom learning of mathematical concepts in homes and in stores.

Although cognitive studies of transfer did not pay much attention to writing, we can see their influence on later writing studies research—for example, in the role attributed to abstraction in high- and low-road transfer and in the imperative for students to develop theories of writing as a means of promoting transfer. Also, the "actor-oriented perspective" (rather than that of teachers and researchers) dominant in writing studies has its origins in cognitive studies. This chapter outlines the history of psychological research on transfer of learning from early behaviorist work by Thorndike, through cognitivist approaches and their situative critiques, to current efforts to synthesize those approaches.

Thorndike and the Early History of Transfer

The first formal empirical study of transfer in the Western tradition is often attributed to Thorndike, who, together with Woodworth, published three studies on how improvement in one "mental function" might influence the "efficiency" of others (Thorndike & Woodworth, 1901a, 1901b, 1901c). These studies interrogated the assumptions of formal discipline theory, which asserted "the mind was a collection of faculties or powers—observation, attention, memory, reasoning, will, and the like—and that any gain in any faculty was a gain for the faculty as a whole" (Thorndike, 1906 / 1916, p. 236). Formal discipline theory regularly invoked metaphors of the mind as a machine (which could be made more efficient) and as a muscle (which could be made stronger). In contrast, Thorndike and Woodworth argued that previous research had established no correlation between relatively distinct skills like spelling and multiplication (1901a, p. 248) and set out to

examine participants' ability to transfer between two more closely related skills sets.

Thorndike focused on the similarities between two tasks he believed could facilitate transfer but found that training in one task did not necessarily improve performance in another. One study, for example, found no transfer from the ability to estimate area in rectangles to triangles (Thorndike and Woodworth, 1901a, p. 256). Another study found training in identifying one alphabetic pattern (for example, ER) did not lead to improvement in identifying a different alphabetic pattern (say, AN). However, the study did find improvement in those pairings that had "identical elements" (Thorndike & Woodworth, 1901c, p. 558); for example, if subjects were to first look for instances of ES, participants were subsequently more successful finding ERs or SPs (which share an identical letter) than ANs.

Thorndike later expanded on this theory of identical elements in popular texts that explicitly debunked the tendency to valorize certain subjects of study (like Latin) as a means to general improvement:

> One mental function or activity improves others in so far as and because they are in part identical with it, because it contains elements common to them. Addition improves multiplication because multiplication is largely addition; knowledge of Latin gives increased ability to learn French because many of the facts learned in the one case are needed in the other. (Thorndike, 1906/1916, p. 243)

Put into pedagogical practice, Thorndike's theory of identical elements argued for a series of carefully sequenced tasks meant to establish as much overlap as possible from one context to the next. As the field of psychology developed, however, critics came to condemn Thorndike's theory of identical elements as a hallmark of his behaviorism (e.g., Beach, 1999, p. 105).

An early challenge to the identical elements theory of transfer emerged from Judd's (1908) studies of elementary school boys throwing darts at an underwater target. Because the light refracted under water, the target was not where it appeared to be. Judd explained the principle of refraction to half the participants before they threw the first dart. At first, that explanation made no significant difference in the performance of the two groups. However, when (in a second round of the experiment) the depth of the water changed, the participants

armed with a theoretical description of refraction performed considerably better. Judd concluded that it's not identical elements that matter, but rather abstract principles combined with initial learning; Judd's finding began a long tradition of research searching for the optimal sequence of exposure to concrete examples and abstract principles.

Rather than focusing on connections prompted by superficial identical elements, Gestalt theorists understood transfer of learning as the result of an individual's deep understanding. Katona (1940), for instance, compared the "senseless" learning engendered by a "depository of connections" to the "meaningful" learning that results from true understanding of a principle (p. 5-6). Through experiments conducted with card tricks and geometry problems, Katona concluded that meaningful learning occurs when "an integrated knowledge (a whole-principle) [is] acquired and . . . later applied to all tasks involv[ing] the same principle" (p. 127). Werthheimer (1945/1959) similarly argued for the value of whole-quality learning, using the example of children taught to calculate the area of a parallelogram who then struggled to calculate the area of parallelograms with only minute surface-level differences. The problem, he concluded, was that they did not have the kind of "structural understanding" that "plays a decisive role in transfer" (p. 35). This focus on the wholeness of learning was a stark contrast to Thorndike's focus on the match between individual (and often atomized) elements.

The Cognitive Revolution

Thorndike's theory of identical elements held great sway in educational circles during the first half of the twentieth century: it remained "the guiding notion behind a very large number of educational approaches that were especially popular from the period of about 1940 to 1970" (Royer et al., 2005, p. xiii). Not until psychology's so-called cognitive revolution in the 1950s did researchers begin to build significantly different theories of transfer, focusing less on the learning environment and more on individuals' mental representations of that environment.

Concepts and Schemata: Definitions and Methods for Study

The basic unit of analysis in cognitive research is the *concept* (Hammer et al., 2005, p. 95), a mental representation of a category of objects

(whether tangible like "dogs" or intangible like "love") that an individual builds or abstracts through exposure to multiple specific examples. Concepts are often understood in relation to each other; these relationships are sometimes called a schema. Concepts and schemata are often referred to as "deep structures"—as opposed to the surface features of various specific situations.

Methodologically, early cognitivist research on transfer frequently focused on analogical reasoning, tracing how individuals use the concepts and schemata they've developed from previous specific situations to make sense of a new situation. Such studies often adopted the two-problem paradigm pioneered by Thorndike, lab studies that tracked whether exposure to task A would have any discernible effect on participants' ability to complete task B. By setting up "isomorphic problems" in which tasks had the same deep structure but significantly different surface features, cognitivist researchers probed participants' ability to recognize the relationships between them. Overwhelmingly, researchers concluded that individuals are unlikely to make spontaneous connections. Reed et al. (1974), for instance, found that despite what seemed to the researchers like obvious parallels between two problems, participants proved unable to solve the second problem any more quickly or accurately than the first and concluded "there was no significant transfer between the two problems" (p. 439). Gick and Holyoak (1980) found that when asked to solve a difficult problem and provided with an analogy, participants noticed and used the analogy to solve the problem only 20% of the time—hardly much better than the 10% of people who came to the solution without any analogy provided.

Despite the persistent difficulties of documenting spontaneous transfer, cognitivist researchers identified at least five conditions that tend to assist people in transferring knowledge: robust initial learning, an ability to move beyond surface details to recognize more abstract concepts and schemata, hints, a process of comparing cases to build an appropriately abstract schema, and general abilities like heuristics and mindfulness.

Robust Initial Learning

One central finding from Gick and Holyoak's (1980, 1983) foundational research on analogical reasoning is that mere exposure to an isomorphic problem does not have the same positive effect as robust

learning that results in abstracting the relevant concept. The isomorphic problem at the heart of Gick and Holyoak's research relies on a medical dilemma first posed by Duncker (1945): the radiation required to destroy a tumor must be intense enough to destroy the tumor, but such radiation also destroys healthy tissue it traverses; radiation levels low enough to not harm healthy tissue won't destroy the tumor. How to proceed? The so-called *dispersion solution* sends low-intensity radiation from multiple directions to converge on the tumor. Duncker found that participants rarely generated the dispersion solution spontaneously: of 42 participants, only two generated the dispersion solution—and only with a hint.

To study the conditions under which people could generate a solution to Duncker's radiation problem through analogical reasoning, Gick and Holyoak created an isomorphic problem: a general wants to attack a fortress located at the center of several roads that radiate like spokes from the hub of the fortress; the roads have been mined to explode under the weight of any substantial army. If the general sends too many troops down one road, the mines will detonate; if the general doesn't send enough troops to the fortress, they cannot succeed. The general's solution is to send smaller groups along each road: each group is too small to set off the mines on their road, but collectively they can capture the fortress. Using Duncker's radiation problem and this isomorphic military problem, Gick and Holyoak designed a series of experiments to gauge what kinds of exposure to analogous problems might help participants generate the dispersion solution.

Gick and Holyoak (1983) found that deep learning is necessary for people to draw out the implications of their analogies. In one experiment, before participants were given the radiation problem, they were asked to read and engage with two analogous stories by writing about the similarities between the stories. Researchers then rated the degree to which those descriptions articulated a schema that focused on the convergence of dispersed forces. When subsequently given the medical radiation problem, individuals whose descriptions were rated as good schemata were able to generate the dispersion solution without a hint 91% of the time; those with an intermediate schema could do so only 40% of the time; and those with a poor schema only 30% of the time (pp. 23–24). This finding strongly suggests that robust learning in the form of an emergent abstract schema leads to increased rates of spontaneous transfer. Similarly, Gentner and Gentner (1983) concluded that

exposure to an analogy does not have the same effect as robust learning that results in a rich mental representation.

An Ability to Move Beyond Surface Details to Abstract Schemata

Gick and Holyoak's (1980) research also makes clear that surface differences impede transfer. For instance, when they gave participants the story about the general and a second story that had more surface differences despite a deep structural similarity, they found that surface differences impeded (but did not entirely inhibit) analogical reasoning. One means of promoting transfer, then, might be moving beyond, even erasing, surface-level details. This ability to overcome the distractions of surface details is characteristic of expert knowledge. For example, Chi et al. (1981) found that while expert physicists tended to sort physics problems according to deep structural differences (like the laws of physics), novice undergraduate physics students were more likely to focus on surface details (sorting problems according to objects or keywords—like planes or blocks on an incline). One of the characteristics of expertise is the ability to use surface-level features, like springs, to access deep structural knowledge, like the laws of energy.

However, in later research, Gick and Holyoak (1983) identified a tension: although having an abstract schema makes it easier to recognize analogies that might be obscured by surface-level differences, it is also true that particular surface similarities sometimes prompt an individual to make the connection to an abstract schema. (This finding resonates with Nowacek's [2011] claim that genre can be an exigence for transfer and Lindenman's [2015] idea of metagenres, discussed in Chapter 8.) As a result, the "'optimal' level of representation for successful analogical thinking may typically lie at an intermediate level of abstraction" (p. 9).

Hints

Another recurrent finding in the analogical reasoning studies is that people's ability to transfer dramatically increases if they are prompted to use their prior knowledge. Gick and Holyoak's (1980, 1983) research, for instance, is filled with examples of the importance of hints. Throughout their eleven experiments, participants were more likely to achieve the dispersion solution if they were given a hint—that is, if they were told "you may find that the first problem you solved gives

you some hints for solving the second problem" (1980, pp. 337–8). This tendency is particularly visible in the fourth experiment of the 1980 study. All participants were asked to memorize three stories—one was the relevant story about the general and two others were distractor stories—and then given the radiation problem to solve; some participants were given the hint that the earlier story might prove helpful; others were not. With the hint, 92% of participants could identify the problem the general faced as useful and generate the dispersion solution—but without the hint, the percentage of participants able to generate the dispersion solution plummeted to 20%. Hints, it appears, can even overcome distractor stories with false analogies. Similarly, Reed et al. (1974) found that most participants given two isomorphic puzzles did not, when left to their own devices, solve the second problem any faster or more accurately than the first, suggesting the lack of any transfer. However, when the second problem "included an additional paragraph that described how the second problem was related to the first" (p. 439), rates of transfer increased dramatically. Together, these studies suggest the power of hints or prompts to facilitate transfer.

Articulating an Abstract Principle from Comparative Cases

In addition to the value of hints, research in the cognitivist tradition argues that prompting participants to draw abstract principles from multiple examples facilitates analogical problem solving/transfer of learning. Although early research (Judd, 1908) argued that participants given a brief explanation of the abstract principle performed better than those without, subsequent research argued that simply providing participants with the abstract principle behind an analogical solution was consistently less effective than requiring participants to compare multiple examples and actively abstract the principle themselves. More specifically, researchers examined multiple factors that might influence the process of abstracting principles, including how many example stories participants were given, whether those stories illustrated the general principle or were "distractor" stories, whether participants were also given an explicit articulation of the abstract principle, and whether the participants were asked to articulate the abstract principle for themselves. Three findings stand out as particularly important for writing studies scholars.

First, providing participants with the abstract principle is not as helpful as providing examples (in the form of stories). Gick and Holyoak (1983) found that participants given only the principle improved their ability to generate the dispersion solution at a lower rate than participants given stories or stories and the principle (66% rather than nearly 80%).

Second, what helps participants most is working with *multiple* examples or stories—especially when participants are asked to abstract a general principle. Gick and Holyoak (1983) found that if participants were given two stories illustrating the dispersion principle from different domains, the frequency of generating the dispersion solution without a hint more than doubled the rates with only one analogy. Furthermore, working to actively compare those examples proves crucial, as illustrated by Gentner and colleagues' research on analogical encoding (the process of not just reading two analogues but actively comparing and connecting them). In a study of business students learning new negotiation strategies, Gentner et al. (2003) found that participants who actively compared cases exemplifying a new principle were more than twice as likely to transfer that principle to a subsequent negotiation than participants asked to describe but never compare sample cases. Gentner's theory of analogical encoding proposes that individuals can inductively build their own schema through comparisons, and that serial exposure to multiple examples is far less effective in facilitating transfer of learning than actively comparing them to build an appropriately abstract schema grounded in specifics.

Third, explicit articulations of the underlying principle provided by the researcher are helpful inasmuch as they ensure that participants' self-generated principles are on the right track. For instance, Gick and Holyoak (1983) evaluated the quality of participants' articulations of their general principle (or "schema"). They concluded that when participants were given an explicit articulation of the general principle in addition to being asked to describe in writing the similarities between the stories, the "addition of the principle had a strong influence on schema quality" (p. 26) as well as eventual transfer. In short, for writing studies scholars interested in helping students "learn how to learn", this finding—that multiple examples combined with an explicit articulation of the principle helped participants increase their rates of transfer—may offer important pedagogical guidance.

General Abilities: Heuristics, Mindfulness, and the Value of Automatized Cognitive Processes

Finally, researchers in the cognitivist tradition asked whether there might be general, portable strategies that can facilitate transfer. After briefly reviewing the idea of general heuristics, we turn to the idea of mindfulness that characterizes Perkins and Salomon's ideas of high-road and low-road transfer. Because Perkins and Salomon receive so much uptake in the field of writing studies, we conclude this section on cognitivist research by contextualizing their work within the cognitivist tradition of "dual processing" research.

One manifestation of the hope for "general skills" that might facilitate transfer was the idea of a general heuristics—or "methods and rules of discovery and invention" (Polya, 1945/1957, p. 112)—for mathematical problem solving. Much like ancient rhetoric's *koina topoi* that serve as a means of invention in any situation whatsoever (Aristotle, 2004, p. 90), Polya's (1945/1957) popular text aimed to articulate a series of questions that could prompt productive mathematical problem solving for any type of problem. The bulk of the book is a dictionary of heuristics—largely consisting of questions (Can you derive the result differently? Do you know a related problem?), prompts (Examine your guess. Look at the unknown.), and significant concepts (corollary, setting up equations). Polya frames this book as a generative catalog of the behaviors of expert mathematical problem solvers, not a narrow prescription. Heuristics like these have had a long shelf life as general strategies that can be used across varied contexts—the ultimate portable, transferrable knowledge.

Polya's work with general heuristics was extended by Schoenfeld in two important ways. First, Schoenfeld (1985) empirically demonstrated the positive effect of Polya's heuristic strategies; students in a classroom focused on five of Polya's heuristics did significantly better on a test designed to probe their problem-solving skills. Second, Schoenfeld worked to help students internalize a series of heuristics *and* learn to choose among them. Working from transcripts of problem-solving sessions, Schoenfeld (1992) argues that experts exhibit extraordinary self-monitoring skills that help them try out and discard a series of possible approaches—and that such self-monitoring strategies can be taught. After taking a course based on his heuristic pedagogy, the number of students who would jump into a solution attempt and pursue it no matter what dropped from 60% to 20%. This self-regulation is

another manifestation of a general strategy that might transfer—and facilitate transfer—across problem types. Certainly, writing studies scholars have long been interested in this type of self-monitoring (from Flower and Hayes's [1981] discussion of the monitor onward), and it is increasingly considered in studies of writing transfer (Driscoll & Powell, 2016; Driscoll & Wells, 2012).

While Schoenfeld focused on the portable strategy of self-monitoring, Perkins and Salomon (1988, 1989) focused on mindfulness. Transfer, they note, suffers from a Bo Peep problem: people assume that transfer will automatically follow learning, like sheep trailing after the nursery-rhyme maiden—but such trust is "inordinately optimistic" (1988, p. 23). To explain why transfer does (and does not) take place, they posit two types of transfer: low-road and high-road transfer. Low-road transfer "reflects the automatic triggering of well-practiced routines in circumstances where there is considerable perceptual similarity to the original learning context" (p. 25); for instance, when a person sits down to drive a truck after having only ever driven cars, "the steering wheel begs one to steer it, the windshield invites one to look through it, and so on" (p. 25). High-road transfer "depends on deliberate mindful abstraction of skill or knowledge from one context for application in another" (p. 25) and can be either forward looking or backward reaching.

These are familiar concepts to scholars in writing studies, imported by researchers interested in transfer of writing skills (e.g., Anson, 2016; Beaufort, 2007; Kain & Wardle, 2005; Nelms & Dively, 2007; Nowacek, 2011; Reiff & Bawarshi, 2011; Yancey et al., 2014). What is less well known, though, is how this model of transfer is in quiet conversation with another tradition of cognitivist research, research focused not on the types of analogical problem solving discussed thus far in this chapter, but on attention, memory, and perception. The high-road/low-road model is one among several ways of understanding transfer. On one hand are those scholars who valorize mindfulness and dismiss the more routinized process Perkins and Salomon associated with low-road transfer; on the other are scholars who articulate the value of what they call automaticity in the development of abstract schema and expertise. Salomon explicitly acknowledged the connection of this work to the tradition of attention research by noting that the "construct of mindfulness . . . is based on the distinction between

controlled and automatic processes (Schneider & Fisk, 1984; Shiffrin & Schneider, 1977)" (Salomon & Globerson, 1987, p. 625).

To better understand what the work of Perkins and Salomon offers writing studies and what it obscures, it is helpful to also understand theories of dual-processing. Although a wide range of dual-processing theories use different terminologies, they share the idea that every individual possesses "two different modes of processing" characterized by "processes that are unconscious, rapid, automatic, and high capacity, and those that are conscious, slow, and deliberative" (Evans 2008, p. 256). Kahneman (2003, 2011) calls those two processing systems "System 1" and "System 2" and explains that

> The operations of System 1 are typically fast, automatic, effortless, associative, implicit (not available to introspection), and often emotionally charged; they are also governed by habit and are therefore difficult to control or modify. The operations of System 2 are slower, serial, effortful, more likely to be consciously monitored and deliberately controlled; they are also relatively flexible and potentially rule governed. (Kahneman, 2003, p. 698)

Whereas the dual-processing scholarship persistently acknowledges the complementary nature of these two systems, other scholars especially value the flexibility of System 2's effortful, mindful control—suggesting that it is a portable quality or strategy that can facilitate transfer across multiple contexts. (See, for instance, Hatano and Inagaki's [1986] discussion of adaptive expertise.)

Flexibility and control are valorized in Perkins and Salomon's concept of high-road transfer. In an earlier essay, Salomon and Globerson (1987) connected this mindful process with increased levels of abstraction. Referring to research by Gick and Holyoak (1983) on the limited usefulness of providing participants with an already formulated general principle, Salomon and Globerson conclude that it's better for subjects to be "actively engaged themselves in mindfully abstracting the problem's underlying principle. Having an abstraction," they determine, "is not the same as mindfully deriving one" (p. 633). In a similar vein, Salomon (with Perkins) largely dismisses low-road trans-

fer in a subsequent publication, using the stimulus-response language of behaviorism so reviled in cognitivist research.[2]

Other scholars, however, are less dismissive of the value of more automatized processes. Shiffrin and Schneider (1977), for instance, are part of a tradition of inquiry interested in how people manage the cognitive load limitations of short-term memory. Faced with the problem of how individuals divide their attention among multiple sensory inputs, Shiffrin and Schneider distinguished between what they call "automatic detection" and "controlled search."[3] Although controlled processes "may be set up, altered, and applied in novel situations for which automatic sequences have never been learned" (pp. 156–7), the continued advantage of automatic processes is that they are not constrained by the capacity limitations of short-term memory and "their speed and automaticity will usually keep their constituent elements hidden from conscious perception" (p. 160).

The hidden value of automated, even unconscious processes is also at the heart of the work of Kahneman, well known both for the Nobel Prize in Economics he received for his work on decision-making and for his best-selling *Thinking, Fast and Slow* (2011). Kahneman began as a cognitive psychologist "rooted in the psychology of perception" (2011, p. 6) and interested in attention; early in his career (Kahneman, 1973), he argued for a "capacity model" of attention that informed the work of Shiffrin and Schneider and others. In *Thinking, Fast and Slow*, Kahneman calls on that research to defend the importance of System 1 (or "fast") thinking and argue that the routinized automaticity of System 1 is where skilled expertise, built up over long periods of time, resides. Although Kahneman acknowledges that System 1 is also the home of less informed intuitions, he argues this is not a fault of System 1, merely the reality of how Systems 1 and 2 co-exist. Indeed, Kahneman suggests, if blame is to be placed, it should fall at the feet of the mindful abstractions of System 2, which are often too slow to kick in

2. "The major difference between the low and the high roads to transfer lies in the processes that yield the transfer: *automatic, stimulus-controlled*, and extensively practiced behaviors or cognitions versus mindful deliberate processes that decontextualize the cognitive elements which are candidates for transfer. The hallmark of the high road is the mindful abstraction it involves." (Salomon & Perkins, 1989, p. 124, emphasis added)

3. Shiffrin and Schneider were by no means the first to offer such a model, as a lengthy section relating their model to previous models (pp. 171–184) indicates. See Evans (2008) for a thorough review of the scholarship.

(2011, pp. 416–7). It is easy to fault System 1 for leading people to intuitive, unconsidered mistakes. After all, Kahneman notes, "When we think of ourselves, we identify with System 2, the conscious, reasoning self that has beliefs, makes choices, and decides what to think about and what to do." But, Kahneman adds, System 1 should not be so easily dismissed: "Although System 2 believes itself to be where the action is, the automatic System 1 is the hero of the book" (2011, p. 21). In short, Kahneman and others in the tradition of research on attention offer an important counterbalance to ways in which the valorization of mindful high-road transfer has often dismissed more automatized low-road transfer. For writing studies scholars, this tradition of cognitivist research may offer a framework for reconsidering both the frequency and the value of unconscious or automatized transfer. (See, for instance, Donahue, 2012; Nowacek et al., 2019; Ringer, 2018).

Situated Learning Critiques of the Cognitive Approach

Although the cognitivist approach to studying transfer has been highly generative, it has not been without criticism. Lave and Wenger's (1991) notions of communities of practice and legitimate peripheral participation have received much attention within writing studies, but it was Lave's (1988) earlier work on mathematics in everyday life that offered a new paradigm in psychological studies of transfer. Critiquing the limitations of cognitivist studies confined to laboratories, Lave established the advantage of "moving into the experienced, lived-in world as the site and source of further investigations of cognitive activity" (p. 44). The Adult Math Project studied how individuals use math in contexts like supermarkets and dieting and concluded that people's mathematical reasoning is profoundly affected by context. As a whole, the Adult Math Project challenged both the theoretical assumptions and methodological approaches of previous scholarship.

Some of these situative critiques are already familiar in writing studies, including Beach's (1995, 1999) idea of "consequential transitions." His study of two generations of shopkeepers studying mathematics in Nepal illustrates the ways in which context matters for cognition. Younger students transitioning from school to work continued to use many written mathematical notations but also added the finger calculation strategies used by experienced shopkeepers. Experienced shopkeepers largely maintained their established finger calcu-

lation strategies but added some modified written notations to their practices. In both instances, individuals adapted classroom strategies in ways informed by their identities and contexts (1995). Carraher et al.'s (1985) work is less known in writing studies, but also moved out of the laboratory setting to argue for the importance of context. Researching young people in Brazil who did rapid mental calculations as part of their livelihood on the streets, Carraher and colleagues gave participants mathematical problems in a lab and on the street and found that participants with more context were much more likely to provide the correct answers (36% versus 98%) and used very different problem-solving routines. In subsequent research, Carraher and Schleimann (2002) abandoned the term *transfer* as "misleading" because it "suggests a relatively passive 'carrying over' and deployment of learning from one situation to another," seeking instead a new understanding of transfer as a process of "adjusting and adapting . . . prior knowledge" (p. 19).

Although the situated learning critique dramatically altered transfer research in the field of psychology, we can trace how issues central to the earlier cognitive research evolved in subsequent scholarship. We begin this next section by discussing how the notion of concepts changed and what that means for methods of studying transfer. We then track how situative scholars revisit the importance of two conditions central for transfer of learning in the cognitivist tradition: hints and abstracting general principles.

Revised Definitions of Concepts and New Methods for Study

In light of situated learning critiques, scholars questioned whether the concept was still the most helpful unit of analysis, revising their understanding of what concepts are and where they come from. For instance, Hammer et al. (2005) offer a "resource-based view of learning," arguing that "learning a new idea is not an all-or-nothing acquisition, but involves an activation of existing resources in new combinations" (p. 114). For Hammer and colleagues, concepts are no longer the basic unit of analysis but are "assumed to be built from finer-grained knowledge elements that have become tightly linked" (p. 96).

The situated learning critique brought a significant shift in research methods as well. Bransford and Schwartz (1999), for instance, critiqued previous studies as too focused on direct application to accurately reflect actual processes of learning and argued for a focus

on preparation for future learning (discussed within writing studies by Driscoll [2015]). Methodologically, rather than following the usual two-problem paradigm, Schwartz and Martin (2004) developed a "double transfer" study—an approach that not only affirms the value of conceptualizing transfer as preparation for future learning, but also illustrates the need for new methods to investigate those new understandings.

In a similar vein of methodological innovation, Lobato (2003, 2006, 2008, 2012; Lobato & Siebert, 2002) articulates an actor-oriented theory (AOT) that grows out of her desire to extend the theories of Lave (1988) to empirical studies (2003, p. 19). Traditional studies of transfer, Lobato points out, "privilege the perspective of the observer and rely on models of expert performance, accepting as evidence of transfer only specific correspondences defined a priori as being the 'right' mappings" (Lobato, 2006, p. 434). For example, traditional studies might conclude that a student who could state the formula but was unable to accurately calculate slope on the transfer target problem offers no evidence of transfer (Lobato & Siebert, 2002). However, Lobato found that when she stopped looking for the answers she expected based on her own expert knowledge and shifted "to a consideration of the type of conceptions that students could have developed given the instructional treatment," she found considerable evidence of transfer. Her careful analyses revealed how students' incorrect answers were often informed by their efforts to draw on class discussions. Transfer is, in this actor-oriented framework, "in the eye of the beholder" (Lobato, 2008, p. 300). Traditional cognitivist studies aimed to teach participants to think like experts; if participants didn't solve the test problems correctly, researchers saw no transfer and questioned the quality of initial learning, the role of distractor problems in analogical reasoning, and so forth. Lobato changes the paradigm by arguing that even if participants fail to give the expected answer on researchers' tests, that "negative result" does not indicate that there wasn't transfer of learning; it means only that what students learn didn't manifest in the ways researchers expected. Some writing studies scholars may draw connections between this AOT framework and Nowacek's (2011) critique of negative transfer.

The methods of many studies described in the remainder of this chapter follow on this actor-oriented perspective, demonstrating a similar shift in how data are collected and analyzed. Studies take place over

weeks or months, rather than during a single visit to a lab; they often rely on interviews and classroom observations; they include discourse analysis to unearth the development of students' understandings over time. The AOT perspective embodied in these studies "emphasizes the interpretive nature of knowing and the transfer of learners' underlying conceptualizations, relinquishes a predetermined standard for judging what counts as transfer and draws upon inductive qualitative methods" (Lobato, 2012, p. 243).

The Role of Hints, Reimagined

The situated learning critique led scholars to reimagine the role of hints by drawing on an idea from linguistics and anthropology: framing. For Hammer and colleagues (2005), frames are "a set of expectations an individual has about the situation in which she finds herself that affect what she notices and how she thinks to act" (p. 98). Similarly, Engle (2006) describes frames as "meta-communicative signals that help establish what the participants are doing together in it, when and where they are doing it, and how each person is participating in it, thus creating a 'frame' in which their activities can be interpreted" (p. 456). Engle tracks how a teacher of fifth-grade students frames their conversations—both in terms of time (reaching forward and back) and in terms of roles (framing them as authors of knowledge)—in ways that later make possible intercontextuality between the initial project and a subsequent project. What Engle calls "expansive framing" has "a family resemblance" to the types of hints described by Gick and Holyoak (1980, 1983), in as much as they "encourag[e] students to orient to what they know as being of continued relevance across times, places, people and topics" (Engle et al., 2011, p. 622).

More recent studies have sought to understand why individuals attend to particular aspects of situations. Lobato et al.'s (2012) study of *noticing* employs striking methodological innovations to learn more about how classroom instruction might influence what seventh graders learning about slope notice. First, in two different classes teaching slope, researchers used three cameras and a four-stage data-coding process to "track what individual students noticed during instruction" (p. 444); then they conducted individual interviews that included prompts to work on transfer tasks. Lobato and colleagues identified different trends in transfer among students in the two classrooms *and* linked those trends as "related conceptually to the divergent centers of focus

that emerged across the two classes" (p. 473). What students "noticed mathematically" during the class sessions aligned conceptually with the reasoning they articulated in interviews and influenced (without overdetermining) subsequent transfer. Lobato and colleagues' theory of noticing goes far beyond earlier studies of hints, offering a powerful way to balance the influence of classroom instruction with the idiosyncrasies of individual learning. Pedagogically, framing is a strategy that can be easy to implement; methodologically, Lobato's study of noticing suggests the value of triangulating detailed analysis of classroom discussion with participant interviews and texts to illuminate individual cognition as a profoundly social achievement.

Questions of Abstraction, Revisited

Cognitivist studies of transfer often equated abstract concepts and principles with expertise that allowed participants to look beyond surface details, and much research focused on how participants might build abstract understandings from multiple examples, controlling for as many variables as possible. Did it matter if participants were given a general principle? Did it matter if they were given multiple concrete examples in story form? Did it matter how many? Did it matter if there were distractor stories? Did it matter if participants were coached to abstract principles from the stories? After the situated learning critique, however, researchers increasingly moved outside the laboratory and many began to question the role that material objects and contexts might play in learning and transfer of learning.

Some scholars have argued that abstract examples more effectively facilitate transferable learning than concrete instantiations (Kaminski et al., 2008, 2013). On the other end of the spectrum, scholars of embodied cognition[4] argue that cognition is "deeply dependent upon characteristics of the physical body of an agent, such that the agent's beyond-the-brain body plays a significant causal role, or a physically constitutive role, in that agent's cognitive processing" (Wilson & Foglia, 2017). In many ways, this work resonates with the work of writing studies scholars such as Olinger (2020; Prior & Olinger, 2019) and LeMesurier (2016) and with the discussions of distributed cogni-

4. A full review of theories of embodied cognition and their relationship to embedded cognition is beyond the scope of this chapter; see Menary, 2010; Pouw et al., 2014; and Wilson & Foglia, 2017 for three excellent introductions.

tion found in Chapter 3. Nemirovsky (2011), for instance, is interested in the physicality of learning and focuses on *episodic feelings*, that is, "feelings embedded in the specific circumstances of a time/place lived by the participants" (p. 311). He analyzes a moment in which Eleanor (a ten-year-old talking with an interviewer about graphs generated by motion detectors) makes a connection between the two-button motion detector she's currently holding and the one-button version she'd used the previous week. When Eleanor "stretched back her right hand, which [was] precisely the bodily activity that had accompanied her past statement of the one-button rule 'the farther back you hold it the higher it is'" (p. 333), she was prompted to a new understanding of the two-button detector. Nemirovsky argues that "episodic feelings are reexperienced bodily: Often the memory of a past event or situation emerges together with a bodily pose that partially reproduces the one that was adopted during that past event or situation" (p. 314). In this view, transfer of learning is not enabled by abstract principles but cued through concrete instantiations, including material environments and physical poses—a view not unlike Rifenberg's (2014) discussion of "embodied multimodal pedagogies." (See also the discussions of embodied cognition in Chapter 4 and Chapter 11.)

Between those two extremes—between those who insist on the superiority of abstraction and those who focus almost entirely on the value of physical contexts for transfer of learning—are a variety of theories and pedagogical techniques. The pedagogical technique known as concreteness fading (Fyfe et al., 2014) takes students through three stages: enactive (focusing on concrete models and physical experiences), iconic (stripping away details and using graphic symbols to link the concrete experience to the concept), and symbolic (using an abstract model to "highlight relevant structural patterns," p. 12). Goldstone and Son (2005) tested the concreteness fading hypothesis through different sequences of computer simulations. When asked to complete a subsequent transfer task, the students who began with the more concrete simulation demonstrated higher rates of transfer—affirming the concreteness-fading hypothesis that concrete instantiations and abstract learning need not be at odds, particularly if the concrete instantiations appear early in the learning process.

Additional research suggests not only that spatial information in initial learning fosters abstract models that facilitate transfer in subsequent tasks, but also that conscious awareness of the relationship

between the concrete instantiation and the more abstract task is not necessary for transfer of learning (Day & Goldstone, 2011, 2012). Day and Goldstone (2011) conducted an experiment in which participants were asked to engage with two computer simulations: a visually based simulation required participants to position a fan to move a ball; a text-based simulation required participants to manage media campaigns that would exert a "force" on population growth. Despite their surface differences, the tasks both used forces (like wind from a fan or ad campaigns) to manipulate an outcome (like ball location or population size). Although moving a ball in one simulation has no obvious correlation to the task of increasing population in the other, individuals from Western societies tend to associate movement to the right with an increase and movement to the left with a decrease. Day and Goldstone therefore hypothesized that "[i]f participants have a natural tendency to translate population increases to rightward movements in space, then a congruent ball training scenario would lead to the development of a spatial model that could be applied to both tasks" (p. 557). This hypothesis was supported by three findings.

- When participants were asked to move the ball to the right in the first simulation, then asked to increase the population in the second, researchers found increased levels of transfer.
- When participants were asked to move the ball to the left (subconsciously perceived as a decrease), the indications of possible transfer disappeared.
- When participants completed the population simulation first, they did not demonstrate the same elevated ability to solve the second task showed by participants who completed the ball task first: because the population task was not "overtly and saliently spatial" in the way the ball simulation was, "no such transfer occurs" (p. 556).

Concrete, spatial instantiations matter—influencing transfer even across very dissimilar contexts.

What proved *not* to matter in Day and Goldstone's study was conscious awareness of the relationship between the concrete instantiation and the more abstract task. In a second version of the experiment, participants were asked several open-ended questions after they finished the experiment in order to determine their level of awareness of any connection between the two simulations. Awareness of the analogous relationship between the simulations was "generally beneficial

for performance, [but] was not a necessary condition for transfer" (p. 559). Participants briefly told of the analogous relationship did not demonstrate increased levels of transfer, but participants led through a detailed process of mapping the correspondences between the two simulations demonstrated decreased levels of transfer. Surprised by that finding, Day and Goldstone concluded that perhaps "the intensive focus on explicit correspondences distracts participants from the perceptual and spatial information relevant for the formation of the mental model" (p. 561). The focus in this line of research—on the helpfulness of unconscious knowledge—is reminiscent of perceptual research on the value of automatized, unconscious transfer and of several scholars in writing studies (Donahue, 2012; Nowacek et al., 2019; Ringer, 2018; see also the discussion of automaticity in Chapter 11). In summary, within the ongoing debate over the advantages of abstract versus concrete instantiations, some researchers argue that conscious awareness of connections need not be necessary for—and may even impede—transfer of learning from one context to another.

Conclusion

Our goal in this chapter was to map the vast terrain of research on transfer of learning from the cognitive and situated learning perspectives, highlighting not just the conclusions, but the evolution of theories and methods as well. In the chapters that follow, many of these early studies reappear as touchstones and starting points.

For readers from writing studies, the research synthesized in this chapter suggests at least two lines of methodological innovation. First, the work of Lobato and colleagues underlines the importance of adopting what she calls an actor-oriented perspective. Although it is not unusual to see the actor-oriented perspective cited in writing studies research (e.g., Bromley et al., 2016; DePalma & Ringer, 2011; Driscoll & Wells, 2012; Gorzelsky et al., 2016; Hayes et al., 2016), many studies continue to examine data through the default lens of researcher and instructor expectations rather than centering students' perspectives or highlighting tensions between various participants' perspectives. Lobato's focus on actor perspectives as well as her innovative methods of drawing connections between classroom contexts and individual cognition (Lobato et al., 2012) offer valuable suggestions for future researchers. Second, there is a relatively small but intrigu-

ing tradition of research that highlights the important role material contexts may play in the transfer of learning across contexts (e.g., Day & Goldstone, 2011, 2012; Nemirovsky, 2011). These studies suggest the importance of continuing these inquiries within the field of writing studies, following the lead of LeMesurier (2016), Olinger (2020), Rifenburg (2014), and others.

This body of research has important pedagogical implications as well. Instruction—particularly in first-year writing classes—has already been powerfully influenced by arguments that developing conscious vocabulary for (Downs & Wardle, 2007) and even theories of (Yancey et al., 2014) writing might facilitate increased transfer of learning about writing. Such arguments echo Perkins and Salomon's (1988, 1989) ideas of high-road transfer. Studies of analogical encoding (Gentner et al., 2003) and various prompts to abstract principles from provided samples (Gick & Holyoak, 1980, 1983) might suggest to teachers further strategies for helping students to develop abstract schemata that promote transfer. Additionally, work in the dual-processing tradition (Kahneman, 2011; Day & Goldstone, 2011) questions whether such explicitly articulated schemata are always necessary for transfer of learning; such studies might encourage instructors to consider whether carefully scaffolded learning opportunities might still promote transfer of learning even if they stop short of asking students to articulate the schemata explicitly.

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