Concept Creation, Coherence, and Cohesion

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Abstract

This paper explores why actors may develop different interpretations of a new concept. It leverages work from cognitive science to define this interpretive process in terms of creating coherence: fitting the new concept into the existing conceptual schema. We argue that variation in conceptualization results in part from cognitively cohering the concept in different ways. We appeal to the social structure of the group to explain this variance. Cohesive groups favor establishing similarities between the new concept and something familiar in the existing schema. Diffuse groups lack a clear, agreed-upon schema to hook a new concept into, and therefore favor making sense of the new concept without directly integrating it into the schema. We illustrate the relationship between social cohesion and cognitive practices by analyzing the different conceptualizations of the computer during its introduction in the insurance industry from 1940-1960.

Contemporary sociology has become increasingly interested in how new concepts get formed and developed. As actors encounter new things in the world, they form conceptual representations of them which, in turn, influence future interactions. Often actors develop different conceptualizations of the same new object. In the sociology of technology, for instance, Pinch and Bijker (1987) show that some groups interpreted the new bicycle in terms of safety; whereas, others focused on speed. Given these differences in interpretation, sociologists have generally tried to explain the mechanisms that select a particular interpretation—for example, why the safety bicycle emerged as the dominant conceptualization. Or, absent a selection process, what enables translation between alternative interpretations, for example boundary objects (Bowker and Star 1999). Sociological research has paid less attention to how these different interpretations form in the first place. Yet, to fully comprehend the subsequent selection and translation processes requires an understanding of the socio-cognitive processes that develop the initial interpretations.

How different social groups interpret a new concept is partly a function of the cognitive processes that the groups use to construct these interpretations. Durkheim explains that these cognitive processes entail fitting the new concept with existing beliefs and conceptions. He asserts, "If they [new concepts] are not in harmony with other beliefs, other opinions, in a word with the whole gamut of collective representations, they will be denied; minds will be closed to them; they will be as if they never were" (Durkheim 1912 [2001], pp.333-4). DiMaggio (1997) provides a more modern interpretation of Durkheim's assertion, describing "the whole gamut of collective representations" as a schema into which a new concept must fit. Following this schema image, it is quite conceivable that actors vary in how they fit the same new concept within their conceptual schema. For instance, the concept of safety bicycle fits the bike into the conceptual schema by focusing on the "safety" relation, but the speed bicycle focuses on the "speed" relation. This possibility of different ways to fit in the new concept lies at the heart of Swidler's (1986) notion of culture as a "tool kit" – actors may differ in how they apply their cognitive tools.

In this article, we begin to develop an explanation of why actors may vary in how they fit a new concept within a conceptual schema. We call Durkheim's "fitting in" process creating *coherence*. Recently, cultural sociologists have been building closer ties with cognitive science (Cerulo 2002; DiMaggio 1997) and we believe research into the various cognitive devices actors use to make sense of concepts provides a helpful framework to specify the coherence process. In particular, cognitive science has developed individual theories about how cognitive processes like analogies or conceptual combinations work such that, taken collectively, they show the various ways actors can fit a new concept within an existing schema. We use this work to further define coherence along two dimensions: the aspect of the schema to which the new concept is linked, and whether that link emphasizes similarities or differences. These dimensions, in turn, express the different ways a new concept can cohere. Analogies, for instance, map relational structures between schemas and highlight similarities; whereas, classification works at the attribute level and focuses on differences. Therefore, using an analogy leads to a different kind of coherence than using classification.

While cognitive scientists help explain what cognitive coherence is, they do not pay as much attention to why actors may vary in how they cohere. To address this important concern, we leverage the long standing work that relates social with conceptual structure to argue that the social structure of the group doing the interpretation places different constraints on the cognitive processes of coherence. In particular, we focus on the cohesion of the social group, invoking Martin's (2002) concepts of tightness and consensus to measure the level of cohesion. We propose that cohesive groups require something familiar within the existing schema to pull the new concept in, consequently favoring coherence processes that emphasize similarities over differences. In contrast, diffuse groups generate a different kind of constraint. Because there is no clear schema to hook a new concept into, these conditions favor making sense of the new concept without integrating it directly into the schema.

Finally, we illustrate this argument by analyzing the discursive strategies among different groups within the insurance industry use to interpret the new concept of the computer when it was introduced in the 1940s – 1960. The coherence processes varied from using an analogy with human thinking to using the conceptual combination "information processing machine." We explain these differences in creating coherence in terms of the level of cohesion of the social groups to which these interpretations were targeted. We believe this work extends the renewed interest in the structural characteristics of culture and knowledge by exploring how social and conceptual structures of existing schemas influence the production of new concepts and knowledge. We also believe that this analysis contributes to the growing sociological literatures that invoke social cognition, such as organization theory and sociological studies of technology, by showing the need for greater appreciation of the variation in the cognitive processes actors use to make interpretations.

We begin by applying insights from cognitive science to define coherence.

Different ways to cohere – Insights from Cognitive Science

The term "coherence" is vague. Philosophers describe coherence as a characteristic of belief systems and focus on its role in the justification of beliefs (Thagard 2000). However, while conceptual schemas vary in their level of internal coherence, each has the potential to form a new concept. Thus, in this paper, we are not interested in coherence as a criterion for justification, but in coherence as the process for fitting in a new concept. While cognitive scientists do not typically use the word "coherence," they more generally address how actors leverage different aspects of the cognitive repertoire to form new concepts. These explanations, in turn, form the basis for a more formal definition of conceptual coherence.

Cognitive scientists define conceptual schemas in terms of the concepts, the attributes that define them, and the relations between the concepts (Gentner, Holyoak and Kokinov 2001). In general, the coherence of a new concept involves retrieving one of these aspects with which to fit the new concept. Specifically, a new concept can be fit in at the conceptual, attribute, or relational level. In addition, cognitive scientists specify the nature of fitting in as showing how the concept is either similar to or different from the retrieved aspect of the conceptual schema (Gentner, Holyoak and Kokinov 2001). For example, fitting the new concept in at the attribute level could involve showing how it shares that attribute or how it differs from that attribute. These processes characterize two important dimensions of coherence – what in the conceptual schema the concept is fit into and whether the fitting in involves establishing similarities or differences. Cognitive scientists also explain the kinds of cognitive devices actors use to form new concepts, such as analogies, metaphors, or classification, in terms of these two dimensions (Gentner, Holyoak and Kokinov 2001). These cognitive devices, in turn, represent different ways actors can cohere a new concept into their conceptual schema. Consequently, an actor who uses an analogy understands the same concept differently than an actor who uses classification.

Cognitive scientists tend to consider these devices piecemeal to develop theories about how they function; however, for our purposes we consider them collectively to show differences in how they cohere. To make this discussion more concrete, we use a thought experiment to explain the different ways to cohere a new vegetable X into an existing vegetable schema. We have purposefully chosen to use the example of vegetables because it is significantly different than our empirical example of computers within the insurance industry. We focus on three common cognitive devices discussed in the cognitive science literature – analogy, classification, and conceptual combination – to show how they cohere the new vegetable X. While this list certainly is not exhaustive, it illustrates the substantial differences in how a concept can cohere.

Since coherence involves relating the new concept to an element of the conceptual schema, it is first necessary to further define its elements. We begin with concepts. Concepts denote the different categories that identify similar instances and differentiate them from other concepts (Zerubavel 1996). Examples of concepts for the vegetable schema may include pepper, romaine lettuce, and root vegetable. Eleanor Rosch and Mervis (1975) recognized that concepts occur at different levels of aggregation. Some concepts, like romaine lettuce, are quite specific, whereas others, such as pepper, are more general, including among its members other concepts like bell peppers and jalapeno peppers.

For each concept, a set of attributes characterizes its members (instances of that concept). For example, among the many attributes that root vegetables have, some include growing in the ground, having tough outer skin, and being harvested mostly in the fall. Sociologists typically follow Rosch and Wittgenstein in the view that there is no one set of attributes that all members have; rather, members may share different clusters of attributes (Hannan, Polos and Carroll 2007; Rosch and Mervis 1975; Wittgenstein 1958). For instance, jalapeno and habanero peppers both are hot, but bell and apple peppers are sweet; nevertheless, they all are thought of as peppers. This implies an additional process that identifies which of the shared attributes defines the concepts. Sociologists call this process the institutionalization of the concept and have emphasized the social processes that determine the salient attributes (Berger and Luckmann 1966; Hannan, Polos and Carroll 2007). This view also implies that there is an inherent structure to each concept, where some instances are more prototypical than others (Rosch and Mervis 1975).[1] Some types of peppers may be seen as more core than others. Given that the salient attributes are socially defined, groups may differ in their definition of prototypical members. In Italy, the sweet bell peppers may be seen as the prototypical pepper, but in Mexico, the hot jalapeno may be the prototypical pepper.

Different concepts may overlap with each other to the extent that they share attributes. For example, the concepts of romaine lettuce and peppers share the attributes of green and crunchy. As a result, within a schema at a given point in time, concepts vary in how precisely they are defined and how they are demarcated from other concepts at the attribute level. Population ecologists are beginning to develop explanations of how the internal structure and overlap between categories at the attribute level influence market behavior (Hannan, Polos and Carroll 2007).

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[1] Cognitive scientists propose several different ways to determine the core attributes of a concept beyond typicality (see Cerulo 2002) for a review). For instance, there is the exemplar and theoretical view. While these approaches differ significantly in explaining the identification of the salient attributes, they share the same fundamental belief that only certain attributes define a concept. We are agnostic to this debate and use the prototypical approach simply as an example.

Finally, concepts are connected through a series of relations. Like attributes, there are many different kinds of relations: causation, functional, comparison, and opposition to name a few. For instance, root vegetables has the relation of "is denser than" with peppers, whereas jalapeno has the relation of "is member of" with peppers, rain has the functional relationship of "provides nutrients to" with each of the mentioned vegetable concepts. There is a complex relational structure that relates different concepts together independent of the attributes that define each concept. And, just as certain attributes may be favored over others, so too may certain relations be favored.

With the elements of a conceptual schema better specified, now consider the emergence of a new vegetable X that requires actors to cohere it with this existing schema. For the sake of illustration, imagine that this new vegetable has the following attributes and relations: mealy texture, sweet taste, yellow and red in color, it depletes minerals in the ground preventing other plants from growing and thrives in desert conditions. We can now consider some of the different ways in which vegetable X can be fit into the schema.

Actors could cohere vegetable X through an analogy, for example with a lion. The structure-mapping theory of analogies asserts that analogical thinking involves the relational mapping between the base and the target (Gentner 1983). In this case, the analogy involves mapping the relations the lion has with other concepts to vegetable X and its relations with other concepts. For example, the lion eats it prey just as the vegetable depletes the minerals from the soil or the lion thrives within the Sahara just as the vegetable thrives within its desert climate. Attributes of the concepts play a lesser role; in fact, vegetable X looks nothing like a lion. The analogy of vegetable X with the lion tells us how the vegetable relates to its environment and sources of nourishment as opposed to defining the salient attributes that define and differentiate the vegetable. Therefore, from a coherence perspective, analogical thinking focuses on similarities in relational structure. However, in a pure sense, analogies do not fit the new concept into the base concept's conceptual schema. Vegetable X is not assimilated within the lion's schema, but shown to have a similar relational structure. In this respect, DiMaggio (1997) postulates that analogies are useful tools to link different schemas together.

In another form of coherence, actors could classify vegetable X within the existing conceptual schema of vegetables. Zerubavel (1996) describes this process as lumping and splitting: a process of identifying similar attributes among the different instances of vegetable X and then differentiating these attributes from other concepts. For instance, a set of actors, perhaps plant experts, could determine that of vegetable X's many attributes, mealy texture, is the salient characteristic which defines it. Beyond identifying similar attributes within vegetable X, these actors may also compare it to other familiar vegetables. In this process, they recognize that other vegetables share these attributes such that vegetable X overlaps with them, and must determine whether it should be assimilated within an existing category or exist independently. While there may be other specific processes that do not involve experts, classification in general focuses on differentiation at the attribute level. Therefore, where analogies work mostly at the relational level and focus on similarities, classification works mostly at the attribute level and focuses on differentiation.

Finally, conceptual combination is a third kind of coherence which involves combining aspects of two familiar concepts to define the new concept. In one form, this process combines an attribute from one concept to another. For example, we could describe vegetable X as a "peach pepper" which maps the properties of mealy, sweet, and yellowish red from the modifying concept, "peach", to the head concept, "pepper." According to Wisniewski (1996), this process involves finding similarities between both concepts as a basis for transferring the properties. In this case, peach and pepper both share the attribute of being eatable which enables an understanding of the differences in texture, taste, and color. Consequently, attribute-based conceptual combination differs from classification in that it builds upon similarities in attributes between concepts and actually transfers attributes from one to the other. In contrast, classification tries to differentiate between conceptual attributes and minimizes transferring. Put differently, attribute-based conceptual combinations result in high overlap between the new concept and the combined concepts, but classification tries to minimize this overlap.

In another form, actors could combine concepts at the relational level (Tripat and Dube 2007). For example, we could describe vegetable X as a "desert plain pepper." This combination does not mean that vegetable X has the properties of a desert plain; rather, the locational relation links the two concepts together. Wisniewski (1996) describes relational combination as a process in which actors seek a plausible scenario that supports the relational link. Thus, relational combination is similar to analogies in that it focuses on relations, but unlike analogies, it links the two concepts together along this relational dimension within the existing schema. Analogies, in contrast, use the relations of the base analog (the lion) to understand the various relations that the target analog (vegetable X) has without integrating schemas.

In summary, each of these cognitive processes coheres vegetable X into the schema differently (see Figure 1). Classification focuses on differentiating the new concept from other concepts primarily at the attribute level. While attribute-based conceptual combinations also work at the attribute level, this process tries to establish similarities. In contrast, analogies and relational-based conceptual combinations work at the relational level, but analogies focus on mapping out the relational structure of the new concept as opposed to integrating it within the existing relations structure.

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Insert Figure 1 about here

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These differences in coherence are not trivial, but form the basis of different interpretations of the same concept. For example, actors who use classification processes, rather than analogies, will recognize the attributes that define and differentiate a concept, but will understand less about how this concept relates with others. In contrast, actors who use analogies learn about the interrelations between concepts but lack a clear understanding of the concept's defining attributes. Similarly, actors who use conceptual combinations will anchor the new concept with familiar concepts but will not as fully comprehend how it differs from these concepts.

Social Structure and Coherence

Cognitive science helps explain the different ways a new concept can cohere with a conceptual schema and its implications for concept formulation, but it does not address the important question of why actors would use one way to cohere over another. Framing coherence as an evaluative process identifies several different possible explanations, including characteristics of the new concept, the conceptual schema, and the actors themselves. While characteristics of the object and the cognitive capabilities of the actor certainly are important to the coherence process, they each have limitations in explaining its variation. The marketing literature has pointed out that certain cognitive devices, such as analogies or conceptual combinations, help simplify highly complex concepts which are difficult to understand (Gregan-

Paxton and John 1997; Tripat and Dube 2007). However, the level of complexity of the object does not explain why actors may use different methods to interpret it. Moreover, cognitive scientists generally agree that analogies create a more involved process because they require deeper understandings of the relational structure (Gentner, Holyoak and Kokinov 2001). Consequently, some actors may simply not be able to analogize and resort to less taxing processes. However, cognitive scientists have also shown that children use analogies as learning aides suggesting that they may not require substantially different cognitive capabilities (Gentner, Holyoak and Kokinov 2001).

We propose explaining variation in coherence processes by addressing the social and conceptual structure of the actors who engage in this process. We focus on the organization of the conceptual schema of the group doing the coherence as placing different kinds of constraints on the group and thus favoring certain ways to cohere. In particular, because more cohesive conceptual schemas resist change, they require something familiar to anchor the new concept, thus favoring coherence processes that establish similarities. In contrast, diffuse conceptual schemas do not offer anything concrete in which to fit the new concept. These conditions favor coherence processes that do not require integration within the existing schema, such as analogies or defining the core attributes of the new concept. This argument requires us to 1) clarify what is meant by cohesive and diffuse conceptual schemas; 2) explain why these characteristics favor different kinds of coherence processes; and 3) identify the conditions under which conceptual schemas are cohesive and diffuse.

To satisfy these criteria, we build upon a long sociological research tradition that links social structure with conceptual structure. Durkheim (1912 [2001]) argued that a group’s conceptual structure reflects it social organization, an argument which, in our case, implies that cohesive social groups tend to have cohesive conceptual schemas. However, cohesion can be described in many different ways, for instance, in terms of relations as advocated by network analysis. We explain cohesion in terms of Martin's (2002) two structural dimensions of consensus and tightness. We leverage Martin because he also focuses on cognitive practices, has established the link between the social and conceptual along these dimensions, and provides a means to empirically measure these dimensions. We move beyond Durkheim and Martin who are focused on explaining the source of conceptual structure because we are interested in the application of that structure to evaluate new concepts. In this regard, we operate in the spirit of Mary Douglas (1966) who showed that the social structure of various religious groups played an important role in whether they accepted or rejected anomalous concepts. However, we consider a specific kind of anomalous concept – one never experienced before. So, where she focused on general acceptance outcomes, we consider the cognitive processes of coherence as a means to develop an interpretation of the new concept. How this concept coheres with the conceptual system, in turn, influences its acceptance. Therefore, we combine insights from Durkheim, Douglas, and Martin to argue that social structures give rise to different conceptual structures, which in turn constrain the cognitive activity of how actors fit in a new concept.

Social Cohesion and Coherence

Martin (2002) defined two relevant structural dimensions of social and conceptual structure. The first is tightness or the degree to which beliefs are interrelated and imply each other; tightness occurs when there is cognitive authority within the social structure. Martin defines cognitive authority in terms of having power of judgments and beliefs within groups (this need not be an authoritative figure). The second dimension is consensus or the degree to which the belief system is shared and agreed upon; consensus typically which occurs when there is a fixed hierarchical structure within the group. We use these dimensions to express cohesion within a group and their conceptual schema.[2] Because tightness refers to relations between beliefs, it corresponds to the relational structure of the conceptual schema. High tightness implies that the relational structure is well specified. Consensus, in turn, maps to the level of agreement in the definition of the concepts. High consensus means that the salient attributes that define the concepts are well agreed upon.

Therefore, conceptual schemas in which there is agreement on the definition of the concepts and the concepts are interrelated through a relational structure are cohesive. Following Martin, such schemas should reflect groups that have a cognitive authority and clear power structure. In contrast, a diffuse conceptual schema is one which lacks agreement on conceptual definitions and specification of the relational structure among the concepts, and such schemas should be reflective of groups without a cognitive authority or a fixed power structures.

Cohesion and diffusiveness create different kinds of constraints that affect how actors within these groups create coherence of a new object. High levels of consensus and tightness produce conceptual schemas that are resistant to change. Consensus induces inertia by making it difficult to conceive of an alternative. The inter-relations of a tight conceptual schema make it difficult to integrate the new concept to the extent that it requires substantial change to the existing relational structure. Given this inability to think of something different or resistance to

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[2] Martin applied his analysis to propositional beliefs and not conceptual schemas. Conceptual schemas do not have the same standards of consistency that beliefs have. For instance, conceptual schemas could be inconsistent. However, given that concepts exist within a broader schema, we believe that the application of Martin's structural features are warranted. Moreover, Martin did not apply tightness or consensus to explain cohesion. In fact, he treats these as separate dimensions, the implications of which we consider shortly. Lastly, with respect to tightness, Martin focuses on the implications between beliefs, but since we are working at the conceptual level, we focus on how these concepts are inter-related.

change the existing structure, cohesive schemas require identifying something familiar within the schema to pull the new concept in.

The basic requirements for familiarity favor coherence practices that establish similarities between the new concept and existing schema. This can occur at the attribute, concept, or relational level. For example, attribute-based conceptual combinations transfer attributes from existing concepts to the new concept making it more familiar, or relational-based combinations increase familiarity by mapping a relation between existing concepts to describe the new concept. In contrast, classification is less appealing because it emphasizes the differences of the new concept from the existing schema. Therefore, we would expect cohesive groups along the dimensions of tightness and consensus to cohere a new concept by establishing similarities with something familiar in the conceptual schema. This requirement promotes the use of cognitive devices such as conceptual combination at either the attribute or relational level.

Diffuse conceptual schemas present a different sort of challenge for coherence. Where cohesive schemas have well defined concepts and relations, diffuse schemas lack clear definition at both the conceptual and relational level. The lack of consensus means there is no common understanding of the underlying concepts, and the lack of tightness means that the inter-relations are not well mapped out. In essence, no aspect of the schema is defined well enough to either establish similarities with the new concept or to differentiate it from the old. Because there is no clear schema to hook a new concept into, these conditions favor making sense of the new concept without integrating it directly into the schema.

One way to accomplish this is the "lumping" process of classification or identifying the salient characteristics that define the concept because this need not involve integration into the schema. But, the "splitting" process of classification or differentiating from other concepts is less effective because it invokes attributes of other concepts which lack common understanding. Douglas (1986) proposes “naturalized analogies” as another means of making sense of new concepts. Recall that unlike other forms of coherence, analogies do not fully integrate the new concept into the conceptual schema used to interpret it. Analogies show a similar relational structure to develop an understanding of the concept. However, analogies do require using the relational structure of a schema to interpret the relational structure of the new concept, which may not be feasible given the diffuse nature of the group. The “naturalized” aspect of the analogy overcomes this issue because it invokes some natural order that is common within the community. Therefore, we would expect diffuse groups to cohere a new concept by rationalizing it through the use of naturalized analogies or defining its core attributes.

It is helpful to think of cohesive and diffuse groups as two ends of a continuum. However, this paper only makes predictions about the conditions of cohesion and diffusion and not what lies in-between.[3] The different ways a group can move along this continuum require additional analysis about the relationship between tightness and consensus, which is not in the scope of this paper.

Coherence of the Computer in the Insurance Industry, 1947 – 1960

[3] Indeed, Martin treats tightness and consensus independently such that changes in either dimension not only create differences in the conceptual structure, but also influence how it is applied to interpret new concepts. For instance, if groups lack a cognitive authority we would expect less tightness or less specified relational structure within the conceptual schema, but lacking consensus means there is no shared understanding of the underlying concepts. In turn, a conceptual structure that lacks tightness may make it less conducive to use relational forms of coherence such as analogies or relational based conceptual combination while favor classification. Or, a group can become less cohesive in different ways, such as the introduction of a new group that has a cohesive, but different conceptual schema.

To illustrate this argument we analyze how different social groups within the insurance and computer industry conceptualized the computer during its commercial introduction in the 1940s through early 1960s. Our goal is to show that the different ways to cohere the computer generated different understandings of it, and to explain this difference in terms of the cohesion of the social groups.

We chose this setting for several reasons. First, the computer represented a novel concept being introduced into a community. After World War II, the business computer emerged as a new product that could potentially help insurance firms conduct their business. Technically, the computer was radically different from calculators and tabulating machines that preceded it. Similar to the sociology of technology literature, we interpret the new technology of the computer as representing a new concept whose meaning was socially constructed. Second, a common issue with socially-based cognitive analysis is that the actual cognitive processes of the actors are difficult to observe. However, the significant financial and organizational commitment it took to purchase a computer meant that customers needed to justify its purchase, leaving a rich archival record of how the market initially conceptualized the computer. We leverage the printed proceedings of annual meetings and special conferences of three insurance associations: the Society of Actuaries, the Life Office Management Association (LOMA), and the Insurance Accounting and Statistical Association (IASA). These detailed contemporaneous accounts describe many insurance firms' thinking and decisions about what computer to adopt and how to use it. These reports were also circulated among insurance firms forming the basis of how they interpreted the computer.

Since how actors fit the computer within their cognitive schema was expressed through the language in their texts and these texts played a significant role in shaping how the insurance industry interpreted the computer, we apply discourse analysis to these texts. We use Fairclough's (2003) discursive approach to identify the two dimensions of coherence. First, these texts use rhetorical devices, such as analogy, that compare the computer to specific aspects of the conceptual schema. Second, the semantic relations and textual representations used in the text either emphasized similarities or differences in these comparisons. Appendix A provides a more detailed discussion of the methodological procedures.

However, one limitation of discourse analysis is that by emphasizing the role of text in meaning making, it marginalizes the role of interaction with the object as another source of meaning. This is of particular concern for technological objects, such as the computer, in which using the technology can generate the meaning structures that define it (Orlikowski 2000). In the insurance industry in particular, Yates (1993) has shown how extended use of the previous technology, tabulating machine, influenced its technological development. Therefore, we supplement our discourse and conceptual analysis with a history of the early usage patterns of the computer. Research in the archives of Metropolitan Life as well as presentations from other firms at industry associations provide extensive data on some specific acquisition and use decisions in these firms. While not the primary focus of the paper, this analysis shows how local conditions further influenced the alternative interpretations of the computer and the process of convergence toward a dominant interpretation.

Third, and most importantly, there was variation in the level of cohesion of the different groups interpreting the computer as well as how the process of coherence used to fit the computer into the conceptual schema. We concentrate our analysis on the period prior to the commercial introduction of the computer in 1954 when various actors provided different conceptualizations of the computer. We focus on the computer enthusiast Edmund Berkeley, who acted as a mediator between the computer manufacturers and insurance firms as well as wrote the popular book *Giant Brains or Machines That Think,* and on the Society of Actuaries' committee that analyzed the computer from 1947 – 1952. Berkeley conceptualized the computer in various ways: through a series of comparisons with pre-existing technologies and the naturalized analogy with human thinking. The Society of Actuary report described the computer through the conceptual combination of "information processing machine." We seek to explain the variation in these ways to fit the computer into the conceptual schema. We propose that the best explanation considers the cohesion of the group interpreting these conceptualizations. Presentations oriented toward cohesive groups, in particular the insurance industry, favored grounding the computer with something familiar either through comparison or conceptual combination; however, presentations oriented toward a diffuse group, in particular, the general public, did not try to fit the computer into a particular schema, but used naturalized analogies. Using Martin's measures of tightness and consensus, we argue that the insurance industry was a cohesive group, but the general public was diffuse. Consequently, when the computer was released in 1954, there were two different conceptions of the computer – one characterized the computer as like a human thinking and the other characterized it as an information processor. As firms implemented the computer, the information processing interpretation became dominant within the insurance industry.

Clearly, these are not the only actors who made interpretations of the computer. For instance, the media also plays a role as well as the computer manufacturers themselves. However, we selected these representatives because they targeted their presentations to groups that had differences in their level of cohesion. That there are other groups and interpretations, while important to the ultimate conceptual formation of the computer, is not as critical to our analysis of the sources of differences in initial interpretation. In addition, within these groups there are other actors. There are computer enthusiasts other than Edmund Berkeley; other reports than the Society of Actuaries'. We focus on these particular interpretations because they were the most influential interpretations. Berkeley, as will be discussed in greater detail shortly, became a prominent actor not only in the insurance industry but in the computer industry as well. The IASA and LOMA committees organized conference panels, equipment displays, and small conferences, but neither produced as comprehensive a report as did the Society of Actuaries Committee, and neither had as much prestige as the professional society did (for the huge influence of the Society of Actuaries committee, see Moorhead 1989).

Finally, we leverage the historical sequence of these interpretations to provide further robustness to our analysis. These reports and books were not released simultaneously: Berkeley made a series of presentations to insurance associations in 1947 and published his influential book that compares the computer with human thinking in 1949, and while the Society of Actuaries Report initiated its study in 1947, it did not publish its findings until 1952. The historical sequence is important because Berkeley developed the comparison with existing technologies prior to the release of his book. So, why did Berkeley emphasize the analogy in the book when he already had developed a different interpretation? In addition, the Society of Actuaries could have used Berkeley's thinking analogy, but instead focused on information processing. Analysis of these choices further supports our supposition that the cohesion of the social group and its conceptual schema influences how it fits in a new concept.

To present our analysis, we first provide the historical context of the setting to ground our discussion. Then, we present each way of coherence and the level of group cohesion in historical order.

The Setting: The emergence of the computer in the insurance industry, 1940s – 1960s.

As information-intensive businesses, life insurance firms had become early and important adopters of information processing technology. Clerks and calculators were fixtures in the industry, performing functions such as figuring premiums, calculating actuarial tables, and performing accounting functions. By the 1940s, virtually all insurance firms used tabulating systems (typically made by IBM) to sort and calculate information represented as punched holes in cards. Indeed, 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 et al. 1986). Life insurance firms had generally divided and specialized insurance operations as they grew, and they used tabulating equipment in line with this approach (Yates, 2005). A typical insurance application had its own set of cards and performed a single, narrowly defined operation on them. By the late 1940s, however, some smaller firms had started to use tabulating technology to integrate premium billing with related accounting operations in order to reduce data repetition (Cassara 1952).

As the clerical labor shortage during World War II was exacerbated by a post-war life insurance boom, insurance firms were seeking technology to automate more of their processes. From 1948 to 1953, the cash value of existing life insurance policies grew 51% and their number rose by more than 24% (Bureau of Labor Statistics 1955). Insurance employment grew only 12% during the same period. As a result, the insurance industry became increasingly interested in new technologies that aided in information processing. One promising technology that emerged during the war was computing. In fact, during World War II a few insurance actuaries worked on the new computing technology being developed for military and computational purposes (Moorhead 1989). After the war, 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. It was the concept of this new kind of computer that appealed to the insurance industry

Before the commercial release of the first business computer, the magnetic tape-based UNIVAC, in 1954, the insurance industry was heavily involved in developing and interpreting the computer. Several practitioners, including Edmund Berkeley, interacted with computer manufacturers in designing early business computers. In addition, industry associations commissioned committees to study the computer and its potential uses for the insurance industry. Information about computers was primarily disseminated through committee reports, paper presentations at association meetings, and other published manuscripts, such as books on the topic and eventually advertisements. Given this heavy reliance on existing information processing technology and interest in the business computer, insurance firms were among the first and largest adopters, accounting for one-third of the computers sold to businesses by 1955 (U.S. Department of Labor). We concentrate our analysis of how different groups interpreted the computer on the period between World War II and the commercial release of the computer in 1954, presenting our analysis chronologically.

Edmund Berkeley and the Analogy with the Human Brain

Edmund Berkeley earned a bachelors degree in mathematics and logic from Harvard University in 1930 and joined Mutual Life Insurance of New York as an actuarial clerk, moving to Prudential in 1934 (see Yates, 1997 for a review of Berkeley's career on which this discussion is based). Although he was quite accomplished as an actuary, becoming a Fellow of the Actuarial Society in 1941, he moved to the methods department as an assistant mathematician. In this capacity, he studied Prudential's methods and processes, in particular the potential uses of symbolic logic with tabulating and then computing technology. Berkeley was well connected in the community, working on advanced computing methods, helping organize the New York Symbolic Logic Group which included academics, representatives from Bell Labs, and insurance professionals, and attending other influential meetings such as that on Numerical Computational Devices.

During the early 1940s, Berkeley also engaged with organizations developing computational devices, including General Electric, Bell Labs, Harvard (where he spent four years in the Naval Reserves working on the Mark I), and IBM. He took a more formal role with Eckert-Mauchly Computer Corporation (EMCC). After convincing Prudential to sign a development contract with EMCC to develop the UNIVAC, he drew up an influential specification for the computer system that supplemented the internal magnetic tape-based operation with card-to-tape and tape-to-card readers and high speed printers to be compatible with existing tabulator practices within the insurance industry, thus shaping the configuration of the first business computer. During this time, Berkeley was also heavily engaged in trying to educate the insurance industry about the powers of the computer. He frequently presented at industry associations, such as Society of Actuaries and LOMA, and even visited rival Metropolitan Life Insurance Company where he discussed applications of computers in insurance.

In the summer of 1948, Berkeley left Prudential to become an independent consultant and writer. In this capacity he wrote the popular book *Giant Brains or Machines that Think*, which develops the analogy of computers with human thinking, and was also a founding member of the Eastern Association for Computing Machinery, which later became the Association for Computing Machinery (ACM), still an influential association in the computer industry. Given his interactions with both the computer manufacturers and the insurance industry at large, Berkeley was what Latour (2007) calls a mediator, helping to translate the meaning of the computer between these different groups. As such, Berkeley had choices in how he presented the computer. For instance, he could have appealed to the computer manufacturers' technical focus, a strong possibility given his mathematical and logic background. Instead, however, Berkeley focused on presenting the computer in ways that his targeted audience could understand.

In fact, Berkeley varied how he conceptualized the computer depending upon the target of his presentation. When he presented at insurance industry associations, he focused primarily on comparing the computer to established technologies. In 1947 he presented a paper to the Life Office Management Association (LOMA) meeting in which he described the new technology both as "electronic sequence controlled calculating machinery …much like a desk calculating machine," and as a "Giant Brain" (Berkeley 1947a, p. 116). In the same year, Berkeley presented another paper at the Insurance Accounting and Statistical Association (IASA) annual meeting (Berkeley 1947b) in which he suggested a comparison of the computer to a tabulating system, discussing potentially using it for a premium billing application derived from current tabulator applications. In his correspondence and negotiation with EMCC on behalf of his company, he elaborated his understanding of the computer as a larger and more powerful tabulator. He imagined that Prudential would use a computer system like it used its tabulating installation: for processing large numbers of transactions with a great deal of input and extensive output of transactional documents such as card records and premium bills (Yates, 1997).

In contrast, Berkeley targeted his *Giant Brain* book for a general audience: "This book is intended for everyone" (Berkeley 1949, p. 1).[4] In fact, there were very few references to the insurance industry within the book. The central organizing principle of the book was his analogy of the computer with the human brain:

> These machines are similar to what a brain would be if it were made of hardware and wire instead of flesh and nerves. It is therefore natural to call these machines mechanical brains. Also, since their powers are like those of a giant, we may them giant brains (p.1)

Throughout the book, he develops the analogy to identify the functional and relational characteristics of the computer that correspond with how human brains think. First, he further defined thinking in terms of specific processes: "a process of storing information and then referring to it, by a process of learning and remembering" (p. 2). He categorized this process along three main functions: "Calculating: adding, subtracting, …; Reasoning: comparing, selecting, …; Referring: looking up information in lists, …" (p. 181). Armed with this basic definition of thinking, he explained that computers use symbolic languages and physical equipment to handle, transfer, remember, and reason with information just as the human brain uses natural language and nerve cells. In fact, he even draws diagrams to show how this process works in a human brain (Figure 1, p.3) and how a machine accomplishes the same tasks (Figure 2, p. 6). Figure 2, below, provides a basic outline of Berkely's core analogy.

****
Insert Figure 2 about here
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To give further plausibility to the analogy, he listed types of thinking a computer would not be good at – "1. Do intuitive thinking. 2. Make bright guesses, and leap to conclusions. 3.

[4] Unless otherwise indicated, all subsequent quotes in this section are from this book and are identified by page number only.

Determine all its own instructions. 4. Perceive complex situations outside itself and interpret them" (p. 8). He also evaluated the effectiveness of various human and machine-based systems to handle information and reason. Berkeley measured these systems based upon the criteria of cost, space to hold the information, ability to keep and erase the information, and versatility (he expressed this information in the form of a table on pp. 16-7). He included not only computing machines, but existing technologies such as the calculator and tabulating machine and human-based systems such as nerve cells, in these comparisons. This continuum helped developed his analogy by showing how computers were similar to, but different from, existing technologies in how they thought like a human brain.   In the rest of the book, Berkeley extensively surveyed how existing computing machines thought according to this definition. This survey included the main computing machines as of 1946: punch card calculating machines, MIT's differential analyzer, Harvard's IBM Automatic Sequence-Controlled Calculator, ENIAC, and Bell Laboratories' General Purpose Relay Calculator.

The comparison with existing technology that he used with insurance audiences and the human thinking analogy that he used with general audiences represent two different ways of creating coherence. The first grounded the computer with familiar technologies that insurance firms used to manage their business, whereas the other rationalized the computer by comparing it with the process of human thinking. For our purposes, it is important to explain this variation.

One possible explanation is that insurance firms' experience with tabulating machines made them more adept at understanding a complex discussion about computers than a general audience. Berkeley certainly was concerned about the general audience's ability to understand: "I have tried to write this book so that it could be understood. I have attempted to explain machinery for computing and reasoning without using technical words any more than necessary"

(p. ix). He even counted the number of technical words used in the book and provided an appendix to discuss them. However, the capabilities of his target audience do not fully explain why he would use an analogy with human thinking with the general audience. The base analog of human thinking is scientific and complicated in its own right, making it an unlikely choice if one was only concerned about the audience's capability to comprehend technical matters. Another possible explanation is that Berkeley's background in logic made him more interested in rational processing. Certainly, his dealings with computer producers and work at Prudential focused on the application of logic (see Yates, 1997). While this interest may explain Berkeley's general focus on processing, it does not explain why in insurance settings he focused on pre-existing technologies and with the general audience he focused on thinking.

Rather, we believe a better explanation considers his reflection of the social structures of the two groups he targeted. During this period, the insurance industry was a cohesive group by a variety of measures, while a general audience is, by definition, a diffuse group. The cohesiveness of the insurance group created conditions that favored grounding the computer in something familiar to help fit it in the conceptual schema – in this case, pre-existing technologies. However, the diffuse nature of a general audience means its members do not share anything familiar to compare it with; instead, to make sense of the computer required rationalizing it based upon a naturalized analogy with human thinking.

By a variety of measures, the insurance industry in the 1940s was a cohesive group. According to White (2001), producers within markets coordinate pricing through observation of other producers. This coordination, in turn, produces cohesiveness. The insurance industry was more coordinated than most other industries because it was heavily regulated, primarily at the state level. In addition, the National Association of Insurance Commissioners (NAIC) facilitated the creation and enactment of insurance regulations across states. This regulatory environment also promoted consensus in Martin's sense in that it reinforced a market hierarchy by making it difficult for any one particular firm to deviate from accepted practice. To provide insurance requires firms to meet certain regulatory requirements which make it difficult for any one firm to deviate from accepted practices. While there was a movement to develop national regulatory oversight during this time period, there were no significant changes in regulations. In fact, as noted, post World War II was period of substantial growth in insurance coverage within the United States. The strong presence of industry associations (Yates 2005) also established cognitive authority within the insurance industry. While not strictly authoritarian, these groups shaped what was discussed through the agendas of their meetings, the vendors invited to display technologies at the meetings, and the committees established to consider issues facing the industry. Finally, with respect to the computer specifically, Yates (1993) observed that prior to the computer's introduction, the insurance industry tended to use technology to process business information and tasks, creating a common understanding of how technology should be used within insurance. As Berkeley evidently recognized at least implicitly, this cohesiveness, especially the consensus view of the use of technology, helped establish conditions that favored grounding the computer within this familiar conceptual schema.

In contrast, a general audience by definition is much more diffuse, lacking any form of consensus or tightness in its conceptual schema. However, everyone thinks. Berkeley leveraged this natural phenomenon to produce an analogy that helped rationalize what a computer was. With this audience, he did not try to fit the computer into a schema, but used the naturalized analogy to make sense of what it was. One might have expected Berkeley to present this analogy in an authoritative way because of his mediating position within the network and his strong expertise in computers. Such an approach favors a narrative style that highlights causal reasoning and explanatory logic. Instead, Berkeley, understanding the requirements of this different audience, tried to make the analogy more familiar by using examples and elaborating key comparative points to construct a narrative picture of the computer as a human brain thinking. In fact, he calls his book “a story” that is meant “to show how they [computers] do thinking operations” (p. vii). Berkeley was showing rather than reasoning or telling.

At the book’s semantic level, he develops this narrative style primarily by using elaborative and additive relations between clauses and sentences. In the early chapters, where he develops the analogy, Berkeley often uses lists, tables, and pictures as a means to further exemplify the analogy itself. Within the text, he tends to elaborate key points as opposed to providing causal reasoning to support his argument. For example, consider this brief passage with the semantic relations inserted:

> As everyone knows, it is not always easy to think. By *thinking* [ELABORATION], we mean computing, reasoning, and other handling of information. By *information* [ELABORATION], we mean collection of ideas – physically, collections of marks that have meaning. By *handling* information [ELABORATION], we mean proceeding logically from some ideas to other ideas – physically, changing from some marks to other marks in ways that have meaning. For example [ELABORATION], one of your hands can express an idea: it can store the number 3 for a short while by turning 3 fingers up and 2 down. In the same way [ELABORATION], a machine can express an idea: it can store information by arranging some equipment. (p. 10).

Berkeley does not argue that the computer must think based upon some argument in which thinking is the logical conclusion; rather, he elaborates what he means by thinking and then provides an example of thinking in comparison with counting with our fingers.

Similarly, when Berkeley presents the examples of thinking machines in existence, he does not try to justify that they are in fact thinking. Rather, he positions these examples in the context of the different aspects of thinking that he highlighted with the analogy. In essence, they exemplify different aspects of his analogy. Berkeley titles each of the chapters to emphasize how the machine exemplifies an aspect of thinking:

4. COUNTING HOLES: Punch-Card Calculating Machines
5. MEASURING: Massachusetts Institutes of Technology's Differential Analyzer No.2
6. ACCURACY TO 23 DIGITS: Harvard's IBM Automatic Sequence-Controlled Calculator
7. SPEED – 5000 ADDITIONS A SECOND: Moore School's ENIAC (Electronic Numerical Integrator and Calculator)
8. RELIABILITY –NO WRONG RESULTS: Bell Laboratories' General-Purpose Relay Calculator
9. REASONING: The Kalin-Burkhart Logical Truth Calculator

Berkeley's implicit understanding of this general audience's diffuse nature led him to legitimize his analogy by developing a narrative of connected examples of machines performing different aspects of thinking. This discursive style emphasizes what is familiar as opposed to what is different in an attempt to make his analogy more intuitive.

The Society of Actuaries Report and "the information processing machine"

During the same time Berkeley was presenting and publishing his ideas, various industry associations (e.g., LOMA, IASA) commissioned committees to examine the computer. In 1947, the Society of Actuaries (SA) established its "Committee on New Recording Means and Computing Devices," which had by far the greatest influence on the insurance industry (Yates 2005). The committee was composed of members from the 1st (Metropolitan Life), 4th (Equitable Life Assurance), and 14th (Connecticut Mutual Life Insurance) largest life insurance firms (Best 1948). Its mandate was to study how insurance firms might beneficially use the emerging electronic computing equipment, and its big report was presented and published in 1952.[5]

Given that members of this committee were exposed to Berkeley's presentations and book, they could have simply adopted his brain analogy as a basis of the report. However, the committee did not conceptualize the computer in terms of thinking, but instead described the computer in terms of the familiar concepts and relations of "information processing machines." Cohering the computer with something familiar is consistent with the cohesive structure of the insurance industry the committee represented and with Berkeley's approach when he addressed the insurance industry. However, there were some significant differences between this report and Berkeley's comparisons. Where Berkeley emphasized similarities with existing equipment, this report combined familiar concepts to focus attention on the function of information processing and then tried to show how the computer differed in this dimension from existing technologies. Differentiation from existing technology was necessary given that the insurance firms were users of the technology and felt it was important to "find out just what such equipment can do for us, how reliable it is, and whether it would help us to further improve the economy with which we serve our policyholders" (Davis et al. 1952, p.5).

The report used "information processing machines" to conceptualize the computer:

> 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. (Davies, et al., 1952, p.5).

[5] The committee continued to exist, though with changing membership, and published several subsequent reports, but none with the impact of the initial one (Yates 2005).

The term, “information processing machine” is an example of a relational-based conceptual combination, asserting that computers are machines that process information. As noted, the concept of machine was well grounded in the insurance industries as they had extensive experience with other kinds of machines such as calculators and tabulating machines. Moreover, the insurance industry was well acquainted with the function of information processing as they used tabulating machines to process customer billing and records (Yates, 2005).

Therefore, similar to Berkeley’s presentations to the insurance industry, this report grounded the computer with familiar concepts. However, the conceptual combination focuses attention on a different aspect of the conceptual schema than Berkeley’s analysis. It highlight the functions associated with information processing as opposed to Berkeley’s straight up comparisons with tabulating machines which concentrated on their attributes and specific uses. Yet, concentrating on the computer’s function fits with the report’s goal to figure out how insurers could use the computer.

A challenge with grounding a new concept with something familiar is that it could end up assimilated within the old. Ruef (2000) observed this challenge: when new healthcare organizations were compared with well-established organizations they had difficulty establishing their own identity. In this case, the function of information processing certainly is not unique to computers given how insurers already used tabulating machines. The committee was well aware of this issue, expressing concerns over whether it was necessary to invest in a computer. In fact, the report rejected applying the computer to process actuarial work and policy settlement work because not “very much economy could be achieved by introducing electronic computers (Davies et al., p. 14).   They also decided against using the computer for file keeping because of the inefficiency caused by lack of random access to data on magnetic tape and concerns over whether tape-based files would satisfy regulatory requirements for records of policy holder information.

Consequently, unlike Berkeley's comparative analysis that focused on establishing similarities, the Society of Actuaries' report highlighted the differences between the computer and tabulating machinery along the technical and functional dimensions. The discursive styles highlight these differences. Where Berkeley's texts primarily used semantic relations to elaborate and expand key points of similarities, this report primarily used semantic relations that first compare and then contrast computers with tabulating machines. For example, when the report detailed the core components of the computer, it often first described the component in terms of the tabulating machine or other relevant technology, which has the effect of making the component understandable. But, then the report used a contrast structure to show how the computer differed along this dimension. This narrative style is most evident the section that defined programming (with the use of contrast highlighted):

> On punched card machinery when we do a job for the first time, we arrange the wiring of the machine by setting up proper contacts through a removable plug board. The board is a separate panel which can be used to do the job, then taken out of the machine and kept, to be used again later. The same idea [ELABORATION] is applied with magnetic tape equipment. Here, instead of wiring a plug board [CONTRAST], a procedure known as programming is applied (Davis et al. 1952, p. 14).

Here, programming is first explained in the context of how jobs were run on tabulating machine to establish a base familiarity with the concept, but it also helps explain exactly how the computer is different – there is no plug board to be wired.

This report also differed from Berkeley's approach in how it legitimized its analysis. In his book, Berkeley used exemplification to build a narrative that made his analogy intuitive, but the SA report used a more authoritative and rational style. Specifically, the report provided the reasons why its analysis is sound and should be adopted by diligently reporting the sequence of actions taken, exhaustively detailing what was done, and explicitly stating its arguments. For example, the structure of the report follows the procedures taken in the committee' analysis – first developing an understanding of what the computer was technically, then considering the various applications the computer could perform, and then reporting on real-life tests of the computer performing an integrated sequence of functions related to billing.

The exhaustive nature of the report also adds to its credibility because readers could see exactly what the committee did and how it related to their own companies. For instance, rather than just focus on the application the report presents as most appropriate, it identifies all the considered alternatives and explains why they were discarded. In all, four potential uses were considered: actuarial investigations, policy settlement work, file keeping, and regular policy service, with the recommendation of focusing on policy service. The rest of the report was a detailed analysis of applying an existing small transitional system consisting of interconnected electronic tabulating devices (which they referred to as a punched-card computer) to perform these functions, down to the data requirements, calculations, and functions. They concluded that a firm could probably do this just as well with such a system as with the large magnetic tape computer systems (such as the UNIVAC) then under development because they "still found that it was desirable to do certain operations outside the computer system … Couldn't we, with a little bit more manual attendance and with a little less automotive machinery, accomplish essentially the same result with a smaller computer?" (Davis et al. 1952, p. 23). They argued that it would be easier to justify the cost of a computer if they expanded the number of activities that it performed to include, for instance, policy-related accounting and actuarial tasks.

They called this integrated application the Consolidated Functions approach. The Consolidated Functions approach presented in the 1952 report was an extension of the tabulator-based integrated premium billing and accounting application used by some smaller and more innovative insurance firms in the early 1950s. The Committee demonstrated the application's workability using IBM's Card-Programmed Calculator (CPC), a small transitional system that used punched cards instead of magnetic tape and lacked a stored program, and thus was more closely related to tabulating machinery than to large magnetic-tape computers like the UNIVAC.

The Committee's vision of computer use as embodied in its Consolidated Functions approach would influence insurance use for the next two decades—indeed, it would take that long for most firms to achieve the integrated application. The report's final summary stressed that the consolidation of functions could occur gradually as firms learned about the computer's capabilities:

> Realization of their full potential will lead us to the consolidation of many different kinds of work which now are departmentally separated. This, however, is not necessarily a matter of sudden, drastic reorganization. The program indicated is more likely to be the introduction of an electronic computer for one related series of procedures, and the gradual step-by-step adaptation of other routines as we learn at first hand the machine's capabilities and limitations. (Davis et al. 1952, p. 49)

Therefore, another way the report distinguished the computer was to identify a newer kind of application that the computer could perform.

Finally, at the semantic level, many of the paragraphs concluded with "therefore" and "consequently" sentence structures that made explicit the causal logic of their arguments. For example, consider the report's rejection of policy settlement work (paying out on policies) as a suitable application for the computer:

> However, the more we analyzed policy settlements as a separate field of work, the more apparent it became that the volume of work involved was relatively small and the wide variety of operations which are necessary seemed to require computer capacity that was quite large. Accordingly [CAUSALITY], we concluded that policy settlement work, taken by itself, did not represent an area where very much economy could be achieved by introducing electronic computers (Davis et al. 1952, p. 16).

Berkeley's book provided none of this procedural detail and had limited argumentation, but instead focused on elaborating key points by providing many examples. One reason for this difference was that the committee issued a report as opposed to a book. The report genre requires detailing procedures and findings, which encourages temporal discussion and providing causal reasoning; however, the book genre is much more conducive to narration.

Figure 3 provides a summary of the coherence processes depending upon the level of cohesion of the different social groups. The more cohesive group of the insurance industry tended to ground the computer with familiar concepts and relations from its schema. This is most explicit with the Society of Actuaries Committee which represented the insurance industry and used relational-based conceptual combination. In contrast, when faced with the diffuse general public, Berkeley did not try to fit the computer into any particular schema, but instead tried to make the computer intuitive through an analogy with human thinking. It is important to recognize that both approaches minimized detailing the core attributes of the computer and instead focused on its functional relations. Thus, both Berkeley and the Committee recognized a need to explain the computer in terms of what it did as opposed to what it was.

However, there was a subtle, but important difference between the committee's conceptual combination and Berkeley's analogy. The conceptual combination identifies "information processing" as the salient function that characterizes the computer, whereas the analogy maps a series of thinking functions in a relational structure that includes the interaction between symbolic logic and physical processes within a computer (see Figure 2). These different choices of conceptualizing the computer created different challenges. Because analogies best function when there is strong mapping between the relational structure, it was important for Berkeley to establish the similarities between the computer and the human brain as well as make this comparison intuitive. Moreover, since this was an analogy, Berkeley made no claims to integrate the computer into the human thinking schema, so he did not need to show differentiation. However, by making the computer familiar in terms of the specific function of information processing, the committee report ran the risk of insurance firms believing that existing technologies could already perform this function and not investing in the computer. Therefore, after establishing familiarity, it was important for the report to reveal the differences.

Early Convergence Toward Information Processing

As a result of these extensive activities to try to understand the computer, two main conceptualizations of the computer emerged prior to its commercial introduction in 1954. Berkeley's brain analogy created the image of a computer with human like qualities that could make decisions and reason. In contrast, the committee's conceptual combination of "information processing machine" created the image of the computer as a machine that managed the routine information requirements that underlie business processes, though it differentiated the computer by creating an application that integrated processing steps that were typically separated, giving it a slightly more human-like element. Soon after the report's release, insurance firms converged toward the information processing view of the computer.

The kinds of computers insurance firms purchased and how they used them illustrated the preference for information processing machine over human thinking analog. Computer manufacturers offered a choice of computers – large, expensive, tape-based machines such as the UNIVAC that required their own separate rooms and seemed almost alive, or smaller, less expensive, often card-based machines such as IBM's 650, which closely resembled the tabulating machine in design. Although the UNIVAC was available a year earlier than the IBM 650, only four insurance firms—two very large and two quite modest in size—took delivery of UNIVACs in 1954 and 1955. Most firms waited to acquire the IBM 650 when it became available in 1955 and transferred existing tabulator applications directly to it. At the 1956 IASA conference, a panel on the new computing technology included 18 papers on IBM 650 applications planned or implemented and only 3 on UNIVAC applications (IASA 1956). By the following year, life insurance companies had acquired roughly 50 IBM 650s (Carlson 1957). According to a Controllership Foundation survey of computer usage from 1954-1957 (1958), 67% of those insurance firms acquiring computers adopted the IBM 650, 23% the UNIVAC or larger IBM 700 series, and 10% a different brand. The industry had converged on information processing machines only slightly more powerful than the CPC used by the SA Committee.

Beyond deciding which type of equipment to use, insurance firms also determined which applications to develop. The same Controllership Foundation survey revealed that although insurers developed a wide variety of insurance applications – 85 unique applications – they converged on one primary application area.   Consistent with gradual progress towards the Consolidated Functions approach outlined in the 1952 Society of Actuaries committee report, 85% of the establishments had implemented at least one policy service application within the Consolidated Functions approach.[6]

There are many reasons for this convergence on computing hardware and application. For example, the IBM 650 is an example of what Hargadon and Douglas (2001) call "robust design" – designing the 650 to look like tabulating machines invoked the institutional memory of using the computer like the tabulating machine. Economic concerns such as the cost of the computer and switching costs from tabulating machines also played a factor. For our purposes, we are not interested in determining which factors mattered the most; rather, we want to show that the conceptual processes of coherence also interacted with the implementation process to further develop the meaning of the computer.

While at the macro level there was convergence, firms varied in which interpretation guided their implementation at the local level. Comparing Metropolitan Life's implementation with Franklin Life's is instructive because both acquired the same UNIVAC machine, but in implementation Metropolitan Life favored the information processing machine image and Franklin Life favored the human image. Giant Metropolitan Life was one hundred times as large as Franklin Life. Although two of Metropolitan Life's actuaries were on the Committee that developed the Consolidated Functions plan, the firm's top executives hesitated to start with such a use, given the company's investment in the existing record system, the organizational disruption that would be required to integrate previously unintegrated operations, and the potential disruption of customer relations posed by the premium billing application. As a result, "the company, … although inclined to accept the idea that some sort of consolidated operation

[6] The survey included data on 61 installations across 39 unique insurance firms. State Farm inflates this number because it duplicated its application choice across all of its establishments. But, without State Farm, 72% of the firms implemented at least one policy service application.

was indicated as a long-range objective, still felt that a system should be applied to a localized area as a means of getting started" (Davis 1953, p. 15). Its executives viewed the transfer of an actuarial application from tabulating equipment to computers as less risky to its operations than the Consolidated Functions application, and they calculated that this application would allow them to pay back the computer investment in just four years.

More importantly, Metropolitan Life was concerned that clerical workers would react negatively to a new technology that could potentially replicate much of the integration of functions for which they were responsible and thus initially wanted to emphasize the technology's tabulator-like, rather than brain-like, characteristics. The firm developed a campaign to show employees that the UNIVAC would not reduce its demand for clerical labor, including displaying a model in the lobby and posting a sign above it that read as follows (as shown in Yates, 2005, p. 164):

U nchanging
N eed
I s for
V olumes of
A dditional
C lerks

In contrast, Franklin Life executives chose to integrate multiple functions as they computerized. In 1951, when the firm chose UNIVAC, Franklin Life's sales were growing at five times the industry rate**,** and the office force needed to service its policies was growing so rapidly that it would soon require building a new headquarters office building (Becker 1954; Vanselow 1954). One executive argued that adopting a UNIVAC would slow the clerical growth enough to postpone need for a new building for several years. To show that a UNIVAC would pay off for the firm in four years, he proposed a plan to consolidate operations even beyond what the Society of Actuaries Committee would recommend in its report issued in the following year. Unlike the much larger Metropolitan Life, which feared retaliation from clerical workers if the computer was portrayed as an integrated "thinker," Franklin Life favored this interpretation because it meant the firm did not need to hire additional clerical workers and could save on building costs.

CONCLUSION

In this article, we have offered a more refined explanation of Durkheim's notion that new concepts must cohere with existing conceptual schemas by appealing to cognitive science to show the different ways in which this may occur. Actors have choices about what aspect of the conceptual schema they fit the new concept to. Actors could concentrate on the attributes that define the concept in a classificatory sense or they could focus on how concepts relate to other concepts. In addition, actors could seek similarities with the conceptual schema or try to differentiate the new concept. Changing emphasis along these dimensions generates different interpretations of the same concept. Berkeley's comparison of the computer with tabulating machines encourages an understanding of the computer in terms of the attributes it shares with tabulating machines; however, his analogy with human thinking conceptualizes the computer in terms of the thinking function without a clear understanding of what attributes constitute the computer.

We invoked another aspect of Durkheim's work by appealing to the social structure of the group trying to understand the new concept to explain the variation in coherence processes. Cohesive and diffuse groups present different challenges for coherence which encourage their members to purse different strategies to fit the new concept in. The empirical case further revealed that the choice of coherence strategy also has different implications. The Society of Actuaries Committee, targeting a cohesive group (of which they were members), defined the computer in terms of an established function, requiring to then show how the computer was different. In addressing a diffuse audience, the general public, Berkeley used an analogy that lacked any pretense of integration with an existing schema, and thus did not need to further differentiate the computer, but rather to show how its relational structure was similar.

There are some limitations to our approach. First, our perspective assumes that the cognitive processes involved in concept creation (whether by the author or audience/user of the new technology) are deliberative. Analogical thinking, conceptual combinations, creating metaphors or classification are all require deliberate cognitive effort to make sense of new concepts. These kinds of thought processes frequently seem to occur in economic market contexts like the computer where producers are trying to commercialize different kinds of products. However, DiMaggio (1997) recognizes that in many cases actors do not engage in deliberative cognition, but come to quick, “hot” impressions. When meeting someone new, we may immediately categorize them without going through these arduous cognitive gymnastics. We contend that while “hot” impressions may occur with a new concept, they are often evaluated later during additional social interaction. And, these evaluations involve the kind of coherence processes we outlined. Nevertheless, we believe it is important to develop an understanding of the conditions under which “hot” cognition is used and the influence of this process on the formation of new concepts.

As in many concept and category type studies, we focused our attention on the new concept and how it fit within the conceptual schema. While we invoked the structural characteristics of the schema, we do not address the fact that the existing structure can change itself to accommodate the new concept. However, Thagard's (2000) theory of coherence in epistemology asserts that often coherence involves changes in what the concept coheres to as opposed to the new concept being defined. An interesting area for future study could consider the conceptual schema itself and the second order changes that occur as new concepts enter. In addition, our emphasis on cohesion of the social group suggests that highly cohesive groups are less likely to change the existing conceptual schema, which requires further empirical testing.

Our focus on the kinds of schema elements invoked does not address which specific element was recalled in the interpretive process. Our arguments about social structure do not provide much insight into why, for instance, the Society of Actuaries' report focuses on "information processing" as opposed to "routine business processing" or why Berkeley makes an analogy with the human brain and not with robots. Additional research into the social factors that influence what specific concept, attribute, or relation is recalled during the concept formation process is necessary. Zerubavel (2002) has proposed an intriguing explanation that norms and customs guide us in our selection process. Cognitive scientists tend to focus more on the structural characteristics of the conceptual schema favoring some elements over the other as well as the goals of the actor involved in the process (Gentner, Holyoak and Kokinov 2001).

Finally, cohesion is but one characteristic of the social groups and cognitive schemas that can play a role in concept formation. The size of the conceptual schema, type of relations, or even the number of schemas involved can also influence this process. Making the structural characteristics of the conceptual schema more explicit suggests that network analysis may be a useful methodological approach to begin to understand some of these structural influences. We have also downplayed the characteristics of the new object to be conceptualized that may influence how the audience tries to cohere it with the categorical system. For instance, high status actors may have their own identity independent of any classification (Zuckerman et al. 2003) that can also affect the coherence process. Yet, our analysis can also be informative to those enthusiasts, mediators, or institutional entrepreneurs who are trying to introduce new concepts. Presenting a focused identity to differentiate your new concept from others (as proposed by McKendrick et al. 2003) may not be a fruitful strategy when the group is cohesive because these conditions favor grounding the new concept in something familiar.

This paper also has important implications for the growing interest in conceptual and categorical dynamics and the normative effects of cognitive schemas. Our analysis shows that new concepts can enter a schema in a variety of different ways. This initial coherence, in turn, can influence the durability of the concept. Are well defined and demarcated concepts more likely to persist than those that lack clear definition but fit into the relational structure of the schema? Moreover, this analysis encourages research to continue to expand our focus from the individual concept to the system and its dynamic nature. Many explanations of the normative constraints imposed by concepts concentrate on the concept itself, where well defined and demarcated concepts have stronger influence (see Berger and Luckmann 1966; Hannan, Polos and Carroll 2007; Lamont and Molnar 2002 for examples). Coherence, by definition, takes a more system-wide view, which suggests an alternative source of normative power. How the concept fits into the conceptual system and the constraints on how it is applied can have normative effects in addition to its definition and demarcation. Fitting into the system can create constraints just as fitting within a concept can.

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Figures

Figure 1: How Different Cognitive Processes Represent Different Kinds of Coherence

	Analogy	**Classification**	**Conceptual Combination**	
			Attribute	*Relational*
Coherence Process	Relational mapping of base with target, but do not fit new concept into existing schema	Lump similar objects together, and differentiate from other concepts	Transfer property from one concept to another	Linking two concepts together through a relation
Focal Part of Conceptual Structure	Relational structure	Attributes of new concept and related concepts	Shared attributes between concepts	Relations between concepts
Nature of Comparison	Relational similarities	Attribute similarity within the concept, attribute differences between concepts	Attribute similarities that enable transfer	Similar relation between concepts
Interpretive Outcome	Relational structure of new concept, not attributes.	Salient characteristics that define new concepts and differentiation from other concepts	Combination of the two existing concepts to characterize new concept	Relation between two existing concepts to characterize new concept

Figure 2: Berkeley's Analogy with Human Thinking

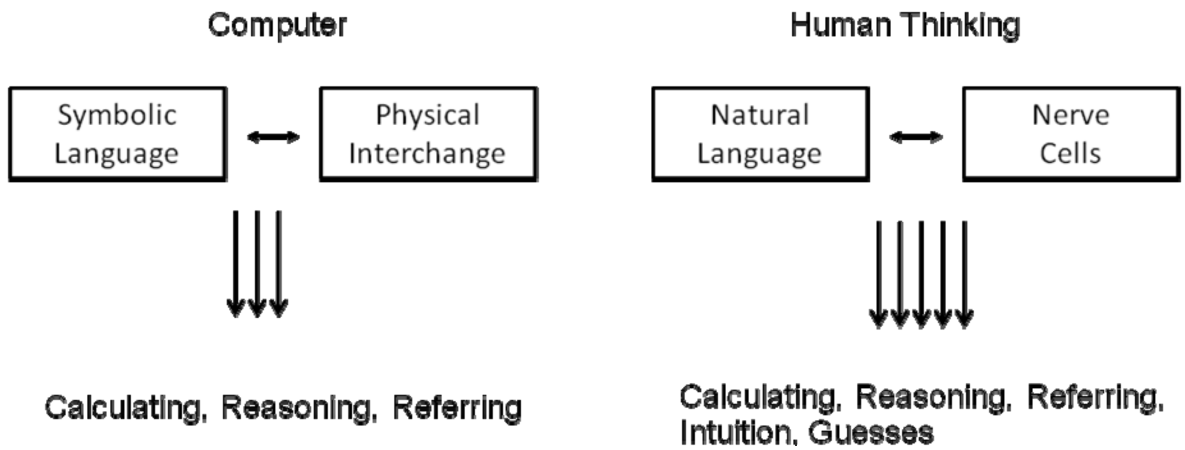

Figure 3: Comparing Coherence Processes with Cohesion of Social Group

	High Group Cohesion	Diffuse Group
	Insurance Industry	**General Public**
Berkeley's Insurance Industry Presentations (1947)	• Comparison with existing technology • Focused on similarities in attributes, less so on functions	
Berkeley's *Giant Brain* book (1949)		• Analogy with human thinking • Focuses on computer's ability to reason, count, and retrieve information without defining what computer is • Elaborative and additive semantic style to make analogy more intuitive
Society of Actuaries' Report on Computers (1952)	• Conceptual combination – "information processing machine" • Focused on function of processing business information, limited specification of attributes • Contrastive and rational style to emphasize how computer differs from other machines	

Appendix A

We use the discursive analysis as a tool to identify the different aspects of cognitive coherence: 1) to what in the conceptual schema does the text compare the computer, and 2) whether the comparison emphasizes similarities or differences. The rhetorical devices used in the text, such as analogies or attribute comparison, express the aspects of the schema through which the document fit the computer within the existing schema. And, the semantic relations establish an underlying logic that emphasizes equivalence or differences with what the rhetorical device compares the computer. The discursive style also establishes a logic that justifies the conceptualization presented in the text.

Identifying the rhetorical devices is rather straightforward as most texts developed a single or small number of metaphors, analogies, comparisons, or conceptual combinations. We followed Fairclough (2003) to examine the semantic and textual relations to develop an understanding of the explanatory logic of the texts. We first considered the genre of text, such as whether the text was a report, book, or presentation, because the genre structures texts in specific ways and influences what kind of semantic relations surface. For example, because the Society of Actuary analysis was in the form of a report, in the beginning there were many temporal relations detailing the process of analysis to develop the report. In contrast, Berkeley expressed his ideas in the genre of a book which was more narrative in style and lacked explanation of how the analysis was done.

Next, we considered the different kinds of semantic relations between sentences and clauses as well as relations between different parts of the text. Fairclough recognizes that there are many different kinds of semantic relations, such as causal, conditional, additive, temporal, elaboration, and contrastive. Because we are interested in the issues of similarity and differentiation in concept formation, we focused on whether the relations were additive or contrastive with the base concept of comparison. Examples of additive and elaborative relations include lists, exemplification, and conjunctive phrases to further clarify similarities, while contrastive relations use phrases like “however”, “instead”, “but” to highlight differences. We present examples of the semantic analysis in the main body of the paper.

The semantic relations help establish a logic within the text that legitimatizes the particular conceptualization of the computer. For instance, appealing to examples develops a logic of showing that this interpretation is correct as opposed to providing explicit causal logic that deduces the interpretation. Fairclough (2003) calls this narrative approach “mythopesis” as it tells a story that legitimatizes the account as opposed to appealing to authority, custom, or moral explanations. The semantic relations, textual structure, argumentative style, and the style of the text collectively develop an explanatory logic the focused either on highlighting how the computer was similar or different to what the rhetorical device identified as the salient comparison.