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Shareability: The Social Psychology of Epistemology*

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Psychologists and cognitive scientists interested in the nature of internal representations of human knowledge often use observable regularities or structures to infer what the innate constraints on those representations must be like. It is possible, however, that certain structures might come about only when a group of people share a knowledge domain. Furthermore, it is possible that there are analyzable constraints on knowledge structures that emerge when knowledge is being shared. Such constraints are referred to in this paper as "shareability" constraints. A number of examples of observable structures in human knowledge are discussed in terms of shareability constraints. An attempt is made to determine which sorts of structures are most shareable, and how those structures may differ from the sorts of structures that are easily represented by the individual mind but not easily shared between minds.

Cognitive psychologists, cognitive anthropologists, linguists, and other cognitive scientists have often ascribed observed regularities to innate constraints. That is, the level of analysis for contraints has been the brain. At the same time much of the research of cognitive science has concerned itself with the structure and representation of knowledge that is shared among many brains. Hence, it may be that an equally legitimate level of analysis is the community of brains, where "shareability" constraints may arise because shared knowledge must be shared. These levels of analysis need not be mutually exclusive. It is consistent to propose that some mental mechanisms are best understood on the individual level (such as perceptual mechanisms that are of invariant survival advantage to the individual), while some mental mechanisms are best understood on the group level (such as language processing mechanisms that are of group survival advantage). An analogous distinction has become very important to biologists. There is evidence that natural selection operates on *both* the individual and the group (see Gould, 1982). It is also reasonable to presume that constraints that operate on the individual and those that operate on the group level can interact in important ways.

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Perhaps the best known work dealing with shared knowledge is Lewis' *Convention* (1969). Lewis analyzes the role of shared knowledge, or convention, in various social institutions, and in determining widely held beliefs and values. However, he does not address the *psychological* issues of how convention affects ongoing cognitive processes, or how convention affects the structure and mental representation of shared knowledge. More recently, Clark and his colleagues (see Clark & Marshall, 1981) have addressed the first of these psychological issues by investigating the role of mutual knowledge in determining referents, etc., in ongoing conversations. For instance, Clark and Carlson (1981) argue that the ongoing cognitive processes that govern language production and comprehension use knowledge of common ground to produce or comprehend utterances. In this paper I will address the second of the psychological issues mentioned above: in what ways does the fact that shared knowledge must be shared influence the structure of knowledge?

There are two major directions that the shareability argument can take. The "weaker" argument is that many cognitive or linguistic structures have the form they do because they must be shared. The "stronger" argument is that only in the sharing do the forms exist; that is, no individual mentally represents the eventual outcome of the communication of thoughts.[1] It is the former argument that I will develop in this paper, since it is both more plausible and more tractable. Thus, the preferred version of shareabil-

[1]The "strong" version of shareability theory would claim that mental representations appear to have a certain structure because the structure emerges when the knowledge is shared, yet the structure is not represented in the individual. This version of shareability is similar to arguments raised by social psychologists (see Lewin, 1947) who promoted the term Group Dynamics to mean those aspects of human behavior that only emerge (yet predictably emerge) when people are with other people. It is argued that the emergence of social regularities comes from dynamic processes that occur when individuals get together, and that those dynamic processes are, indirectly, a consequence of the human mind. Similarly, it could be argued that when people get together certain dynamic processes lead to the emergence of certain knowledge structures. It might be that the very act of trying to observe an individual's knowledge structure demands that the person share the knowledge thus causing an emergent structure. We might expect, for instance, that even if knowledge is truly represented in a continuous form, in the process of sharing that knowledge with an experimenter it must go through a discrete filter and thus appears to be discretely represented.

ity assumes that observed structures are "psychologically real", but without the structures necessarily implying a constraint of internal representability. Note that the shareability hypothesis does not assume that the constraints on knowledge structures are independent of the human mind, rather that the constraints emerge from the problem of sharing knowledge and these are not just constraints imposed by the individual mind.[2] In the paper I will proceed by discussing some specific examples from the cognitive science in terms of shareability. The research areas I will first discuss (the study of semantic structures and other issues in knowledge representation, especially categorization) deal with shared knowledge, yet investigators have traditionally focused on constraints in the individual mind. Then I will briefly sketch shareability in relation to theories of language acquisition.

SHAREABILITY CONSTRAINTS ON SEMANTIC STRUCTURES

Others have pointed out that knowledge, in a language or any other semiotic system, is shared knowledge (see Hamlyn, 1981; Watt, 1981). My proposal is that *because* shared knowledge must be shared there are certain rules, constraints, and evolutionary laws that emerge on a "second order" level; that it is the interaction of human minds that forms knowledge systems. A relevant area of interest in the cognitive sciences is the description of structures found in certain semantic domains. A "semantic domain" is usually taken to mean a set of words that all seem interrelated, such as color terms, emotion terms, or animal names. There have been a number of different ap-

[2]To simplify matters, I will generally assume that shareability constraints emerge only when a group of people share knowledge, and that the need to share knowledge has not played a significant role in the physical evolution of the brain. However, this is not necessarily inconsistent with my general argument to suppose that the brain has physically evolved to handle those structures that are most shareable. For example, one possibility is that the constraints of shareability lead to the development of innate constraints within each individual such that, from a combination of individuals, the structure emerges. This is not unknown in the animal world where, for instance, ants in a group form a predictable complex structure, yet a single ant certainly cannot produce that structure (see Thomas, 1974). Perhaps, then, there is something like a social biology of epistemology; the genetic encoding of an individual human might have evolved so as to encourage the development of certain knowledge structures once a group of humans get together. A related possibility, although less consistent with the preferred version of shareability developed in the paper, is that shareability could lead to the development of innate constraints on knowledge representation such that the constraints for observable structures could be seen in each individual; thus, a combination of people would not be needed *after* the evolutionary process being posited here has had an effect. That is, shareability might be responsible for the establishment of the structural constraints, but not their maintenance. Note that this account differs from traditional evolutionary explanations about innate mental representation because it does invoke shareability constraints as a selective factor.

proaches towards analyzing the structures in semantic domains, but what these approaches have in common is the goal of discovering constraints on knowledge representation. I argue that the structures the different semantic analyses uncover may stem from shareability constraints on knowledge representation.

One of the major methods of analyzing semantic domains is through "componential analysis" as developed in the field of anthropological linguistics (see Goodenough, 1956; Lounsbury, 1956; Romney & D'Andrade, 1964). This method attempts to discover a small group of semantic components, or features, that, when used in various conjunctive sets, define all of the words in the domain. For instance, if we take the four words, "man", "woman", "boy", and "girl", we can use combinations of two semantic components, maleness and adultness, to define each word. Thus "boy" would be +male -adult (plus some "remainder" component true for all four words such as +human; see Clark & Clark, 1977, p. 416–417).

The semantic domains most subjected to componential analyses are kinship terminologies from a variety of different languages. For example, Goodenough (1965) analyzed Yankee kinship terms and came up with a small number of discriminate variables such as "degree of collateral distance between ego and alter", with the values less than two degrees of distance and two or more degrees of distance. (This component separates "cousins" from other relatives.) For other languages, that particular component with those particular values would not necessarily be used. For instance, in the Lapp kinship system there is a term *akke* meaning "father's older brother or father's older male blood relative in his generation" (Goodenough, 1967), which clearly could not be classified according to the two collateral distance values used in the Yankee analysis. However, despite the fact that the specific components, and/or values of components, differ from analyses of one language to the other, the fact remains that, at least with kinship, it is possible to come up with some componential analysis that shows a great degree of structure in the domain. A number of cognitive anthropologists have suggested that these invariances at the structural level are due to limitations in human cognitive processing (D'Andrade, 1981; Romney & D'Andrade, 1964; Wallace, 1961).

Indeed, D'Andrade (1981) makes the argument that "in the process of repeated social transmission, cultural programs come to take forms which have a good fit to the natural capacities and constraints of the human brain" (p. 182). Although this must in part be true, it is also possible that when cultural programs, such as kinship terminology, are passed from person to person they come to take a form which is most easily and efficiently shared.

Consider the problem of introducing a new kinship term into the language. The shareability theory presented here predicts that a new term will be less successful if it is not classifiable by existing components, even if any

one person is perfectly capable of understanding the term. Suppose, for example, that the Yankee kinship terminology consisted only of the words, "father", "mother", "son", "daughter", "brother", "sister", "grandfather", "grandmother", "uncle", and "aunt", and that everyone else has been called "cousin". In order to be more specific, one might say "my uncle's son", or "my father's older brother's son", etc. Now, if I wanted to introduce some new terms, say a term to describe those people who are children of my older sister or children of any other older female blood relative in my generation, and a separate term to describe those people who are children of my older brother or children of any other male blood relative in my generation, I would have some difficulty in description. Basically I would not be able to anchor these new words to the words in the kin terminology system without laborious definitions. However useful these categories are to me for my own personal reasons, they will be very hard to share with others. If, on the other hand, I was introducting this term to Lapp speakers (with a similarly limited vocabulary), it would certainly be more easily described and understood through analogy to existing terms.

Suppose, in contrast, that I wanted to introduce one term that means "my sister's male child or my brother's male child", and another term that means "my sister's female child or my brother's female child". I could simply say that "term 1 is to son as uncle is to father," and that "term 1 is to term 2 as son is to daughter." Even if I were to introduce the term without explicit analogy to other terms, it is still possible that the person learning the term would use an "analogy strategy" (see Baron, 1977) to understand it. (The relevance of analogies to shareability will be discussed further in both the section on categorization and the section on language acquisition.) In sum, the existing structure will determine which new terms are most likely to survive. As I will argue in the next section, it will also determine how new terms are distorted in the process of sharing. Thus the attempt to introduce a term that *almost* neatly fits into the pre-existing structure of the semantic domain will probably result in a distorted meaning that neatly fits into the pre-existing structure.

Componential analyses have been used for other types of words (see Clark & Clark, 1977, for a review), and the methods and theory have been modified to allow for prototype theories of meaning instead of the previously assumed set theoretic theories. For instance, Lounsbury (1964) introduced a strategy for describing kin terms in which he assumes there is, for each term, a primary denotatum and remaining acceptable denotata which can be generated through operations on the primary ones. Since then the importance of prototypes to psychological theories of meaning, instead of just set intersections, has grown significantly (see Rosch, 1975). There has also been a great amount of work in the semantic componential approach, and important extensions of it, in related fields (e.g., Bierwisch, 1970). But what seems common to most of the main approaches to semantics is an assumption that values of semantic components, or features, are

critical to word meaning. What is relevant to shareability theory is that a smaller number of features seem to be used than number of words. This suggests that features are structurally important for the mental organization of semantic domains, and that is seemingly because that organization has a good fit with cognitive constraints. However, some of the structural properties of semantic domains may be due to the constraints imposed by sharing knowledge, and not due to constraints imposed by the individual mind.

There are, of course, alternatives to the componential semantic analysis. If we think of the components in a componential analysis as dimensions in a semantic space, a multidimensional matrix can be created to represent the many kinship terms. This suggests that, for various competing componential analyses for a given kin term system, the question of which analysis has "psychological reality" can be resolved using similarity ratings and multidimensional scaling (Romney & D'Andrade, 1964). In multidimensional scaling, similarity data are translated into physical distances along a number of dimensions. Thus, if "mother" and "father" are rated as more similar than "mother" and "uncle", the multidimensional scaling results should portray that as a greater physical distance between mother and uncle than between mother and father (see Romney, Shepard, & Nerlove, 1972). Romney and D'Andrade found that one componential analysis was clearly more consistent with the multidimensional scaling results than the other analyses were. They argued that the fit was so good that one could study aspects of semantics with multidimensional scaling techniques.

Multidimensional scaling has been used extensively by cognitive scientists interested in knowledge representation for numerous semantic domains. Data are most commonly collected by asking subjects to give similarity ratings on elements in some semantic domain such as emotion terms. (Other sources of data, such as confusion matrices, have also been used; see Shepard, 1980.) The internal representation of the knowledge domain is presumably the intended object of study. Interesting scaling results on similarity data are thought to indicate that the elements are represented in a structured fashion such as a dimensional space, or hierarchical tree. (Alternative scaling structures, such as trees, are also discussed in Shepard, 1980.) Not only are the structural regularities linked to internal knowledge storage, but also to the way knowledge *must* be stored. So, if a set of terms can be shown to behave as if they are represented in a three dimensional space, one inference that is often made is that there is both some psychological reality to the spatial formulation (or some formally equivalent formulation) and some innate necessity for it. But it might be that the structural properties of the knowledge domain came about because such structural properties provide for the most efficient sharing of concepts. That is, we cannot be sure that the regularities tell us anything about how the brain can represent things, or would even "prefer" to, if it didn't have to share concepts with

other brains. Perhaps many of the concepts that a person has are private and the communication of those concepts is especially difficult because the representation might be incompatible with most forms of communication. The mind may be more complex than one would suspect by looking at communicatory attempts alone.

SHAREABILITY CONSTRAINTS ON CATEGORIZATION

Why is it that people seem to categorize things according to specific values along potentially continuous dimensions? Sometimes those dimensions have a binary categorization, as in the case of a feature that is considered either present or absent, and sometimes those dimensions are divided up into a number of categorical chunks, as is the case with musical scales. This is often done even when intermediate values are perceptible, as in the case of color terms. Similarly, why is there a developmental trend toward categorizing and/or perceiving stimuli along values of separate dimensions and away from some notion of overall similarity which combines dimensions (see Smith & Kemler, 1977)? For example, consider two real-world continuous stimulus dimensions such as shape and color. Let "A" be a red circle, "B" a red square, and "C" an orange square with round corners. Yound children will consider B and C to be the most similar of the three, while older children will pick A and B which share a common value on the color dimension.

A related finding is reported by Krauss and Glucksberg (1977) who used an experimental paradigm in which two subjects sit facing each other with an occluding barrier between them such that they cannot see one another. Both subjects are given copies of a set of visual stimuli. One subject (the Sender) must describe each stimulus item so that the other subject (the Receiver) can identify it in the set. Krauss and Glucksberg have found that children are not as able to effectively communicate in this task as adults; indeed, children seem to be unable to share their knowledge because they describe objects in egocentric ways. This suggests that the need to share concepts plays an important developmental role.

This phenomenon might be understood through shareability: It is easier for an individual to agree with another individual about the meaning of a new "term" (or other shared concept) *if* that term can be described by: (a) some small set of the much larger set of dimensions upon which things vary; and (b) some small set of dimensional values (or binary values as on a specific feature dimension). Thus, terms are likely to be defined by the presence of certain features. At the same time, children are learning to pay attention to those features or values on dimensions since they want to be able to learn about the existing shared knowledge structure. Indeed, we might expect that by asking children to describe an object to another person we encourage more of a categorical representation.

For instance, suppose that I wanted to tell you about a physical object category I had in mind and that this object (or object category) could be defined by two real-world dimensions. Let this object be described by its coordinates in this space, $C = S(21, 21)$. Further, suppose that there are two pre-existing terms in the shared vocabulary that also have coordinates in this space, $A = S(5, 20)$, and $B = S(20, 5)$. In an attempt to describe my new term, I might very well say "It is like term A in regard to dimension Y, and it is like term B in regard to dimension X." The listener might thus place the new term at the position, $C' = S(20, 20)$, as indicated in Figure 1.

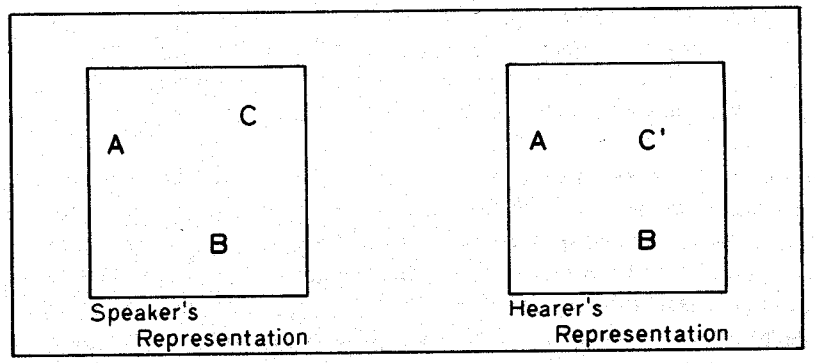

Figure 1. Possible representations a speaker and hearer might have of a set of three items when the speaker introduces a new item, C, by drawing analogy to old items, A and B. The hearer's understanding of the new item, C', might be distorted so as to make it more similar to the old items along the dimensions of comparison.

Over time one could expect mutually held domains of terms to have a dimensional structure that emphasized discrete values along a small number of dimensions. Thus, the presence or lack of a feature would be a useful way to define a number of terms. Indeed, one would expect that of all the possible dimensions available for categorizing real objects or abstract ideas, people would tend toward isolating a few dimensions that they can apply to a number of knowledge domains to ease the problems of agreeing on the meanings of new terms. In this way, ease of shareability would begin to shape the knowledge structure.

One might even expect a "grid" to emerge such that a potentially continuous space becomes divided into discrete cells. (Cells could have prototypical entries and/or clearly defined boundaries; either system is compatible with this proposal.) Note that I am not specifying anything about constraints on internal representation *within* the individual human; I am argu-

ing that a dimensional structure for representing knowledge is efficient for communicating meaning *between* individuals. That is, a small dimensional structure with a small number of values on each dimension is argued to be especially *shareable,* which might explain why such structures are observed; we would not necessarily want to claim that there is an innate necessity for that structure.

This account, moreover, would help to explain the preponderance of *analogies* that people use in the explanations of new terms and concepts. Basically, analogies work by isolating one or more dimensions and pointing out common values on those dimensions. Even if no dimension for comparison is explicitly specified when an analogy is given, we often seem to agree, implicitly, on the basis for comparison. For instance, a simile such as "Walter is like a giraffe" is unlikely to mean Walter has the coloring of a giraffe or the eating behavior of a giraffe, but it most certainly refers to Walter's height and build. The use and understanding of analogies, then, may have a basis in the shareability of simple representational structures.

Consider a variation on the Krauss and Glucksberg (1977) paradigm mentioned earlier: Instead of giving both the Sender and Receiver the stimulus sets, only the Sender would be given a copy. Instead of asking the Receiver to search for the correct match within his copy of the stimulus set, the Receiver would be asked to learn what each item in the set was meant to be. Items could be indexed by names so that a Sender might say, "A blat looks like. . . ." and the Receiver would try to learn the meaning of blat. Now, suppose that the stimulus sets used in this Krauss and Glucksberg variation were a set of items formed by varying values on a small number of dimensions such as shape and size. I have described a prediction of the shareability notion that says that if the Sender wants to communicate knowledge to the Receiver about some stimulus items, the Sender will use *approximate* comparisons (such as analogies) between the new item and mutually shared knowledge about the other items. The lack of precision in these comparisons would lead to systematic "distortions" in the Receiver's understanding, or representation, of the new item such that the new item becomes more like old items with respect to the stimulus dimensions with which it is compared. In particular, if the Sender's version of the set included items all with *distinct,* but some very similar, values on the dimensions, then the Receiver's representation of the stimulus set would include items with the *same* values on the dimensions. Hence, the structure of the Receiver's representation would be determined, in part, by how easily knowledge about the stimulus set could be communicated by the Sender. Moreover, the Sender's representation would also be distorted as compared with the representation of a control subject having a noncommunicatory task such as holding the items in memory. That is, the need to communicate, as well as the need to understand, imposes shareability constraints.

Another prediction from shareability is that as the size of the community of knowledge sharers increases, the distorting effects should increase. Consider a "rumor" version of this experiment in which Person 1 begins as a Sender and Person 2 as a Receiver. The Receiver, after learning the material, then becomes a Sender and a new subject becomes the Receiver, and so on. A prediction from shareability is that the nature of the change from Sender 1 to Receiver *n* is toward a simple dimensional representation of the stimuli such as depicted in Figure 2.

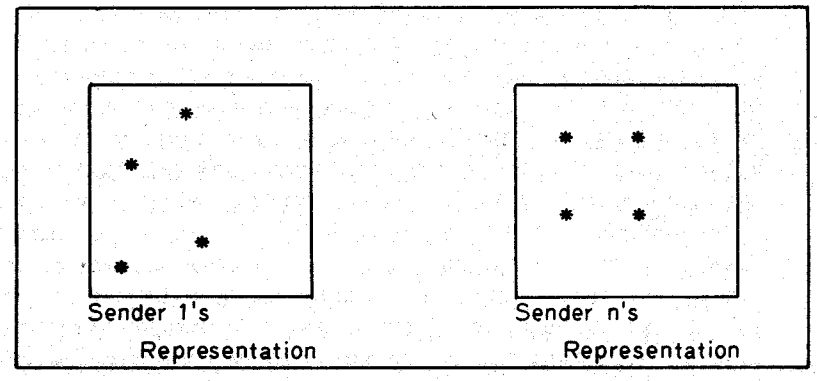

Figure 2. Possible mental representations of similarity between four items in a set for Sender 1 (who is presumably most veridical) and Sender *n* (who presumably shows the most amount of structure).

One way of thinking about these predictions is to consider a combined contagion model and information theoretic (or communication) model. The idea is that successfully shared knowledge spreads from person to person (contagion), but that newly introduced knowledge tends to change so that it approaches a steady-state that *minimizes information loss* as it spreads. In other words, if we think of language as a combination of descriptions, or "rumors" (such as, "the word blat means. . ."), a reasonably stable description is one that fits neatly into the existing structure. One way it can fit into the structure is by being categorized by dimensional values that are already used for other descriptions. Shareability predicts that a description will approach stability as it spreads. Of course, established words are often learned by users without explicit definitions, but instead through contextual cues. However, when words are newly introduced there is presumably more use of description. Also, even when there is no explicit definition there is often implict comparison between words in a common context. For instance, a word can be used in context with its antonym or a synonym.

Bartlett (1932) performed a number of "serial reproduction" experiments similar to the "rumor" version just described. In one condition he

asked subjects to look at and remember a picture and then to reproduce it. Then a second person looked at the reproduction and later reproduced it, and so on. Bartlett found that the reproductions did indeed stabilize in a predictable way. Unusual details were often lost and the most stable version was, according to Bartlett, the most conventional. For instance, an abstract face-like drawing eventually was reproduced as a standard *schematic* face. Bartlett achieved similar results with the "serial reproduction" of stories and descriptive prose, as well as drawings.

Bartlett helped introduce an important concept into the study of human memory: distortions in memory for an object or event make the memory more similar to an existing *schema* for that object or event. Bartlett also found this to be the case when he performed "repeated reproductions" experiments instead of "serial reproductions", that is, when a single subject had to reproduce a drawing or passage of text over and over. However, the distortions were more extreme in the serial case because a single individual's reproductions become "fixed" after a few trials, in contrast to the reproductions across different individuals.

Although Bartlett's results are certainly consistent with shareability, they could be explained without it. It might be that organizing or simplifying processes occur in each individual mind, resulting in a general preference to represent a drawing or text in a simpler way than originally presented. For instance, some of the distortions in Bartlett's experiments made the figures more symmetric, and the property of symmetry has generally been found to facilitate perception and memory of a figure. This explanation is supported by the similar results in the "serial reproduction" version and the "repeated reproduction" versions of the experiment. Shareability, on the other hand, argues that it is the very necessity to communicate an item that forces distortion in a representational structure. When Bartlett points out that schemata are conventions, he is not specifically arguing that the *structure* of the schemata are determined by sharing; it could merely be that the schemata are arbitrary, but once in place have an effect on the incorporation of information about an item and the reconstruction of memories for the item.

The reader should notice that Bartlett used single items in his experiment (whether a face or a story), whereas the variation of Krauss and Glucksberg proposed here would use *sets* of items. The shareability argument is that the structure seen in certain domains of knowledge comes about in the sharing of a set of items. That is, communication about a single item is achieved by linking it to other items in the set, often through analogies or comparisons. Thus, we would expect to see structural constaints emerge in the sharing of an organizing schema because of its relation to other schemata, which would tend to make each schema more "regular" or conventional.

Bartlett's contribution was an important one. The notion of schemata is certainly compelling and many psychologists have supported the importance of schemata to memory (referred to by a variety of names; see Minsky, 1975; Rumelhart, 1980; Schank & Abelson, 1977). However, schema theories have not been as powerful as they promised to be, because it is not clear how to make empirical predictions from the theory; almost anything can be a schema. Perhaps part of the problem is that there has not been a good theory for how schemata and *sets of schemata* come to be the way they are, and thus no way to define how a schema is different from a non-schema, other than whether it is used as a schema. If we can identify certain structures as particularly shareable, those structures should be represented in the relationships between schemata and thus, indirectly in the schemata themselves. This then would let us decide in advance what a reasonable schema was assuming that the shareability of the structures could be specified independently.

SHAREABILITY AND MODELS OF LANGUAGE ACQUISITION

Most knowledge domains that are studied by cognitive psychologists are transmitted, to some extent at least, by language. So in a sense, the researchers studying knowledge representation are studying semantics; one aspect of language. However, the investigations of knowledge representation and language have been somewhat separated by different intellectual and methodological traditions. In the present section I will discuss shareability in terms of the psycholinguistic tradition in a very general sense; a detailed psycholinguistic discussion is beyond the scope of this paper. My motivation for discussing models of language acquisition is to borrow, for my discussion of shareability, some of the causal theories linguists and psycholinguists have developed.

Many researchers have been attracted to the challenge of determining the causal connections between regularities in language acquisition and universal regularities in language. Chomsky (1965) posited a species-specific, language-specific mechanism for learning language. In the most simple version of the Chomskian approach, the language acquisition device constrains the process of acquisition which, in turn, determines universal aspects of language. This causal approach is often referred to as "learnability". Modern learnability theories (see Pinker, 1979) attempt to use the fact that language must be a learnable system in order to put formal constraints on possible languages.

Newport (1981) has also argued that language is the way it is because of learnability constraints: "I would like to suggest that the property of

having highly analytic forms, with units inside of units organized in constrained ways, arises from the learning processes through which such systems are passed" (p. 113). As Newport points out, an aspect of language that is considered to be universal is that the components of language are discrete in nature as opposed to continuous. The discreteness of language can be seen in the case of American Sign Language (ASL), a form of communication, that because of its spatial medium, is potentially more continuous than ordinary speech. Yet, ASL is formed of discrete components, such as morphemes, while "middle" values between components are meaningless, as in spoken languages. Perhaps this is because of an innate language acquisition device that constructs languages, nonverbal as well as verbal, only in a discrete, analytic way. Indeed, Newport's explanation of observable structures is that there are internal constraints. However, suppose that each individual's representation of semantic meaning, for example, begins with a continuous, non-analytic, representation. Now suppose that no two individuals have exactly the same representation and that, indeed, part of the language learning process involves the continual active modification of the meaning representation. According to shareability theory, the representations that overlap from one individual to the other would be more constrained than the representations that do not. Because many individuals are trying to share a common semantic understanding of a term, the resulting overlapping representation would approximate something discrete. This shareability account is consistent with an observation Newport makes: "...not all communication systems are organized in this [discrete/analytic] fashion; early, newly evolved communication systems display this analytic character to a lesser degree than older, more successively learned communication systems" (p. 118).

Many developmental and cognitive psychologists have challenged the claim that language learning mechanisms are language-specific. Perhaps the main justification for challenging language-specificity is parsimony; if language can be acquired in the way it is via general cognitive mechanisms, why posit specific mechanisms? For instance, Clark (1973) argues that certain aspects of language acquisition are determined by the nature of perceptual and cognitive constraints, such that the order of acquisition of spatial terms is determined by the order of application of the concepts in "P-Space", the child's representation of perceptual facts. Another approach (see, for example, Bruner, 1975a,b) to challenging language-specific learnability theories is to claim that pragmatic or communicative needs determine the nature of language acquisition and thus the nature of language universals.

Although most investigators consider the causal connection between language acquisition and language universals from a learnability perspective, another possible causal account is that children acquire language in the way that they do because of the nature of language itself. This is displayed

in Figure 3, which graphically illustrates Class A (learnability) and Class B ("representability") models. A representability argument might seem rather counter-intuitive, especially considering learnability arguments; that is, how did language get to be the way it is if not through learnability constraints? However, consider the fact that most children do come to learn a pre-existing language. Now, what if the nature of that language was determined by something other than learnability? That is, learnability is a *necessary* condition (a language must be learnable to be learned), but learnability might not be a *sufficient* condition to determine language structure. In other words, suppose children could learn lots of qualitatively different types of languages, but that the languages that happen to exist are not of those types. If this were true, looking at learnability constraints to explain language acquisition, and thus linguistic universals, would be misguided; perhaps language acquisition is determined by the structure of what is to be learned. Such a proposal would be consistent with a "representability", or Class B, model.

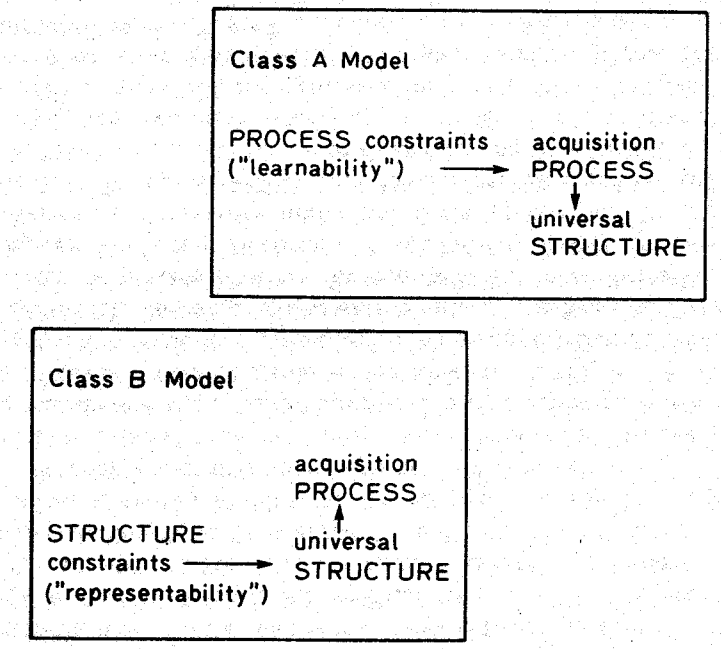

Figure 3. Class A (learnability) and Class B ("representability") models of language acquisition and formation. Class A models assume that learning process constraints on acquisition determine language structure. Class B models assume that mental representation, or structure, constraints determine language structure and, indirectly, language acquisition. Either model can be made more specific by emphasizing particular constraints such as, language-specific innate constraints, general cognitive constraints, or pragmatic constraints.

In fact, as discussed in the first sections, there is a tradition of research in psychology that attempts to explicate internal representation constraints by looking, for example, at similarity data, and semantic, conceptual, and categorical knowledge structures, although the tradition in psychology of inferring internal representation has not concerned itself solely with language, and has not emphasized acquisition as a phenomenon to be explained. An example of a Class B model in the psycholinguistic literature itself is suggested in Clark and Clark (1977). The argument could be made that general memory limitations might determine how vocabulary is stored, and thus the nature of semantic universals. It is also possible that the most "learnable" language for the child may not be the most useful language for the adult community. Thus, a representability model could emphasize the importance of pragmatic usefulness for adults in language evolution. However, there is an incompleteness in Class B type models in general; they really do not say why language got to be the way it is. What is misssing is a dynamic notion of language evolution; a point I will return to towards the end of this section.

One of the most important arguments in favor of shareability theory is that language is a communicative system (and thus shared). Of course, linguists and psycholinguists have not been blind to this fact about language, and there is an area of research known as "pragmatics" which looks at how communicative needs are implemented in language. An important area within pragmatics is the study of how language acquisition is determined by communicative needs (see Bates, 1976). For instance, Bruner (1975a,b) proposes that pre-speech behavior provides the basis for language acquisition in the child. Bruner's position differs from the claim Chomsky and his colleagues make that the child has an innate deep structure of linguistic universals which allow the child to acquire the specific surface languages that those around him speak. Bruner claims that the characteristics of universals are already present in the child's pre-speech environment, and hence need not reflect any language-specific universals. While pragmatic constraints present in a pre-speech environment may indeed constrain language acquisition, it is hard to see how they could also determine the fully developed and rich language adults use.

It seems that at the heart of this controversy is the following question: If there is no innate language acquisition device and pragmatic constraints do not uniquely determine language, why are languages the way they are? I would like to use shareability to propose an approach towards answering this question which claims that laws of language formation are not directly determined by the individual. I think that such an argument is a necessary addition to pragmatic approaches which do not seem to have fully exploited the theoretical importance of language as a communication system.

As Figure 4 illustrates, shareability combines learnability and representability in a dynamic, evolutionary model. Learnability now has its influ-

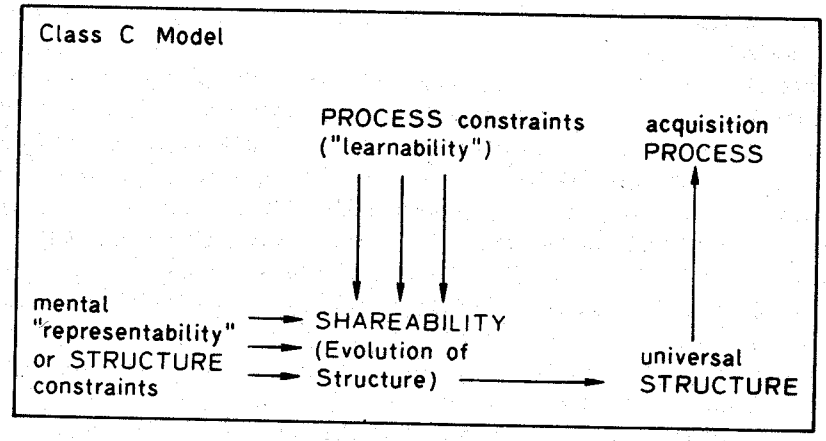

Figure 4. The Class C (shareability) model of language acquisition and formation assumes that constraints of mutually held and learned knowledge determine language structure and language acquisition. Multiple causal arrows refer to the role of more than one human mind in the creation of cognitive constraints.

ence on acquisition indirectly and, similarly, representability has an indirect influence on structural constraints in this model. Both learnability and representability become multiple constraints, as more than one individual must be able to learn and represent the language. Thus, we must postulate some sort of time factor as relevant to the creation of an emergent structure; we must allow for evolutionary laws of epistemology that determine which knowledge structures survive over time. Consider syntax, for example, as it is one aspect of language that is highly structured. Syntactic relationships, such as transformations, have been linked to the psychology of language, and although there has been dispute over the appropriate links between transformations and production and perception, or even about whether natural languages are best described as transformational grammars (as opposed to some other type of grammar), a common belief has been that syntactic relationships do tell us something about mental constraints on language learning or representation. But suppose that the syntactic structure evolved over time so that certain regularities come from the evolutionary process and only indirectly from mental constraints. For instance, suppose that the innovations that survive have special kinds of relationships to existing forms that make them memorable by speakers (e.g., new constructions that can be paraphrased via transformation rules).

A case in point is the notion of phonemic deep structure proposed by Chomsky and Halle (1968) that predicts how spellings correspond to sounds via transformational rules. This approach to phonology, like most generative syntactic approaches, postulates abstract underlying forms and

rules that never occur at the surface level. It thus postulates mental constraints that lead to a specific structured mental representation. For instance, Chomsky and Halle propose an underlying form for phonology that is remarkably like the surface form of Middle English. However, as Crothers and Shibatani (1975) point out, there is an "obvious HISTORICAL explanation" (p. 517; emphasis theirs) for the correspondence between present day English phonology and that of middle English. Crother and Shibatani's argument about phonology is completely compatible with the general shareability notion proposed here; structures can be shared in a community that reflect the *evolution* of the structure and not simple constraints on mental representation.

In general, the syntactic structures we have are mostly *generative;* that is, there are rules by which new expressions can be formed and understood. For instance, we can form new words by combining morphemes with appropriate inflectional rules, etc. The generative properties of rules in language (and perhaps in other systems such as music) make the whole system more *shareable* by the community, for the same rules that a speaker uses to form a new construction can be used by a hearer to understand it. It is possible that the individual need not even represent those generative rules directly, while still taking advantage of a shared structure. This would work if, while forming new words, people used analogies to existing words, which they might do so as to make the new word more memorable for the word users. Baron (1977) has clarified this distinction between using an analogy strategy and using rules: "Note that to use the analogy strategy, one does not have to know the orthographic rules beforehand in any direct sense, but the strategy is not useful unless the rules are there to be used. Hence we may speak of using rules without knowing them." (p. 561). For the case of spelling-sound rules, Baron points out that to pronounce a new word one needs to know only how to pronounce a whole word plus general strategies for forming analogies; one never has to rely on knowledge of specific letter-sound correspondences. (For instance, one might pronounce "wight" analogously to "night" with a general strategy that allows one to infer that only the first phoneme need be changed.) In general, therefore, whether a speaker forms a new construction by use of a generative rule or by analogy to an existing construction, he or she will be making the construction more shareable because it is thereby consistent with an existing structure to which that the hearer has access. Similarly, when a hearer understands a new construction in either of these ways, his or her understanding of the form will be consistent with the existing structure.

As mentioned, one aspect of the shareability model is that language structure is determined dynamically. Compatible with the model, then, is the fact that languages are constantly changing, especially when the specific changes seem to reflect changes in communicative need. For instance, a

universal characteristic of language found at the phonological, syntactic, and semantic level is that there are pairs of features in which one member is "unmarked" and one is "marked". Although Greenberg (1966) has suggested that there is an internal psychological explanation for this universal ("...there is perhaps justification for seeing a similarity between the implied, fundamental characteristic, that is the unmarked member, whether in phonology, grammar, or semantics, and the Gestalt notion of ground, the frequent, the taken-for-granted, whereas the marked character would answer to figure in the familiar dichotomy" (p. 60)), the evidence from language change suggests that the marked/unmarked pairs survive to the extent that they serve a purpose in the context of the present language structure. For instance, Greenberg points out that a marked "item tends to lose its mark whenever it no longer contrasts with the corresponding marked item" (p. 63). This suggests that marked and unmarked pairs do not simply stem from some sort of internal constraint that must represent language in terms of figure and ground, but instead that marked and unmarked pairs are useful in defining contrasting sets. (As I argued earlier, commonly used contrasting sets are useful for defining new words in terms of existing words.)

Perhaps a way to assess the role of knowledge sharing constraints versus internal constraints in knowledge structures would be to create very different types of structures and look at learnability. People can probably learn to use most finite state grammars if they receive explicit instruction, but can they learn to use those grammars correctly without that instruction, in which case the structure is only implicit in the exemplars? What about types of structures that are even more different? What would happen when a group of individuals was put together to develop a system of some sort, versus when an individual has to develop the system alone? Does tightness of structure and efficiency increase as more people have to share, or does it change qualitatively?

CONCLUSIONS

I have been assuming that shareability is potentially a constraint on knowledge structures because I assume that humans do learn knowledge from other humans and, moreover, that humans want to agree on what they "know". This implies the constraint of agreeability and presumably, of minimizing information loss between people. Psychologists tend to use evolutionary arguments to explain individual utility, but not social utility. For instance, psychologists have argued that it would be likely for spatial competence to be innate because it is of invariant survival value to the individual (see Shepard, 1981). Shareability theory suggests that it would be likely for certain knowledge systems to emerge because of their survival

value to the *group* of knowledge holders. It is my hope that by considering the constraints that the process of *sharing* puts on knowledge structures, we will eventually have a deeper understanding of human knowledge acquisition and representation.[3]

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[3]A possible extension of shareability is that it might be relevant to understanding the workings *within* the individual as well as to understanding the workings *between* individuals within a group. This idea is based on the assumption that the individual brain can be thought of as a collection of separate subsystems. Suppose that one part of the brain must communicate with a part that works somewhat independently (e.g., control of motor activity vs. spatial perception vs. language production). A communication system mutually acceptable to the subsystems might be necessary. Perhaps in this way we can talk to ourselves about non verbal processes, such as "Get your arm back and look at the ball", in the seconds before contact is made with a tennis ball. I like to think that we primarily think in deep continuous ways, but eventually we must make those thoughts discrete and sequential so that we can translate them into behaviors (especially linguistic behaviors) and it is to this later stage of thinking that we have introspective and observational access. In other words, we need a ("executive") structure that is accessible by deeper structures, but those deeper structures are different in nature from the top level structure.

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