THE PROCESS OF SCHEMA DEVELOPMENT: HOW THE INSURANCE INDUSTRY CONCEPTUALIZED THE COMPUTER, 1945 - 1975

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Abstract

Schemas are an important concept in organization research. While much is known about the value of schemas, explicit theoretical models of how they develop are lacking. Our study of the insurance industry's development of the computer schema from 1945-1975 addresses this gap. We find that schema development involves three key inter-related socio-cognitive processes: assimilation into an existing schema, deconstruction, and unitization of the new schema into a cognitive unit. Our study shows that these processes are associated with different learning transfer effects. More broadly, these findings have implications for learning and change processes, and the cognitive paradigm in organization studies.

Schemas are a key concept in strategy and organization research. Adopted from cognitive psychology, schemas are cognitive structures that contain categories of information and their relations (Fiske & Dyer, 1985; Fiske & Taylor, 1984; Walsh, 1995). They are an important mechanism for organizational research because they help give form and meaning to environments and subsequent interpretation and action. Management scholars have increasingly applied the construct of schemas to explain a wide variety of organizational and market behavior such as technological adoption and evolution (Hargadon & Douglas, 2001; Kaplan & Tripsas, 2008; Rindova & Petkova, 2007), formation of industry boundaries (Ruef & Patterson, 2009), building relational capital (Blatt, 2009), improving competitive positioning and resourcing (Howard-Grenville, 2007; Reger & Palmer, 1996), strengthening identity (Sluss & Ashforth, 2007), and strategic flexibility (Nadkarni & Narayanan, 2007).

Surprisingly, despite the significance of schemas in organizational research very little is known about how they develop and are acquired (Fiske et al., 1984; Walsh, 1995). While there has been growing interest in how schemas change, this has mostly focused on the extension of existing schemas (Noda & Collis, 2001; Raff, 2000; Rindova & Kotha, 2001). This is problematic because any given theory of cognitive structure must be embedded in a theory of cognitive process (Anderson, 1978). To truly understand how schemas influence behavior and the implications of their changes, we need to know more about how they are formed.

Our study addresses this research gap by asking "*how do new schemas develop over time?*" Given the nascent state of extant theory, we use theory-building (Eisenhardt, 1989) and theory-elaboration methods (Lee, 1999). Empirically, we analyze how the life insurance industry developed a new schema for the computer from 1945-1975. While the computer was a significant new technology, it took the life insurance industry almost thirty years to develop a schema for the computer that differentiated it from earlier office technologies, most notably the tabulating machine.

Our central contribution is a theoretical framework that helps open the "black box" of schema development. Our study shows that schema development involves *assimilation* with the existing schema, *deconstruction* of the combined schema and then *unitization* to establish the new schema as a distinct cognitive structure. Intriguingly, our study also shows that these three processes are associated with negative transfer effects of learning, positive transfer effects of learning, and zero transfer effects of learning respectively (see Figure 1). Broadly, these emergent findings contribute fresh insights to learning theory, change theory, and to the increasingly influential cognitive paradigm in strategy and organization studies.

THEORETICAL BACKGROUND

The schema construct emerged in modern psychology as researchers began to explore the cognitive factors that influence how individuals process information (Walsh, 1995). Schemas were viewed as simplified representations of the world that enable people to order and interpret their complex information environment (Fiske et al., 1984; Gentner, Holyoak, & Kokinov, 2001). While different terms, such as "knowledge structures", "schema", and "cognitive maps", surfaced, the definitions converged to describe schemas in terms of an associative knowledge network that consists of categories and the relations between them (Hayes-Roth, 1977). Categories refer to the classes of things that are associated together through a variety of relations. For example, Fiske and Dyer (1985) describe a hypothetical expert professor's schema as including the categories professors, work, personality, socially awkward, and lifestyle that are organized into sub-units and are connected together through a series of relations.

Cognitive psychologists investigated how schemas influenced the way individuals gained, processed, and stored information (Quillian, 1967; Rips, Shoben, & Smith, 1973; Rosch & Lloyd, 1978). They conjectured that individuals created schemas that helped them order and interpret their information environment (Fiske et al., 1984). By knowing what to expect from social relations and events, individuals could focus on the most relevant features of their situations (Fiske et al., 1985). Individuals were thus theorized to use schemas to quickly simplify their understanding of the world, improving efficiency by economizing attention. For example, some researchers described how if one category associated with the schema is activated in memory, then others would also be activated depending on the strength of the relationships among them (Fiske et al., 1985). Other researchers focused more specifically on particular types of categories such as group traits and goals, events at standard social situation, or competitive positions in a group or industry (Howard-Grenville, 2007; Reger et al., 1996).

Organizational scholars applied this insight of the relationship between schemas and information processing to organizational and market settings. This application extended the unit of analysis from schemas of the individual to collective schemas operating at the organizational or industry level. Benett and Cropper (1987), as one illustration, noted how the schemas of four government planners for their contentious workplace became fused together to reveal a "hypergame" atmosphere. Other studies exploring schema at the supra-individual level of analysis highlight common industry perceptions or understandings that become institutionalized and taken for granted as professional common wisdom (Huff, 1982; Ruef et al., 2009). Rosa and colleagues (1999) go as far to argue that agreement on a common schema between customers, producers, and other invested third parties facilitate market exchange.

Another important insight from organizational work is that schemas can both define the competitive landscape and provide the rules of competition – an underlying premise of institutional theory (Powell & DiMaggio, 1991). For example, Porac and colleagues (1990; 1989) uncovered the cognitive schemas underlying the Scottish knitwear industry's perception as a supplier of "high quality fully fashioned classic knitwear". Moreover, the authors found that this schema helped form and formalize many useful transactional relationships among buyers, suppliers, and even competitors. More recent empirical work suggests that shared schemas provide a continuity of understanding about the sequence of future events such that firms can maintain a rhythm of improvement, keep dispersed organizational members synchronized, and more readily adapt to changing circumstances (Bingham & Eisenhardt, 2011; Nadkarni et al., 2007). However, researchers also quickly point out how schema use can be harmful as well as helpful (Walsh & Ungson, 1991). Yates (1983) analysis of the "Detroit mindset" and its influence in delaying U.S. automakers' response to Japanese improvements in quality and their aggressive entry into the U.S. auto market provides supporting evidence of the deleterious use of a schema.

Yet while extant research has been quite explicit about the implications of using a schema, it has been far less explicit about new schema development. Hence, empirical studies use a variety of assessment procedures to identify the presence and nature of a schema, but provide little understanding about how that schema forms. Likewise, while scholars explore how an existing schema use may be both enabling and crippling to organizations, they under-explore how those schema initially emerge. While there is general intuition that schema develop with increasing experience in a domain, what happens during the experience itself (as well as before experience) largely remains unclear. Although some research suggests that collectively shared knowledge structures such as schema may be forgotten over time (Argote & Todorova, 2007) or might undergo socially induced change or information induced change over time (Poole, Gioia, & Gray, 1989), this work predominately focuses on alterations to existing schema, not the development of a new one.

Fortunately, however, recent research has begun to address more explicitly the dynamics of schemas and so provides some insight into schema development. One stream addresses how categories emerge and develop over time (Lounsbury & Rao, 2004; Rao, Monin, & Durand, 2005; Rosa et al., 1999). This work highlights the importance of the differentiation between categories in order to establish a distinct category (Hannan, Polos, & Carroll, 2007). New schemas risk being fully integrated into existing knowledge structures (Ruef, 2000). Yet because this work focuses on only one component of schemas, categories, and overlooks other relevant components (e.g., relations among categories), it is not clear if what happens at the category level happens at the schema level. Another stream of research focuses less on the cognitive structures and more on how individuals and organizations can use these structures in creative ways (Gavetti, Levinthal, & Rivkin, 2005; Rindova et al., 2007; Tsoukas, 2009). They highlight how particular cognitive processes, such as analogies and conceptual combinations, can help interpret new categories. However, while this work provides insights into how schemas can expand and change, it does not address how the new schema is differentiated from the old and becomes established as a new schema. More broadly, by focusing on whether a well-developed schema is present or absent, such emphasis on dichotomies in extant research generally neglects the progressive development of schema over time. A third stream considers the socio-political processes involved in establishing collective schemas (Kaplan, 2008; Pinch & Bijker, 1987). But, while this perspective provides insights into the selection of a schema, it does not fully address where these various interpretations come from. Overall, while existing literature points to the importance of schema, and suggests that the development of a new schema involves the identification of new categories and relations that serve as the basis to process future information, there is little in-depth understanding about how this developmental process occurs. Our study seeks to address this gap. Hence, we ask, "*how are new schema developed over time?*"

DATA AND METHODS

Given the general lack of research on schema development, we combined theory elaboration (Lee, 1999) and theory generation (Eisenhardt, 1989) in our analysis. Thus, we were aware of the extant literature on schema and so examined data for the relevance constructs such as categories and relations among categories. But, we also looked for unexpected types of processes by which those categories and relations developed over time and became institutionalized as a new schema.

Our setting is how the life insurance industry developed a new cognitive schema to interpret the computer from 1945-1975. This historical case is useful since as a radical new technology the computer did not exist in a previous schema. And, the large financial and organizational commitment to purchase a computer left a rich archival record of public discussion about the computer that provides insight into this process, particularly in the insurance industry.

Our main unit of analysis is the collective schema of the insurance industry as it unfolded over time. This presented several methodological issues. First, it is hard to get access to the schemas themselves and the cognitive processes that generate and represent them. To overcome this obstacle, previous research has focused on written discourse as representing the schemas and playing a central role in cognitive processes (for example, see (Barr, Stimpert, & Huff, 1992; Tsoukas, 2009). Narratives are particularly salient for this case. In her analysis of the insurance industry's use of computers, Yates (2005) argued that most insurers learned about and discussed the computer through texts within the various professional and trade associations. She identified three main associations in which these discussion took place beginning in the mid 1940s: Societies of Actuaries (SOA), Life Office Management Association (LOMA), and Insurance Accountant and Statistical Association

(IASA). Each of these societies commissioned reports on the computer and had many presentations from insurance firms about how they intended to use, or actually did use, the computer. We collected these documents from the societies, as well as the commissioned reports, books, and presentations by insurance representatives at special conferences outside the industry that focused on the use of computers and electronic equipment. Since we are interested in the life insurance industry's schema, we privileged their accounts, but we also captured the manufacturers' presentations within these associations and the general media accounts.

Another methodological issue concerns how to characterize the schema and measure changes to it. Consistent with the theoretical discussion that defines schemas in terms of its categories and relations, we are interested in identifying these elements within the texts from the association proceedings. To accomplish this, we adopt Carley's (1993, 1997) method of cognitive mapping. Cognitive mapping is a form of content analysis that involves processing sentences within a text to isolate the nouns and verbs.[1] The nouns and verbs refer to the categories and their relations and thus capture a cognitive schema represented in the text. We did this process manually for each sentence within each text that discussed the computer during our time period (this included analysis of over 180 texts, comprising approximately 1,300 pages).[2] This process generates frequency tables of the categories and relations that comprise the schema.[3] Like Hayes-Roth (1977), we interpret frequency to mean strength – the more frequent the category or relation used, the more salient it is. Comparing

[1] Carley's approach to cognitive mapping is similar to Axelrod's (1976) cause mapping, used by strategy scholars (see (Barr et al., 1992)) in that it parses sentences and maps out their connections. However, where causal mapping searches for causal relationships, Carley's approach recognizes any kind of relationship.

[2] For example, consider the following statement from an article presented at an association meeting: "The cards are then mechanically calculated and punched with the unpaid number of weeks and the unpaid portion of the first-year's premium and commission to be withdrawn." (Beebe, 1947: 191). Here, the categories include the cards, machines (implied by the term "mechanically"), and data ("the unpaid number of weeks and the unpaid portion of the first-year's premium and commission"); and the relations between cards, machines, and data are "calculated" and "punched".

[3] Carley (1993, 1997) recognizes that the analyst must decide how to code frequency – either as each occurrence or whether it occurs in the text at all. Since many of these texts were procedural in nature, they had many occurrences of the same concepts and relations. Consequently, we only identified whether they were present in the text.

the overlap and differences between schemas at different time periods can also help measure change. To supplement these tables, we created stylized diagrams of the schemas at various time-periods to help visualize what they may look like (see Figure 2). A final issue concerns the collective nature of the schemas. The frequencies across the texts at a given time period help indicate how wide-spread these interpretations were. Yet prior research has shown that individuals and groups can vary in their schema representations (Kaplan, 2008; Pinch et al., 1987), raising the concern that our schema does not accurately represent the broader community's interpretation. Consistent with these studies, however, our data shows iterative periods of convergence and variation in the schema representation within the insurance industry.

In order to identify some of the mechanisms involved in the schema development process, we extend Carley's method (1997) by considering the historical context and the actual use of computers. Our analysis of the association's materials revealed the importance of technological changes in the computer, how the insurance industry used the computer, and broader trends about computer technology such as the development of management information systems (MIS) in the late 1960s and 1970s. Therefore, we supplement our analysis of association proceedings with historical analysis of technological changes, research on the life insurance industry's uses of the computer (Yates, 2005), and the general history of these broader movements (Haigh, 2001).

Finally, we focused on the time period 1945 – 1975. While the computer was not commercially released until 1954, we collected works dating back to 1945 to get a sense of the pre-existing schema as well as early interpretations of the computer before it was actually used. A unique feature of this case is that the insurance industry developed a schema prior to the commercial release of the computer and their use of the computer which helps us assess the influence of experience in modifying a schema. While the computer and its schema certainly continue to evolve even today, we stop in the mid 1970s because by then the computer schema had fully emerged as an independent knowledge structure – our primarily concern in this paper.

HISTORICAL CONTEXT AND SUMMARY OF THE SCHEMA DEVELOPMENT PROCESS

Life insurance firms provide policyholders coverage against potential loss in exchange for premiums. Beyond the actuarial and investment analysis, much of the work in insurance firms are routine and clerical in nature: preparing and processing policy records, determining the premiums paid, dividends, and agent's commissions, as well as notifying and collecting policyholder's premium payments, and the accompanying accounting procedures to record these transactions (Adams, 1946). Historically, insurance firms invested substantially in clerical workers and technology to efficiently manage the policy and accounting processes (Yates, 1989). By the 1940s, virtually all insurance firms used a combination of business machines--tabulating machines, sorters, verifiers, calculators, and addressing machines—to sort and calculate information represented as punched holes in cards. These punch cards became the record on which policy and accounting information was stored. IBM historians have noted that "Insurance companies were among the largest and most sophisticated business users of punched-card machines in the late 1940s and 1950s" (Bashe, Johnson, Palmer, & Pugh, 1986).

During World War II, industries in general experienced a clerical labor shortage, which was exacerbated in insurance by a post-war life insurance boom (Bureau of Labor Statistics, 1955). As a result, the insurance industry became increasingly interested in new technologies that aided in information processing. One promising, radically new technology that emerged from the war was the computer. The U.S. government in World War II used primitive computers mainly for computational purposes such as calculating missile trajectories. After the war, technology manufacturers in search of a commercial market began developing what became known as business computers, intended not solely for computational work but also for managing business processes such as processing premiums. Part of the process of adopting the computer involved developing interpretations of what the computer was – to develop a schema that captured the computer.

Our historical analysis surfaced three emergent but distinct socio-cognitive processes shaping the insurance industry's development of the computer schema: assimilation, deconstruction, and unitization. These processes were temporally phased, although they shared some overlap, and were social in the sense that the social environment they were embedded in influenced their outcome. We also found that each process relates to a particular transfer of learning effect – that is, negative transfer, positive transfer, and then finally zero transfer respectively (see (Fiske et al., 1985) for a discussion of transfer effects) . Figure 1 summarizes these combined findings. It shows that before the computer was even commercially available in 1954, insurance companies assimilated the computer into an existing schema, treating it as a familiar office machine. We call this stage *assimilation*. While assimilation helped initiate action to purchase the computer, it did have a negative transfer effect from the existing schema to the new schema because the more novel aspects of the computer, such as programming and decision making, did not receive much attention and so were largely ignored.

After gaining some experience with using the computer into the 1960s, insurance companies began to critically evaluate their performance. These evaluations coupled with technological advances caused the insurance companies to reflect more deeply about how they had assimilated the computer. We call this reflective process, *deconstruction*, because it led to the weakening and extension of some existing categories and relations in the existing schema. This process had positive transfer of learning effects in the sense that deconstructing the existing schema facilitated incorporating novel categories and relations into new structures. Finally, the last process served to strengthen these more novel categories and relations of the new computer schema so that it became a stand-alone cognitive structure. We call this stage *unitization*. It has a zero transfer effect in the sense that because the new schema is dissociated with the existing office machine schema there are no transfer effects. In the following sections, we discuss the details of each socio-cognitive process.

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Insert Figure 1 About Here
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THE ASSIMILATION PROCESS

The existing literature argues that assimilating a new technology into an existing cognitive structure, such as a schema, can help facilitate adoption because it increases understanding and legitimization of the new technology (Hargadon et al., 2001). Our data, however, reveal that assimilating a new category within an existing schema can have negative, not positive, transfer effects. Specifically, we found that insurance companies initially assimilated the computer by fitting it directly into their existing schema for office machines, developing an interpretation of the computer as an office machine. This assimilation came at the cost of pushing into the background other interpretations of the computer, in particular an analogy with the human brain that emphasized the novelty of the computer. Initial uses of the computer reinforced this interpretation, limiting the development of a new computer schema.

To show this assimilation process, we first develop the existing schema based on the discussions of the pre-existing office technologies. Prior to the computer, the insurance industry primarily used tabulating machines and related office equipment such as collators and printers to process insurance work. To illustrate how insurers thought about this technology, consider a passage for how Prudential used various tabulating machines to prepare important documents – lapse registers, insurance agent's premium statements, and summary cards for managers:

From approved new business applications policy writing and beneficiary cards are key punched and verified. The policy writing cards are mechanically sorted and matched with master cards (by collator) to insure the accuracy of the age, kind, premium and amount of insurance in each case. The policy writing and beneficiary cards are next mechanically merged in policy number order and used to write the policies on a bill feed tabulator. After completing the listing of the agents' register sheets, the new business, reinstatement and life transfer cards are reproduced to in-force file cards. (Beebe, 1947: 191-2).

This passage highlights the focus on the punch cards as the primary unit of information, the machine doing the work, and the functions through which it gets processed, manipulated, and calculated.

To get a more general sense of the schema, we collected all the articles in the three insurance trade associations that discussed these technologies during the period in which they first began to discuss the computer, mid-1940s through the early 1950s. Following Carley (1993), we developed the cognitive schema by identifying the categories and verbs (relations) used in these texts. Table 1 presents the list of categories and relations of the pre-existing schema and how often they occurred by article for each year.

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Insert Table 1 About Here
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While the texts invoked a wide variety of categories and relations, Table 1 shows a concentration around clerks, punch cards, and machines (note, we rolled up specific mentions of machines, e.g. addresseograph, into the machine category). Clerks interacted with the various kinds of machines according to the listed relations to manipulate punch cards to complete a business process. The relations between these categories centered on creating or "punching in" punch cards, making computations related to the business process ("tabulate," "calculate"), processing the punch cards ("sort," "file," "merge," "matching") and writing out the output ("print," "list," "post"). Consistent with Bebe's (1947) passage, generally the main unit of information was the punch card – the relations were between the machine and the punch card and not the data found on it. Yet "check" and "verify" indicate the need for verification of the information actually punched on the cards. Verification involved both mechanical and manual processes as clerks often validated the results from one machine before passing it along to a new machine. “Reproduction” – or the creation of new punch cards with the same information – was also frequently required because cards were used for different purposes. Some estimated that life insurance firms had as many as 10 different versions of the same card, making verification and consistency between the cards hard to manage.

Another important feature of Table 1 is the persistence of the existing schema for office machines throughout the time period. New categories and relations did not emerge in later periods and the concentration around machines, punch cards, and clerks remained in tack. This is important because public discourse about the computer began in 1947 and this table suggests that it did not significantly alter the pre-existing schema. Instead, insurers used this existing schema to help interpret the computer. The initial discourse on the computer included presentations at conferences from insurance and computer manufacturers, commissioned reports to study how the computer can be used, and even books on the subject.[4]

From these discussions, two dominant interpretations emerged. An executive from Prudential who had extensive interactions with computer manufacturers, Edmund Berkeley (see Yates (1997) for more detailed discussion of Berkeley), developed an analogy of the computer with the human brain. He discussed the computer as a mechanical brain and outlined what the computer could do at industry meetings, and later he further developed the analogy in his 1949 popular book, *Giant Brains*. In contrast, other texts described the computer as an office machine, often making direct comparisons with tabulating machines. Most importantly, the three societies also commissioned committees to generate reports about the computer and its potential use in the

[4] Studies of cognitive practices often focus on the media (Rosa et al., 1999). In this case, the general media did not start actively discussing the computer until closer to its commercial release in 1954, typically using the brain analogy.

insurance industry. In 1952, the Society of Actuaries' Committee on New Recording Means and Computing Devices issued a major and influential report, and both IASA and LOMA hosted panels at their conferences about potential use of computers and in 1953 co-sponsored an Electronics Symposium focused exclusively on this topic. Unlike Berkeley's work, these reports characterized the computer as an electronic version of existing technology, often using the label "machine" to describe the computer. The 1952 Society of Actuaries' report stated:

> These new machines have been called computers because they were developed primarily for mathematical work. It is a mistake, however, to think of them today as purely computing machines capable only of a large amount of arithmetic. In recent years, some very important improvements have converted them into machines capable of a wide variety of operations. Nowadays we must think of them as *information processing machines* with computing representing just a part of their total capabilities. (Davis, Barber, Finelli, & Klem, 1952: 5).

Since we are interested in the insurance firms' conceptual schema, we concentrated on the 32 texts presented by insurance representatives during this initial time period. Table 2 compares some of the most frequent categories and relations for the pre-existing schema, the computer as a machine interpretation, and the brain analogy. The bold face indicates that the category and relation is shared between the existing schema and the interpretation of the computer, showing the strong similarities between the existing schema and thinking of the computer as a machine. The core categories still focus on machines and punch cards. In fact, "machine" is used more often to identify the computer than the term "computer". Clerks are less represented primarily because these articles focused more generally on the computer itself and only speculated about how it could be used within the insurance context. Relationally, the machine interpretation focused on similar kinds of transaction-oriented functions: entering in information ("read," "punch in"), computing ("compute," "add,"), processing information ("sort,") and writing results ("write").

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In contrast, the brain analogy uses categories and relations that mostly do not overlap with either the existing schema or the computer as a machine interpretation. While there are similarities, such as “data”, “computer”, and “add”, the brain analogy concentrates on categories and relations associated with decision-making and thinking. New categories, such as “problem” and “operation”, and relations, such as “look-up”, “solve”, “store”, “remember”, and “think”, reflect the processes associated with gathering information and processing it to make decisions.

Finally, Table 2 also shows that the insurance industry quickly converged on characterizing the computer as a machine. Of the 32 texts that discussed the computer from 1947-1954, 27 adhered to the computer as a machine interpretation. Of the 5 remaining texts, Berkeley authored 4 of them. Many rejected the brain analogy outright. E.F. Cooley of Prudential Life, argued: “I might use the term "giant brains" to tie in my subject with the more or less popular literature on this subject. But I hate to use that term since there are false implications in it, implications that these machines can think, reason and arrive at logical conclusions, and I don't agree that this is true (Cooley, 1953: 355).” Computer manufacturers also emphasized the machine interpretation during this time period. They presented 32 texts, ranging from documented question and answer periods in society meetings to exhibits to prepared remarks. Those that addressed the computer used the machine language. IBM even adopted the label “electronic data processing machine” to describe the computer, which quickly became common after the commercial release of computers in 1954.

The convergence to the machine interpretation helped build the developing conceptual schema of the computer. The high overlap in categories and relations between thinking of the computer as a machine and the existing schema indicate that that this interpretation assimilated the computer within the existing schema. Indeed, labeling the computer as a machine categorized it into an existing category, but in addition the machine interpretation used many of the same relations as well. However, it was not complete assimilation. Table 2 also reveals some new categories and relations that were not present in the existing schema. In addition to "punch card" and "data", "information" was added as focal units of what the machine processes. The Society of Actuaries' report even referred to computers as "information processing" machines (although it uses the term "machine" more frequently in the text). In addition, the texts on the computer highlighted the relation of "comparing" data which reflects more of the decision-making process associated with the brain analogy. Programming was another new relation introduced by the computer.

The lower frequency of these categories and relations, together with the brain analogy, suggest that, although present, they were less salient than those categories and relations that overlapped with the existing schema. Interestingly, these categories and relations represented some of the more novel features of the computer and help differentiate it from existing technologies. Berkeley (1949) made this differentiation explicit in his *Great Brain* book, where he used a table to show how the computer differs in thinking ability from previous technologies. Consequently, these novel categories and relations were not completely ignored, but faded into the background as the insurance industry focused on the more machine-like qualities and functions of the computer. The first section of Figure 2 visualizes the result of this assimilation process. The computer is interpreted as a machine, which reinforces the existing schema and focuses attention there; the more novel categories and relations of information, the mechanical brain, and decision-making are pushed out into the periphery. Consequently, there is a negative transfer effect from the existing schema to the new schema because much of the novelty of the computer gets less recognition and development

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In 1954 the computer was released and the insurance industry shifted from simply discussing what the computer could do to actually developing uses for it. Insurers invoked the schema developed in Figure 2 to think about how the computer should be used and justified. Because insurers used office machines to more efficiently manage clerical processes, they used cost effective logic to justify the use of the computer. The 1952 Society of Actuaries report argues: "That with these computers, many of us can make substantial reductions in our operating costs. Realization of their full potential will lead us to consolidation of many different kinds of work which now are departmentally separated (Davis et al., 1952: 49)." Thinking of the computer in terms of existing office equipment also influenced how insurance firms initially used the computer. A series of surveys conducted by the Controllership Foundation in 1954-7 provides insight into how the assimilated schema influenced which computer they purchased and how they used it. First, 68% of the implementations purchased IBM's 650 – a smaller computer that more closely resembled a tabulating machine and could be wheeled in to replace a tabulating machine as opposed to requiring a separate room like the UNIVAC or IBM 705. Second, rather than create new business processes, life insurance firms converted existing office applications, such as premium billing and accounting, over to the computer (this did not vary by kind of machine). Yates (2005) notes that this incremental use of the computer persisted throughout the 1950s and into the 1960s.

Overall, we find that the development of a new schema first involves being assimilated into an existing schema. Why does this happen? One reason relates to the power of well-defined existing schemas. The inter-relations of categories in such schemas make it difficult to add new categories since it requires substantial change to the existing relational structure (Reger et al., 1996). Given this resistance, introducing a new cognitive category (e.g., computer) often requires identifying old categories that appear similar to it in the existing schema to pull it in. The existing schema used by the insurance industry was well defined in both the categories and inter-relations, which made it hard for the insurance community to conceive of a radically new technology and cognitively difficult to make substantial changes in their schema to accommodate it as a novel schema. Indeed, insurance firms had been long-time users of tabulating equipment and had developed common routines and uses of this equipment (Yates, 2005). These common uses helped establish consensus around the categories of clerks, machines, and punch cards, and the transaction-oriented relations (See Table 1), and maintain consensus around them over time – i.e., they were just as likely to appear in a text after the computer was introduced in 1947 as they were before.

Another reason for assimilation was the context in which information about the computer was disseminated. Learning about a radically new technology such as the computer requires significant cognitive effort that not all insurance firms were able or willing to invest. While a few firms like Prudential engaged directly with computer manufacturers, most learned about the computer through attending presentations at industry association meetings and reading the popular press (Yates, 2005). The industry associations allowed members to present their different ideas at their conferences; however, these associations gave authority of conceptualizing the computer to assigned committees that interpreted the computer as a machine.

THE DECONSTRUCTION PROCESS

Although assimilation of the computer into the existing office machine schema remained dominant, the schema began to gradually and subtly change in the 1960s. More specifically, the idea of the punch card as the central processing unit of information expanded to consider the data within the card. Also, the categorization of the computer as a machine began to weaken as the significance of programming became more apparent. Finally, the decision-making aspects identified new users of the computer beyond clerks, which also helped develop new relations as well. We call this process deconstruction to emphasize the incremental process in which existing categorical boundaries and relations began to breakdown. Unlike the first process of assimilation, which reflects negative transfer of learning effects, the process of deconstruction reflects positive transfer of learning effects.

Table 3 illustrates the deconstruction process at the level of changes in categories and relations. Similar to Table 2, it compares the categories and relations used in two articles that discussed how each insurance company used the computer to manage their premium billing function in 1960 with those of the assimilated schema in which the computer is interpreted as a machine (column 2 from Table 2). Bold face indicates that the category or relation is shared between the assimilated schema and the article. Table 3 shows that the core categories of punch card, clerk, and machine and their transaction-oriented relations persisted into the 1960s. In fact, within the texts of the two 1960s articles are pictures of punch cards with their data (see Appendix A for a brief discussion of the use of diagrams). However, there are also a significant number of new categories and relations in these two articles.

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Insert Table 3 About Here
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Closer examination reveals that in many cases these new categories and relations extended or moderated the machine, punch card, clerk categories and their relations. These connections are shown by the bold italics in the table. Take, for example, the punch card category. In the 1950s schema, punch cards served as the primary unit of information that was manipulated and handled by the machines and the clerks. While the 1960 articles invoked the punch card through its diagrams and general language, much of their discussion focused on the information that the punch cards contain, such as premium amount, loan interests, and dates. For example, the Leverence article specifies that the Billing Routine of the computer must take into account these lower level data: "For example, the Waiver Premium clause could be terminating because the insured is nearing its 60th birthday. On a policy such as our Family Income Plan, the term period may be expiring. The routine must take all of these things into consideration to create the proper results for the current premium (Leverence, 1960: 495)." In addition, the main output of the computer was not just punch cards, but also reports, lists, and notices. These 1960 versions deconstructed the existing punch card to include the data the card contains as well as the way the card is processed within the computer.

A similar deconstruction occurred with the machine category. While the 1960s articles still thought of the computer as a machine, even using the verb "machinized", they also highlighted the routines and programs within the computer. As the Leverence quote illustrates, the routines and programs, not the computer itself, did the work of processing the data. Finally, this deconstruction was not limited to the categories, but also occurred with the relations. In the 1950s, text used the relation "verify" to highlight how clerks would need to check the output of the machines; however, in the 1960 texts, "verify" is also used as an internal process that computers can perform to check its own work. Thus, verification was no longer just a human endeavor, but something that computers could do which further differentiated the computer from other office machines.

While Table 2 and 3 both have significant overlap and differences between earlier and later schemas, they differ in that the non-overlapping categories and relations were essentially ignored in Table 2 during the assimilation process, but they received more attention in Table 3 during the deconstruction process (highlighted by the bold italics). In the 1960s, rather than push the novel categories out of focus, some insurers started to bring them into conceptual focus. While the insurers still thought of the computer as a machine, they began to recognize that it was not the machine that they thought it was – it was a much more sophisticated piece of equipment that can process data automatically. By expanding the conceptual focus to include these more novel aspects of the computer, the deconstruction phase reflects positive transfer effects from the existing schema to the new emerging one.

A key question is why did these more positive effects occur in the 1960s and not during the initial commercialization of the computer in the 1950s? One reason has to do with the technological advances during this period. In particular, hardware and software changes in the early 1960s significantly improved the computer's ability to store and process information. Solid state computers with disk drives increased data storage and enabled random access of data (Ceruzzi, 1998), and processing power increased to support more real-time processing (Chandler, 1997). On the software front, IBM released the software package, Consolidated Functions Ordinary, for the insurance industry in 1962. This application incorporated the suggestions of the Society of Actuaries' report that functions surrounding the processing of premiums and policies be consolidated together. Collectively, these technological improvements improved the computer's ability to manage data at lower levels than the punch card.

In addition to technological advances, insurers learned that their initial conceptions of the computer were too limiting. Studies conducted by consultants in the 1960s found that computers generally did not produce their expected returns. The often-cited McKinsey & Company blamed the computer's conservative use as a "super accounting machine (Garrity, 1963: 174)" that stemmed from assimilating the computer into the pre-existing schema. Consistent with this assessment, some early adopters of computers in the insurance industry actually experienced an increase in cost as opposed to an anticipated decrease (Yates, 2005). These assessments raised doubts about whether the assimilated schema was valid, making it more open to change.

Insurance companies further learned about unforeseen issues through using the computer. Before actually using the computer, programming was not viewed as something significantly different than managing operations with tabulating machines. In fact, the influential Society of Actuaries' report defined programming through a comparison with the physical process of wiring tabulating machines together (Davis et al., 1952). However, when it came to actually programming the computer, insurance companies learned that it was significantly more important and complicated than anticipated. Many insurance firms significantly underestimated programming costs, which ran from 33%-100% of the hardware rental and in some cases caused companies to question the benefit of using computers (Yates, 2005).

Learning about programming introduced new categories of users and further deconstructed the computer as a machine schema. To illustrate, consider C.A. Marquardt's of State Farm description of programming: "Electronic Data Processing equipment is a tool and not an electronic brain, or any other kind of brain. … It is nothing more than a superspeed "moron" acting on detailed instructions. The programmers who direct its operations are the real "brains" (Marquardt, 1960: 255)." Marquardt did not completely abandon the classification of computer as a piece of equipment, but he also highlighted how computers did not completely fit with the pre-existing machine classification either. Computers follow "detailed instructions"; whereas, machines are operated upon. Moreover, Marquardt recognized a new kind of user, the programmer, who interfaces with the computer in a more technical sense as opposed to clerks who operate the machines. Through their programming experiences, insurance firms began to realize that computers did not operate the same way as tabulating machines and interfaced with new kinds of people.

Faced with the initial disappointment of early computer uses and unforeseen issues, insurance companies could have abandoned the computer all together. However, the significant investment, in terms of both cost and organizational capital as well as the promise of technological changes, encouraged insurance firms to stick with the computer. Instead, insurance firms began to re-evaluate their logic to justify the purchase of and measure the effectiveness of computers. Rather than only consider cost reductions as prescribed by the SOA's 1952 report, they began to consider more intangible measures such as operational benefits and improved service. At a symposium at the 1960 IASA annual conference that focused on the justification of the computer, one participant questioned:

> Is it proper to ignore the ability of a computer to provide management with information it has never had before merely because we cannot predict exactly how effectively management will ultimately use this information to increase long-term profits? [Goes on to list several projects] None of these projects will result in an immediate cost reduction nor will they add anything of value to our product to justify a price increase. However, our company feels that these kinds of computer applications are of real value and will contribute to more effective operations and thus higher profits over the long run. (Orkild, 1960: 239).

Shifting the reasons to use a computer recognized management as an important under-explored user of the computer – managers use the computer to get information to make decisions that affect operations. Recognizing managers as users began to deconstruct the initial focus on the clerk as the key user of the computer. And, unlike clerks who used computers to process transactions, managers used the computer to gather information, which also expanded the transaction-oriented relations between the user and the computer to more decision-oriented relations.

The deconstruction process was not temporally abrupt, but developed throughout the 1960s. In fact, looking at the articles in the 1960 IASA Proceedings, from which the articles for Table 3 were selected, shows that of the 21 articles that discussed the use of office machinery in insurance operations, 15 either addressed older technologies prior to the computer or used language that reinforced the assimilated schema. In addition, Yates (2005) notes that from a usage perspective, the more incremental uses of the computer adopted during the initial commercialization of the computer still persisted even though IBM had released its CFO software.

To summarize, the second section of Figure 2 visualizes the deconstructive changes. While machine, clerk, and punch card and their transaction-oriented relations still persist, they have become noticeably weaker (signified by the dotted-lines) as insurers expanded their conception of computers. Because the newer categories and relations do not replace the assimilated schema from the previous period, the conceptual focus of the schema actually expands and becomes more complex. Yet it also has a less ordered structure in the sense that machine classification is less salient and the relations have become weaker. This deconstruction had positive transfer effects from the existing schema to the emerging new schema since having some familiarity with components in the existing schema (e.g., machine) helped insurance firms see how the computer could still be used as a machine but in novel ways that linked to new categories and relations.

Why is deconstruction useful in new schema development? One reason is that it helps counter the perseverance effect of the existing schema. Many studies find that a major feature of schemas is that they are difficult to change; they can even persist when individuals know that the information underlying is incorrect (Lord, Ross, & Lepper, 1979). Yet a few studies suggest that this perseverance effect may be overcome by telling people to more thoughtfully monitor how they are evaluating evidence and to more carefully assess the presence of biases as they interpret new data (Anderson, 1982). Consistent with this finding at the individual level of analysis, our study at the collective level of analysis shows that when insurance firms (and other industry constituents such as consultants) began to challenge the presumed benefits and uses of the computer, the validity of the assimilated schema weakened. This destabilizing of the previously strong conceptual boundaries between categories and relations in existing schemas helped shift attention to previously ignored new categories of the new schema (e.g., information, programming, and managers).

A related question is why deconstruction generates positive transfer effects from the existing schema to the new schema? Our data suggest that the combination of categories and relations in existing schemas often share conceptual overlap with combinations of categories and relations in new schema. Thus, the weakened learning of initial categories and relations affect the ease of learning new ones. Knowing, for example, the attributes of the "machine" category in the existing schema allowed insurance companies to more easily understand how the computer was similar to, but different than, traditional tabulating machines. Insurance companies were able to see how "machine" could go together with other categories such as clerk and punch card through transaction-oriented relations. But, through a weakening of the original conceptualization of "machine" (which occurred through practice with the computer, technological advancements, critical analyses, etc.), insurance companies were also able to see how "machine" could be associated with new categories such as information and brain and new relations such as decision making and thinking. In general, this finding in our study of positive transfer of learning from the existing schema to a new schema is consistent with prior studies suggesting that the degree of learning the first set of components in an individual's knowledge structures may facilitate the learning of the second because some of the components overlap (Finkelstein & Haleblian, 2002; Fiske et al., 1985).

THE UNITIZATION PROCESS

While deconstruction helped make the novel categories and relations more salient, it did not establish these categories and relations as a new schema. We observe that categories and relations became a new schema through unitization in the 1970s. Hayes-Roth (1977) defines unitization as the process through which a group of categories and relations get connected in such a way that they are recalled as a unit as opposed to individually – much like the clerk, machine, punch card relationship of the initial schema. We apply unitization to the development process to define the process through which new categories and relations break ties with the existing schema and become a single unit in memory. This unitization makes changes to underlying categories and relations more difficult and helped establish the novel computer schema for future cognitive processing. While unitization does not reflect any significant transfer effects from the existing schema, it plays a critical role in schema development.

One way to measure unitization is by the overlap in the categories and relations used between accounts – the more the overlap and concentration of certain groupings, the higher level of unitization. To illustrate this process, Table 4 compares the categories and relations used in two articles that discussed how each insurance company used the computer to manage their premium billing function in 1972. Bold face indicates that the category or relation is shared between two accounts. Table 4 shows that the ambiguity and lack of structure during the deconstruction process was converging to a smaller group of categories and relations that focused on information processing for decision-making and servicing. Computer "applications" "provide" and "prepare" "information" in the form of "reports" and "lists" to "assist in decisions" by "agents" and management, and "giving service" to "policyholders". Comparing Table 4 with Table 2 shows that many of the highlighted categories and relations in Table 4 simply did not exist in the earlier versions of the computer schema in Table 2. Indeed, the cards mentioned in Table 4 are not punch cards, but index cards, filled within information from computers, to be used by agents and the service department to provide better sales and services to customers. The idea that computers can be used to share information to improve service further expands the emerging justificatory logic of computers from the 1960s that has shifted from tangible cost control to more operational intangibles.

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Insert Table 4 About Here
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Yet, it is difficult to extrapolate the collective insurance schema from two examples. Analysis of the articles in the 1972 and 1975 IASA proceedings, however, indicate that this schema was widespread. The pictures of punch cards that filled the proceedings in the 1950s and 1960s had given way to samples of reports, policyholder notices, and lists that emphasize the information produced by computers (See Appendix A). A survey of the articles in these issues shows concentration away from the transaction-oriented articles found earlier toward management oriented uses of the computer, such as financial planning, budgeting, corporate planning, and agency management systems. Some titles included: "Financial Planning Systems", "Agency Management Information Systems", and "Terminals for Inquiry, Transaction Capture, and On Line Update".

The last section of Figure 2 illustrates the unitization process. A unit structure has emerged around the categories associated with information-processing, decision-making, and servicing, which are distinct from the original assimilated schema in the 1950s. This process had the effect of actually simplifying the complex structure exhibited during deconstruction around more general categories. It also focused perception on this unit as the original assimilated schema faded.

A key question is why did the schema unitize around information processing and decision-making? After all, the deconstructed schema was much more complex and broad, suggesting that it could have converged on any number of categories and relations. Again, technological advancements played an important role. A key development was the development of database technology to manage data throughout the organization. In 1975, Robert Shafto of New England Mutual Life Insurance explained that a data base was "that set of data-fields related to the "complete" performance of all required transactions regardless of how those data-fields are organized. … but to truly complete the performance it must also include those needed to provide "management information (Shafto, 1973: 251)." This view of data residing in its own "base", as emphasized by the common splitting of the word "database" into two, represents a shift in thinking about data being tied to a punch card or file to perform a specific transaction. By freeing data from the transactions they support, it could now be used for a variety of purposes, including providing "management information". Smaller computers as well as computers with terminals were also growing in popularity which created and new form of output and allowed for processing closer to the point of consumption.

Related to the growth of database and terminal technology, the management information systems (MIS) movement of the early 1970s also facilitated the unitization process. Howard Arner of American Bankers Life defined MIS as "the orderly combination of facts for management" (Arner, 1972: 15). More specifically, MIS was intended to leverage the computer within the organization to process information to support managerial decisions. The historian Thomas Haigh (2001) notes that at a broad level the MIS movement is closely tied to the systems men occupational group's desire to expand their jurisdictional control within the organization. Systems men were responsible for business process design and forms control within organizations and were very prominent in the insurance industry given its emphasis on clerical processes. In fact, systems men authored many of the computer articles published in association proceedings. Not surprisingly, MIS received significant attention in the insurance industry, having separate sessions at the IASA proceedings in the early 1970s. While MIS had limited success in terms of actually being implemented, it had a profound impact on unitizing the emerging computer schema within the insurance industry. The MIS perspective helped make the unit of computer, information, manager (information user) connected together through decision-making relations more explicit.

Why is the process of unitization related to the development of a new schema? First, unitization of new schemas signals separation from existing schemas. That is, unitization helps separate new categories and relations from those in existing schemas and establishes them as a separate and holistic cognitive unit. Studies in human perception find that ongoing experience with specific configurations of cognitive components and relations can result in the formation of a single image-like representation (Goldstone, 2000). Similar to this view, we found that from the late 1960s into the early 1970s, insurance companies began to evoke a consistent image of the computer that simultaneously integrated all the novel components (e.g., programmer, manager, information) and relations (e.g., assist in deciding, prepare, give service) (See Figure 2 and Table 4). Thus, extensive yet gradual learning of schema categories and relations through practice seems to be an indicator of unitization. The fact that schema structure requires time to form may be one reason unitization did not occur in our study as the first process of schema development but instead as the last process.

A related question is why there is zero transfer of learning from existing schema to the new one? Our data reveal that, once formed, unitized categories and relations are relatively unaffected by existing schemas. Once categories and relations in the new schema are processed together as a single unit in memory they become theoretically equivalent to a totally novel configuration of knowledge. In general, these arguments are consistent with work in cognitive psychology where scholars find that unitized knowledge structures can be processed quickly and automatically with little effect from other knowledge structures (LaBerge, 1974).

DISCUSSION

Using 30 years of in-depth qualitative and quantitative data on how the insurance industry developed a schema for the computer, we have identified some of the socio-cognitive processes involved in the development of a schema. In this section, we summarize the process model and its potential implications for theories about learning, change, and schemas in general.

Framework: A process model for the development of schema

A primary contribution is an emergent theoretical framework for how shared schemas develop over time. This framework highlights three temporally phased processes: assimilation, deconstruction, and unitization (see Figure 2). First, new schemas begin through assimilation. We find that emergent categories and relations in the new schema that overlap with the existing schema (e.g., machine) trigger the existing schema and make it (not the new schema) the conceptual focus. Therefore, because new knowledge cues associations with prior knowledge, the development of a new independent schema seems to unintentionally foster dependence on an old existing schema.

Second, new schemas further develop through deconstruction of existing schemas. Extant literature suggests that in order for new categories and relations to become institutionalized in schemas, they must often replace existing categories or relations (Lamont & Molnar 2002). Our study finds support for a different view. We find through practice, users of the computer began to better understand the uses of the technology. This, in turn, weakened relations among existing categories and allowed new relations such as logical decision making and programming to be made to both existing categories such as machine as well as novel categories such as data and information. The overall effect is an updating of the categories and relations in the existing schema, not a replacement of them as prior studies suggest.

A final process of schema development is unitization. As the novel categories and relations related to the computer became more entrenched and referenced over time, previous categories and relations used to describe the technology were less frequently used. Ultimately they simply did not provide as strong of a conceptual understanding for the computer as did new categories and relations. The new categories and relations became a distinct and single unit in memory that is theoretically equivalent to a novel schema (in this case a computer schema). Thus, a key point is that new schemas only become "stand alone" later in the developmental process.

In summary, our theoretical framework identifies how a collective level schema develops over time. A new schema (1) begins by being assimilated into an existing schema, (2) continues to develop through deconstruction of the existing schema and (3) emerges as a novel cognitive structure through unitization. Overall, this process-oriented framework complements prior research examining the well-developed schemata of organizations (Noda et al., 2001; Raff, 2000; Rindova et al., 2001) by shedding needed light on the early stages of schema development.

Contributions to learning theory

Broadly, our study contributes to the literature on learning by highlighting a more dynamic view of transfer effects (see Figure 1). Prior literature exploring transfer effects of learning is usually cross-sectional and emphasizes *either* negative *or* positive transfer effects of learning from an existing context to a new context (Finkelstein et al., 2002). In contrast, our study emphasizes the role of *both* negative *and* positive transfer effects. First, we find evidence for negative transfer effects. Data show that while assimilation of new schema into an existing schema helped initiate action to purchase the computer, it negatively impacted the development of the new schema because the more novel aspects of the computer (e.g., programming and decision making) became overlooked and underappreciated. Our study thus contrasts with other work on the introduction of new technology which suggests that there is an initial positive transfer of learning from existing knowledge structures to new knowledge structures (Hargadon et al., 2001).

Second, our study also reveals how transfer effects may shift. We find that over time, negative transfer of learning may flip to positive transfer. Data show how the insurance industry's accumulated exposure with the computer weakened the relations among categories in the existing schema such that the more novel categories and relations associated with the computer were given greater attention. Therefore, organizations in the insurance industry experienced a positive transfer of learning as they began to see how overlapping categories such as “machine” could be related to both existing tabulating machines as well as more technologically sophisticated information processing machines.

Finally, data show support for zero transfer of learning. By the 1970s almost 20 years had passed since the commercial introduction of the computer. These categories and relations comprising the computer schema were now invoked in a “all or none” fashion. Therefore, they had no tie to categories and relations to other schemas and thus experienced no transfer of learning (Fiske et al., 1985). In summary, data show that for schema development transfer of learning exists. Moreover, data show a novel and dynamic pattern whereby transfer effects are progressively negative, positive, and then zero. In Figure 1, we illustrate both the distinct and combined effects of negative and positive transfer effects. Uncovering such effects is important since this is the first empirical study that we know of that discusses the transfer of learning effects in collective schema development.

Contributions to change theory

Our study also contributes to our theoretical understanding of change (Tsoukas & Chia, 2002; Van de Ven & Poole, 1995). Specifically, we show that while change to schemas is difficult (Walsh, 1995), our case points to the importance of the social context in which change is embedded – most insurance companies learned about the computer through attending presentations and asking questions about it at industry association meetings. These meetings allowed members to present and discuss their different ideas. Importantly, then, the social exchange of dialogue (Tsoukas, 2009) and the way insurance companies framed their discussions of the computer influenced this process.

Many discussed the new computer technology in the context of familiar business practices. For instance, the 1952 Society of Actuaries' report focuses on the potential business processes the computer could economically perform. It shows that insurance firms identified four potential applications—actuarial investigations, policy settlement work, file keeping, and regular policy service—and ultimately recommended focusing on policy service. The rest of the report was a detailed analysis of how to apply IBM's Card-Programmed Calculator or CPC (a small system consisting of electronic tabulating devices and referred to as a punched-card computer) to perform these functions, providing even the data requirements, calculations, and functions.

In contrast, dialogue of the computer that invoked the brain analogy did not provide such detailed discussions of the computer's actual use. Berkeley's 1947 presentations at the three insurance associations identified a list of potential applications and provided a brief discussion of one. They included no business process diagrams or data requirements. Instead, as mentioned, Berkeley focused on showing that a computer could think the way humans do by isolating the various abstract functions of thinking. As a result, his presentations lacked the same level of detail about the use of the computer that members of the associations were accustomed to, presumably making his analysis harder to understand. His book also provided very little discussion of the actual application of the computer to solve any business problems.

However, our study suggests that while anchoring new ideas within a familiar context appears useful to start change, it may be less useful to sustain change. In particular, the interpretation of the computer as a machine helped users quickly integrate the computer into the existing schema. But, this quick integration seemed to come at the cost of losing sight of computer's most novel aspects. Consequently, while anchoring new ideas within the familiar is useful, organizations must overcome the threat of having those ideas becoming too assimilated. By contrast, not anchoring new ideas within a familiar context may be more useful to sustain change. Thus, while the brain analogy did not provide any significant categories or relation to anchor it in the existing schema thereby making it unable to get traction earlier it did help distinguish the computer from the existing technology so that the computer's more novel features could gain attention later. This suggests that although analogies are useful for change in that they indicate differentiation they must also be made familiar enough to fuel initial action.

Contributions to schema theory

Besides revealing how a new schema develops through the processes of assimilation, deconstruction, and unitization, our study also contributes to schema theory in other important ways. First, our data also reveal the importance of schema validation. Schemas are meant to provide simplified representations of the world that enable more efficient processing of complex information (Fiske et al., 1984). To the extent that they do not accurately represent the world or filter out too much information, they are not useful. That is, a schema must be valid to a certain degree. However, most research that invokes schemas does not directly address their validity (Walsh, 1995). But, validity is a significant issue in schema development because of its novelty and uncertainty. A contribution of our study is that the initial schema of insurance firms is developed in the late 1940s prior to any experience using the computer. The initial use of the computer served as a means to validate the initial schema and demonstrates the importance of the interplay between the enacted schema in practice and the pre-practice cognitive schema. Hence, while much research suggests that schemas develop through "doing" (Howard-Grenville, 2007) our study suggests that they can begin to form *before* any "doing" at all.

Our study also suggests the relevance of schema simplification. Prior research argues that while schemas are simplified representations of the world, these representations become increasing complex over time (Chase & Simon, 1973). That is, the number of categories and relations among those categories are augmented over time. While we found some support for schemas becoming more complex we also find support for schemas becoming simpler. Specifically, Figure 2 shows a progression from a fairly simple structure during the assimilation stage to a more complex structure during deconstruction and back to a more simple structure in unitization – as measured by the number of categories and relations that have conceptual focus. The increasing complexity during the initial stages of cognitive development and decreasing complexity during later stages of develop contrasts with research in psychology which portrays an opposite pattern (Larkin, McDermott, Simon, & Simon, 1980).

Limitations and future research

Like all research, our research has limitations that suggest opportunities for future research. The cost of using a case is that it may include some peculiarities that prevent generalization. We identified three distinctive, but related socio-cognitive processes involved in schema development and presented them in sequential order because that is how they developed in the insurance case; however, future research is needed to validate this order and consider the conditions under which this may not occur. Future research is needed to better understand the nature of the assimilation, deconstruction, and unitization processes themselves. For example, assimilation in our study occurred in a social context in which insurers shared information through society meetings who gave authority of conceptualizing the computer to assigned committees that interpreted the computer as a machine. This suggests that the strength of the existing schema as well as the social environment can influence what form of assimilation takes place. Finally, our research suggests that assimilation, deconstruction, and unitization each have an important influence on transfer effects – namely, negative, positive, and zero respectively. It may be that in a different context these particular processes do not necessarily invoke these particular transfer effects. Overall, an important next step is submitting our emergent findings to rigorous empirical validation.

CONCLUSION:

Our central contribution is a theoretical framework for schema development. Our data indicate three central socio-cognitive processes: assimilation, deconstruction, and unitization. First, a new schema begins by being assimilated in an existing schema. But, we find that this can create negative transfer effects as overlapping categories activate the existing schema, not the new one. A new schema further develops through deconstruction. Here, use of the new technology weakens relations among categories and relations in the existing schema to create positive transfer effects since it allows non-overlapping categories and relations in the new schema to be activated. Finally, unitization is central in schema development. This occurs as new categories are repeatedly activated and relations between those categories form such that they become dissociated with the existing schema and become associated with a novel schema. Hence, there is no longer any negative or positive transfer effects, but zero transfer effects. Overall, by exploiting the unique features of historical analysis, we contribute to the increasingly influential cognitive paradigm in strategy and organization theory by setting forth a fresh and elaborated understanding of schemas and their temporal development that extends beyond their traditional view.

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Table 1: Categories and Relations of the existing schema, 1945 – 1954

		1945	1946	1947	1948	1949	1951	1952	1953	1954	Total
Categories											
Punch Card		11	1	3	6	1	2	4	2	3	33
Machine		8	1	2	6	1	2	4		1	25
Clerk		8			3	1			1	1	14
Data		2	1		1		1	1	1		7
Notices		1	1					2	1		5
Total		4				1					5
Policies		4									4
Premiums		1		1	1					1	4
Sheets		4									4
Number		1		1		1					3
Checks						1		1			2
Dividend		1			1						2
File					1		1				2
Information		1			1						2
Report					1			1			2
43 Items with 1 mention											
Relations	**Categories connected by relations**										
Punched in	Machine, Card	10		2	5	1	2	3	2	3	28
Sort	Machine, Card	7		1	3	1	2	3	2	2	21
File	Machine, Clerk, Card, Data	5			3	1	1	3	2		15
Check	Machine, Clerk, Card, Data	8			2		1	1	2	1	15
Reproduce	Machine, Card	5		2	2	1	1	2	2		15
Merge	Machine, Card	1		1	3	1	1	2	2	1	12
Verify	Machine, Clerk, Card, Data	6		1	1	1	1		1	1	12
Tabulate	Machine, Clerk, Card, Data, Total	5	1	1		1	1	1		1	11
Write	Machine, Card, File, Premium	5	1	2	1	1		1			11
Print	Machine, Card, File, Notices, Report	4		1	2	1			1		9
List	Machine, Card	2			1	1	1	1		2	8
Pull	Machine, Card	3			2			2	1		8
Calculate	Machine, Total, Number	3		1	1					2	7
Match	Machine, Clerk, Card			1	2	1	1	1	1		7
Post	Machine, Card	2			2			2	1		7
44 relations with 6 or less mentions											
Total Articles		12	2	4	9	1	2	7	2	3	42

Table 2: Comparing Categories and Relations Between Different Interpretations of the Computer (frequency totals are for 1945-1955 time period)

Existing Schema		Computer as Machine		Computer as Brain	
Category	**Frequency**	**Category**	**Frequency**	**Category**	**Frequency**
Punch Card	33	**Machine**	8	Information	4
Machine	25	**Card**	6	Mechanical Brain	3
Clerk	14	Computer	5	Number	3
Data	7	**Data**	5	Computer	2
Notices	5	Information	5	**Data**	2
Total	5	**Policy**	3	Operation	2
Policies	4	Procedure	3	Problem	2
Premiums	4	Tape	3	Additions	1
Sheets	4	**Computing department**	2	Answer	1
Relation	**Frequency**	**Relation**	**Frequency**	**Relation**	**Frequency**
Punched in	28	Compare	5	Handle	5
Sort	21	Compute	5	Add	4
File	15	**Write**	4	Calculate	3
Check	15	Read	4	Look-up	3
Reproduce	15	**Sort**	4	Solve	3
Merge	12	Add	3	Store	3
Verify	12	Apply logic	3	Transfer	3
Tabulate	11	**Punched in**	3	Remember	2
Write	11	Program	2	Think	2
Total Articles	42		27		5

Bold means shared category or relation between computer as a machine schema or brain analogy schema and pre-existing schema

Table 3: Comparison Between Assimilated Schema and Articles about Computer in 1960

	COMPUTER AS MACHINE (1947 - 1950s)	Leverence Article (1960)	Horn Article (1960)
Categories	Answer, Application, Billing department, ***Card***, Case, Cash Values, **Clerk**, Computation, ***Computer***, Computing department, Data, Days, Dividend, Equipment, Factors, Figures, **File**, **Forms**, Human, **IBM 650**, **Information**, Instructions, Loan, Machine, Notices, Number, Payment, **Policy**, Problems, Procedure, **Records**, Reserves, Results, Statistics, Stub, Table Factors, Tabulator, **Tape**, Transactions	Agency, Calculations, Characters, **Computer**, Control Center, Customer, ***Features of Policy (23 features listed)***, **Forms**, **Information**, ***Master File***, Pass, **Policy**, ***Policy Master Tape***, Premiums, ***Processing Run***, ***Punch Card***, **Record**, ***Routine***, ***Run***, ***Selection Dates***, System, **Tape**, Trailers	***Accounting Card***, Audit Trail, **Clerks**, **File**, **IBM 650**, **Information**, ***Policy History***, ***Premium Status Card***, Production Report, ***Program***, ***Punch Card***, ***Punch Card File***, ***Punch Card System***, Report, ***Run***, Status, **Stub**, Summary Sheet, Total
Relations	Add, Adjust, Apply logic, Arrange, Audit, Build, Calculate, **Check**, Collate, Combine, Compare, **Compute**, Consult, Control, **Convert**, Copy, Delete, Determine, Erase, File, Handle, Hold, Insert, Interpolate, Know, Look-Up, Match, **Merge**, **Multiply**, **Perform**, Pick, Put, **Post**, **Prepare**, Print, **Process**, Program, **Punched In**, Read, Recognize, Record, Remember, Repair, Reproduce, **Route**, Run Trough, Schedule, Search, **Select**, **Sort**, Store, Subtract, Test, Transfer, Type, ***Verify***, **Write**	Accumulate, Addressed, Appear, Billed, ***Checking (internal to computer)***, **Compute**, Considered, **Convert**, Duplicate, Edit, Listed, **Merge**, **Multiplied**, Pass Through, **Performed**, **Prepared**, **Process**, **Punched**, Re-processed, **Routed**, Set up, Show, Simplified, **Sorted**, Take into consideration, Triggered by, Update, ***Verify***, **Write**	Create, Destroy, Distribute, Facilitate, Mailed, Mechanized, **Merge**, Placed, **Post**, **Prepare**, **Process**, Produce, Pull, **Punched-in**, Put Through, **Route**, **Select**, Summarize, ***Validated (by IBM 650)***, ***Verify***

Bold means shared category or relation between schema in 1960 and Computer as Machine Schema

Bold Italic means new way of thinking about category or relation found in the earlier schema

Table 4: Similarities in Description of Computer Use in 1972

	Tyrrell Article (1972)	Schaefer Article (1972)
Categories	**Agent**, Applications, **Computer**, IBM 360, **Information**, **Letter** to Policyholder, **List**, **Notices**, **Policyholders**, **Premium**, **Record**, **Sales Department Cards, Service**, **Service Department**, Sheets	**Agent, Agency Status Cards**, Clerical Bottleneck, Clerk, **Computer**, Computer Terminals, Display, **Information**, **Letter**, **Lists**, **Notices**, Output, **Policyholder**, **Premium**, **Record**, Report, **Service Department**
Relations	Assists in Deciding, **Contains**, Forwarded, **Give Service**, Handled, **Prepared**, **Provide**, **Run**, **Send**, **Uses (Information)**	**Contains**, Filed, Generate, **Give Service**, Gives, **Prepared**, Print, Program, **Provide**, Quotes, **Run**, **Send**, Sort, **Used by (various departments)**

Bold means shared category or relation between Tyrrell or Schaefer Article

FIGURES

Figure 1: Summary of the Development of Insurance's Computer Schema, 1945-1975

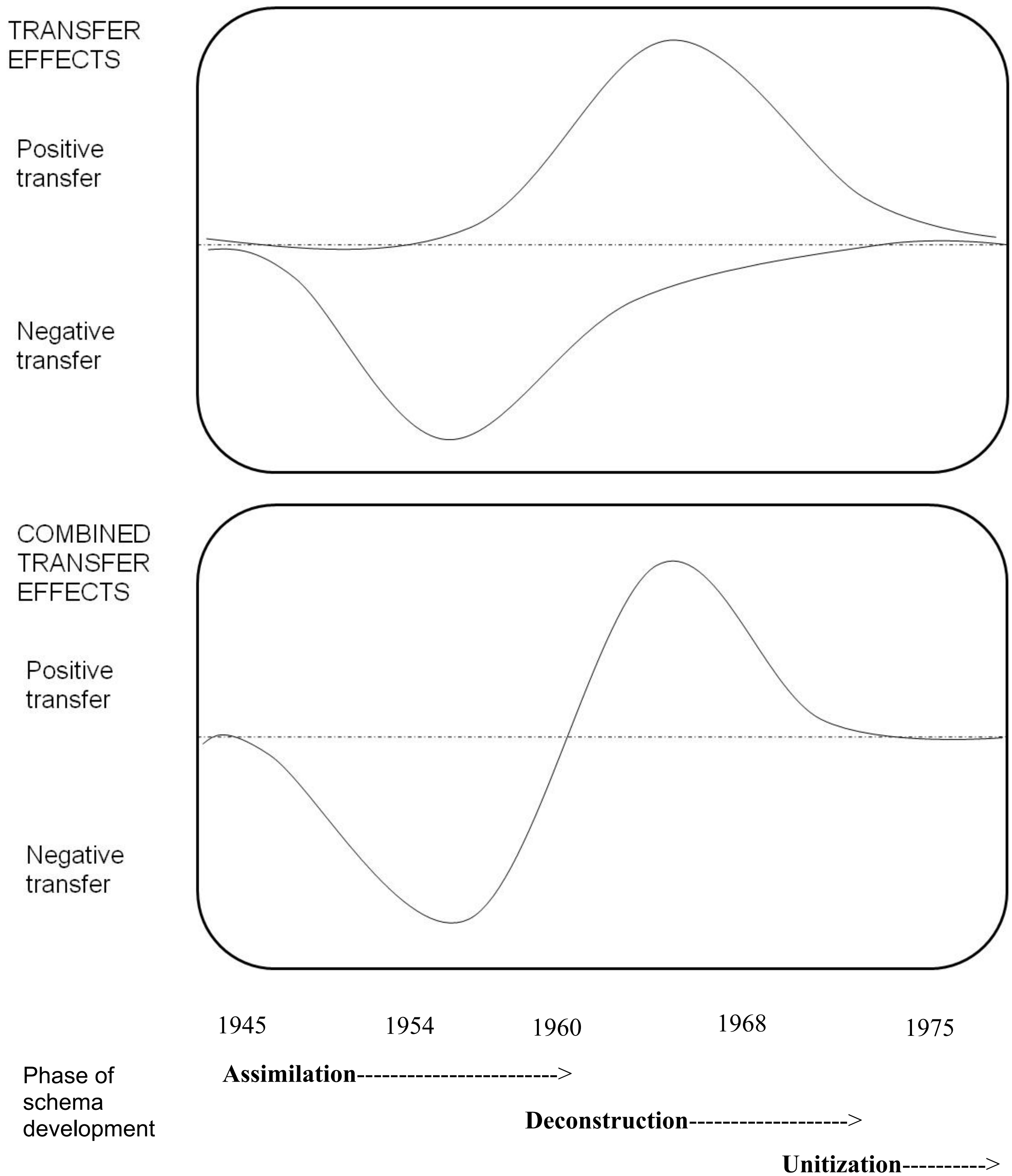
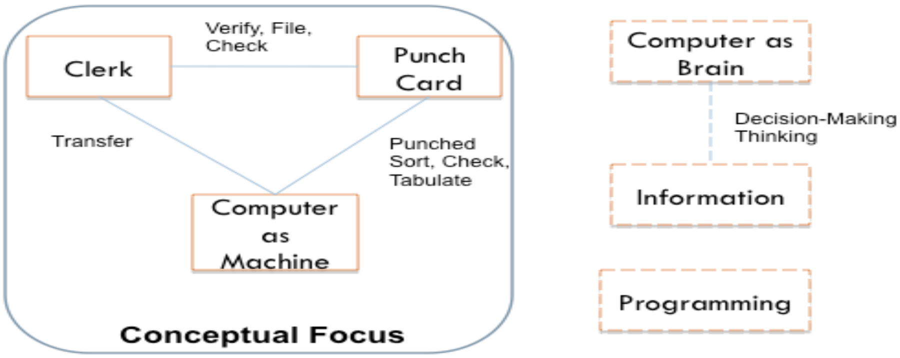
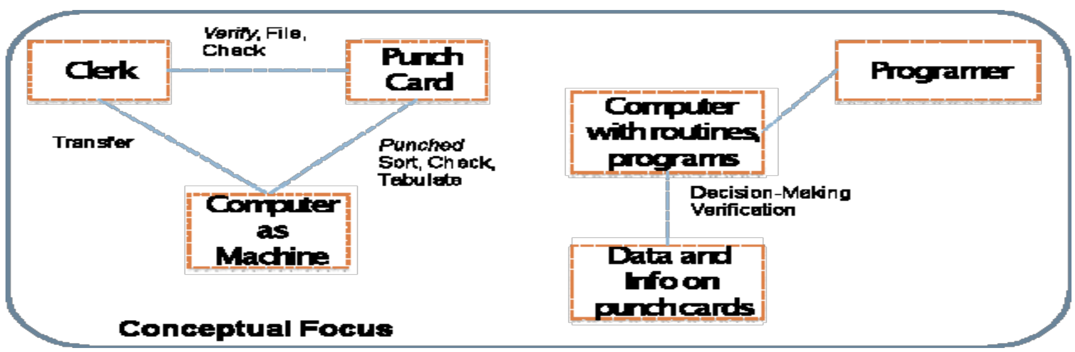


Figure 2: The Different Processes of Schema Development in the Insurance Industry

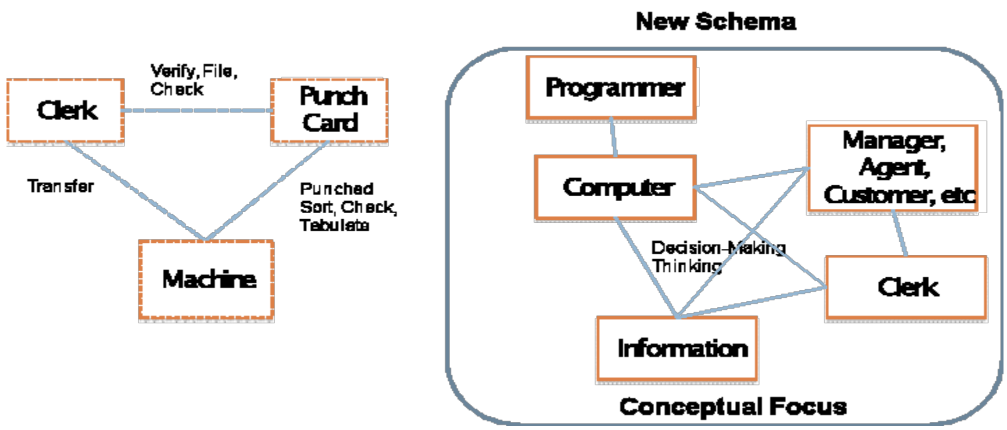
Assimilation (1947 – early 1960s)



Deconstruction (1960s)



Unitization (1970s)

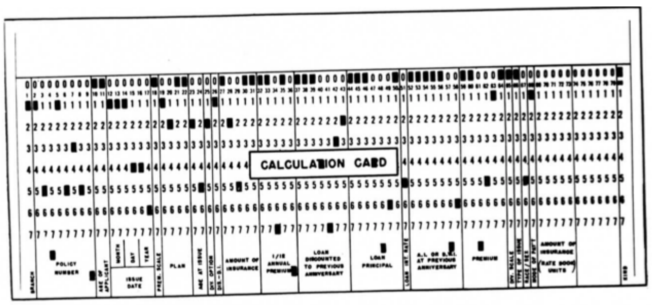


* Dashes mean weakened conceptual boundaries and relations

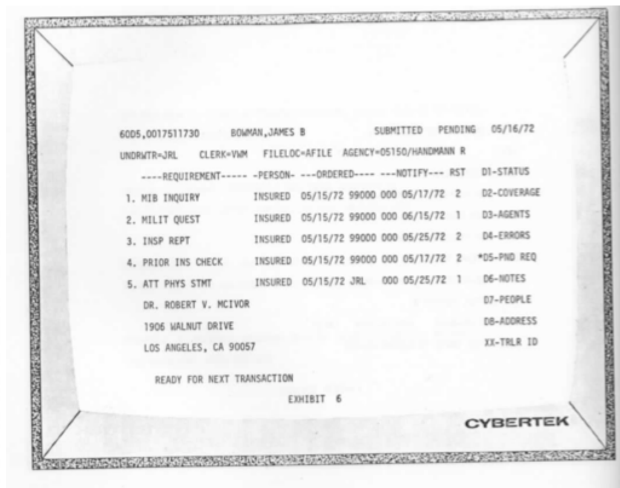
APPENDIX A

In addition to the text of the presentations, insurers also used diagrams and pictures to convey their points. Analysis of the diagrams help show the gradual shifting of focus initial from the punch cards as the primary unit of information to the information contained within punch card. Below is a picture of the punch card used in the SOA Report (Davis et al., 1952: 89) and the other is a snapshot of a terminal screen used in 1972 (Morgan, 1972: 56).

Punch Card, 1952



Terminal, 1972



The following picture comes from an article explaining management information systems (MIS – see page 30 in paper), showing in a different way the shift to information (Winberg, 1972: 21). It adopts the familiar pyramid structure used in Robert Head's article in Datamation to show information as the basis for MIS systems. The pyramid represented three different levels of information, from the transaction processing, to the mid-manager, to the executive, and how information flows in both directions to support planning and decision-making.