DERIVING CATEGORIES TO ACHIEVE GOALS

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I. Introduction

People often derive categories while constructing plans to achieve goals. In constructing the plan for a vacation to San Francisco, someone might derive the categories of departure times that minimize work disruption, people to visit in California, and things to pack in a small suitcase. An infinite number of goal-derived categories exist, including foods to eat on a diet, clothing to wear while house painting, grocery stores that sell fresh herbs, activities to do on a vacation in Japan with one's grandmother, and so forth. Many of these are ad hoc categories, not established in memory but derived impromptu to achieve a current and novel goal. Whereas some goal-derived categories become well established in memory from being processed on numerous occasions, many others are ad hoc, having never been relevant before. For example, foods to eat on a diet might be a well-established, goal-derived category for someone who diets often, but activities to do on a vacation in Japan with one's grandmother is probably an ad hoc category for most people. Although I only address the ad hoc categories that people derive while constructing plans to achieve goals, ad hoc categories also arise in other contexts, including decision making (Kahneman & Miller, 1986), metaphor (Glucksberg & Keysar, 1990), and comparative judgment (Cech, Shoben, & Love, 1990).

A. Overview

The central theme of this chapter will be that understanding the nature of categories depends on understanding their origins and roles in the cogni-
tive system. If different types of categories have different origins and serve different roles, they are likely to develop different characteristics. In Section 1B, I contrast two fundamentally different ways in which categories originate: exemplar learning and conceptual combination. Much current work on categorization focuses on exemplar learning, addressing the induction of category knowledge from experiences with exemplars. Certainly, exemplar learning is central to the acquisition of many categories. For example, the acquisition of common taxonomic categories, such as apple, bird, shirt, and chair, relies heavily on experiences with exemplars. However, exemplar learning is not central to the acquisition of all categories. As we shall see, people often acquire goal-derived categories through conceptual combination, in the absence of exemplars. If the origins of categories determine their characteristics, then the disparate origins of common taxonomic and goal-derived categories should cause them to differ in important ways.

In Section II, I address the structure of common taxonomic and goal-derived categories. If these two types of categories have different origins, then their cognitive structures may differ. Much previous work has found that common taxonomic categories exhibit prototype structure, with some exemplars being more typical than others. Perhaps this structure reflects an outcome of exemplar learning, such as the abstraction of prototypical properties or the storage of prototypical exemplars. In contrast, the formulation of goal-derived categories through conceptual combination in the absence of exemplars should preclude the abstraction of prototypical information. Moreover, the conceptual combination that underlies goal-derived categories may produce definitions rather than prototypes to represent these categories. For these reasons, goal-derived categories may be equivalence classes that do not exhibit prototype structures. Even if prototype structures do exist in goal-derived categories, these structures may reflect fundamentally different factors than the prototype structures in common taxonomic categories, because of their different origins.

In Section III, I examine the role that goal-derived categories play in goal achievement and the conceptual combination that underlies their derivation. As protocol analyses of planning illustrate, people derive these categories while constructing plans to achieve goals. In the initial stages of planning, people retrieve an event frame and begin to instantiate its attributes. In planning a vacation, for example, people retrieve the frame for vacation and begin instantiating attributes such as location and departure. Goal-derived categories provide sets of potential instantiations for these attributes. For example, the goal-derived category of vacation locations provides potential instantiations of the location attribute in the vacation frame, perhaps including Montana, Tahiti, and Paris. To derive more specific, ad hoc categories that serve a plan in a particular context, people often integrate frame attributes with optimizations and constraints. For example, people might combine the frame attribute location with the optimization inexpensive and the constraint enables snow skiing to derive the ad hoc category of inexpensive vacation locations that enable snow skiing. Conceptual combination contextualizes categories, such that optimal and consistent instantiations can be found for frame attributes.

In Section IV, I examine further differences between common taxonomic and goal-derived categories, as well as relations between them. I first address the roles of common taxonomic and goal-derived categories in the time course of categorization. Whereas common taxonomic categories provide the primary categorizations of entities, goal-derived categories provide the secondary categorizations of entities. I suggest that this difference in temporal application produces different representations for common taxonomic and goal-derived categories, which serve different purposes in the cognitive system. I further suggest that this difference in temporal application results in lexicalization for common taxonomic categories but not for goal-derived categories, which often require more productive forms of linguistic expression. Finally, I propose a general framework for representing knowledge, in which common taxonomic and goal-derived categories play different but complementary roles. According to this framework, people use common taxonomic categories to build world models that represent the current state of the known environment. In contrast, people use goal-derived categories to interface world models with event frames for achieving goals. When trying to achieve a particular goal, people cannot succeed if attributes in the appropriate event frame do not map into a world model. Goal-derived categories provide the mappings from frame attributes to world models that make goal achievement possible.

B. Exemplar Learning and Conceptual Combination as Modes of Category Acquisition

Before proceeding to an examination of goal-derived categories, I address a distinction that will be central throughout this chapter. People can acquire categories in a variety of ways. At one extreme, people learn categories primarily through exemplar learning, inducing category knowledge from experiences with exemplars (e.g., Barsalou, 1990b; Brooks, 1978, 1987; Estes, 1986; Gluck & Bower, 1988; Hintzman, 1986; Hom, 1984; Jacoby & Brooks, 1984; McClelland & Rumelhart, 1985; Medin & Schaffer, 1978; Nosofsky, 1984; Posner & Keele, 1968; Rosch & Mervis, 1975). As people encounter a category's exemplars, they extract the exemplars'
perceived characteristics and integrate them to form category knowledge. Upon encountering a new kind of bird, for example, people extract the physical and behavioral characteristics of its exemplars and integrate them into a new category representation. The representations that result from such learning can take the form of prototypes, exemplars, and/or definitions (Smith & Medin, 1981). In general, this kind of learning is relatively passive, bottom-up, and automatic, at least as many psychological theories characterize it. As perceptual systems provide information about exemplars, category knowledge accrues slowly. To the extent that perception and memory are accurate, exemplar learning provides a relatively veridical account of the physical world, although distortions and biases certainly occur.

Conceptual combination constitutes a very different way in which people can acquire knowledge of a category (Barsalou, in press-b; Hampton, 1987, 1988; Medin & Shoben, 1988; Murphy, 1988; Smith, Osherson, Rips, & Keene, 1988). In this form of category learning, people derive new categories by manipulating existing knowledge in memory. In extreme forms of conceptual combination, little experience with exemplars is necessary. For example, people can manipulate knowledge about colors and natural earth formations to derive new categories such as purple oceans, orange rivers, and blue cliffs, even though exemplars of these categories have never been experienced. In contrast to exemplar learning, conceptual combination appears to be relatively active, top-down, and effortful. By deliberately manipulating knowledge through reasoning, people produce new categories that serve their goals. As we shall see, conceptual combination often produces idealized knowledge about how the world should be rather than normative knowledge about how it is.

Knowledge of many categories may evolve through both exemplar learning and conceptual combination. For example, Murphy and Medin (1985) argue that people use intuitive theories to guide category learning (also see Keil, 1989; Markman, 1989; Wellman & Gelman, 1988). According to this view, people's intuitive theories about the world play central roles in the processing of exemplars, including the selection, interpretation, and integration of their perceived properties. In learning psychiatric disorders, for example, learners select, interpret, and integrate symptoms quite differently, depending on whether their clinical theory is psychodynamic or behaviorist. As people extract perceptual characteristics from exemplars, the mechanisms of conceptual combination integrate this information with intuitive theories and other background knowledge to develop increasingly articulated accounts of the category. Features do not simply accrue for categories as exemplars are experienced. Instead, background knowledge assimilates features and may be accommodated in the process.

Although exemplar learning and conceptual combination both play important roles in category learning, each appears more central to some categories than to others. For example, exemplar learning appears particularly important to the acquisition of common taxonomic categories such as apple, bird, shirt, and chair. Extensive literatures on conceptual and linguistic development document the simple fact that adults often point to exemplars, while uttering their category names, to help children acquire common taxonomic categories (Keil, 1989; Markman, 1989; Mervis, 1987). For example, an adult might use an encounter with a cat to teach a child the concept and name for cat, perhaps contrasting them with the concept and name for dog. Clearly, exemplars are central to children's acquisition of common taxonomic categories.

Exemplar learning also appears central to common taxonomic categories for another reason. As I propose in Section IV,A, common taxonomic categories serve to maintain accurate information about the kinds of entities in the world. For example, chair maintains accurate information about its exemplars, including their likely physical properties (e.g., seat, back, legs) and their standard function (e.g., enables sitting). For accurate information to accrue about common taxonomic categories, people must encounter their exemplars, or at least learn about them through hearsay, in which case the original source of the hearsay encountered exemplars. If the representations of common taxonomic categories do not reflect experiences with exemplars, then the information established for them is likely to be inaccurate. As we shall see in Section II,B, the presence of central tendency information in the representations of common taxonomic categories suggests that these categories maintain representative information about their exemplars.

In contrast, exemplar learning appears much less important for goal-derived categories. Consider things to pack in a suitcase. People do not establish this category from experiences with its exemplars. Upon encountering particular shirts, novels, and toothbrushes in the environment, people do not induce things to pack in a suitcase. Instead, reasoning and conceptual combination during planning are central to acquiring this category. Because transporting personal items is often necessary on trips, and because suitcases serve as conventional containers for transporting these items, people must combine concepts for things, pack, and suitcase, along with background knowledge about trips, to derive things to pack in a suitcase. Subsequently, people may search for exemplars, which may in turn influence the evolving category representation. Exemplars may suggest new properties that are relevant to the category and raise problems for existing properties. But because the role of these categories is to optimize a plan, reasoning about exemplars' ideal properties through conceptual
combination may often be more important than acquiring central tendency information through exemplar learning. For example, people may derive the ideal weight of things to pack in a suitcase rather than inducing the average weight. Section III provides numerous examples of how people manipulate knowledge to produce goal-derived categories in the absence of exemplar learning.

II. Structure of Goal-Derived Categories

If common taxonomic and goal-derived categories arise through different mechanisms, their structures may differ. By structure, I do not mean the objective structures of categories in the environment or scientific theories about them (cf. Rey, 1983). Rather, I mean the cognitive representations of categories (Smith, Medin, & Rips, 1984). In this section, I review findings that bear on the structures of common taxonomic and goal-derived categories. Barsalou (in press-b) and Barsalou and Billman (1989) provide accounts of structure that differ considerably from those considered in this section.

A. Prototype Structure in Common Taxonomic Categories

Much work has shown that common taxonomic categories exhibit prototype structure, with some exemplars being more typical of a category than others. For example, robin is more typical of birds than is falcon, which is more typical than chicken. Similarly, chair is more typical of furniture than is lamp, which is more typical than refrigerator. Many theorists believe that an exemplar’s typicality is a continuous function of its similarity to the prototypical information for its category (Barsalou, 1987, 1989; Hampton, 1979; McCloskey & Glucksberg, 1979; Reed, 1972; Rosch & Mervis, 1975; Smith, Shoben, & Rips, 1974; Tversky, 1977). As an exemplar becomes increasingly similar to prototypical information, it becomes increasingly typical. Consider prototypical information for birds, such as small, flies, sings, and lives in trees. Exemplars similar to this information are typical (e.g., robin, sparrow); whereas exemplars dissimilar to this information are atypical (e.g., ostrich, chicken). The ordering of exemplars according to typicality that results from these similarity com-

1 As we shall see in Section II,D,1, prototypical information can exist either in prototype or in exemplar representations of categories (Barsalou, 1990b).

parisons constitutes the category’s prototype structure. In addition, prototype structure extends into the complement of the category, with nonmembers varying in how typical they are of the complement (Barsalou, 1983; McCloskey & Glucksberg, 1979; Smith et al., 1974). For example, butterfly, helicopter, and chair are increasingly typical members of non-birds.

Prototype structure does not appear to be a rigid structure stored in long-term memory (Barsalou, 1987, 1989). For example, the representation of birds probably does not specify explicitly that robins, falcons, and chickens decrease in typicality. Instead, prototype structure appears to be an implicit and emergent property that reflects the importance of prototypical information for a category, in conjunction with comparison and retrieval processes that utilize this information in various categorization tasks (e.g., classification, production, acquisition, reasoning). On a given occasion, the exemplars that are similar to prototypical information are processed more efficiently and confidently as category members than exemplars that are dissimilar. The implicit ordering of exemplars that emerges from this differential processing of exemplars constitutes prototype structure. Because the prototypical information for a category varies across individuals, tasks, and contexts, the prototype structures that emerge for a category vary considerably.

Prototype structure is central to how people represent and process categories. If one peruses reviews of the categorization literature, one sees that no other variable is as prevalent or robust in category processing as prototype structure (Medin & Smith, 1984; Mervis & Rosch, 1981; Oden, 1987; Smith & Medin, 1981). Prototype structure is central to the efficiency of classifying exemplars, with typical exemplars being classified faster and more accurately than atypical exemplars (e.g., McCloskey & Glucksberg, 1979; Smith et al., 1974). Prototype structure is central to the production of exemplars from categories, with people generating typical exemplars earlier and more often than atypical exemplars (e.g., Barsalou, 1983, 1985). Prototype structure is central to the acquisition of categories, with typical exemplars being acquired faster than atypical exemplars, and with typical exemplars facilitating category learning the most (e.g., Mervis & Pani, 1980). Prototype structure is central to reasoning about categories, with typical exemplars facilitating syllogistic reasoning more than atypical.

2 Elsewhere, I have referred to prototype structure as graded structure (Barsalou, 1983, 1985, 1987, 1989). However, I use prototype structure here to highlight the fact that the gradedness within categories reflects the typicality of exemplars, namely, their relation to the prototypical information of their category.
exemplars (Cherniak, 1984), and with typical exemplars producing stronger inductive inferences than atypical exemplars (Osherson, Smith, Wilkie, Lopez, & Shafir, 1990; Rips, 1973).

Yet some theorists have argued that prototype structure is unrelated to the essential structure of a category, as reflected in the formal bases of category membership. This is certainly true on occasion, as Armstrong, Gleitman, and Gleitman (1983) have shown for some categories (also see Rips, 1989). For example, odd number contains a prototype structure because people view some odd numbers as more typical than others. Yet this prototype structure has nothing to do with formal membership, which reflects a discrete, all-or-none rule (i.e., an odd number is any integer that produces a remainder of 1 when divided by 2). All odd numbers satisfy this rule equally, and thereby do not exhibit gradedness in formal membership.3

Certainly, prototype structure and formal membership are unrelated in some categories. But in many common taxonomic categories, formal membership is undefined. Rather than being clear and incontrovertible, membership is debatable and often undecidable. In these categories, membership typically varies continuously rather than being all-or-none. People are highly confident about the membership of some exemplars, somewhat confident about the membership of others, and not confident about the membership of others. In furniture, for example, people are confident that chair is a member, less confident that rug is a member, and still less confident that refrigerator is a member. Not only does membership vary reliably in these categories, typicality usually covaries with it. As an exemplar's membership increases, its typicality increases as well. In these categories, prototype structure reflects the ambiguous basis of membership. A variety of studies document this relationship between prototype structure and membership in common taxonomic categories (Chater, Lyon, & Myers, 1990; Fehr & Russell, 1984, Experiment 5; Hampton, 1979, 1988; McCloskey & Glucksberg, 1978).

B. Prototype Structure in Goal-Derived Categories

As we just saw, common taxonomic categories exhibit prototype structure. What is the structure of goal-derived categories? Do they exhibit prototype structure as well? Or do these categories exhibit some other kind of structure? Two factors suggest that goal-derived categories should not exhibit prototype structure. First, if people do not acquire goal-derived categories through exemplar learning, they should not have the requisite opportunities for abstracting prototypical properties from category members. Nor should people be able to identify and store typical exemplars. As a result, people should not have a basis for judging some exemplars as more typical than others. Second, in the process of deriving a category through conceptual combination, people may deduce the necessary and sufficient conditions that enable its exemplars to achieve an associated goal (as in explanation-based learning; DeJong & Mooney, 1986; Mitchell, Keller, & Kedar-Cabelli, 1986). Moreover, because people define these categories a priori, they may be biased to represent them as simply and elegantly as possible, specifying properties true of all members (Medin, Wattenmaker, & Hampson, 1987). If all members of a goal-derived category are equivalent in enabling a common goal, then people may not have a basis for judging some exemplars as better members than others. Rather than perceiving prototype structure in goal-derived categories, people may perceive these categories as lists of equivalent entities that enable the achievement of particular goals.

In a variety of studies, my students and I have assessed whether goal-derived categories exhibit prototype structure. In these experiments, subjects receive goal-derived categories and judge the typicality of their exemplars. For example, subjects might receive places to go on a vacation and judge the typicality of Montana, Tahiti, Paris, and so forth. The key issue in these experiments is: Do people agree on their judgments of typicality for goal-derived categories? If these categories do not have prototype structures, then people should not respond systematically. Instead, people should either respond randomly or idiosyncratically, such that the average correlation between different judges approximates zero. On the other hand, if these categories have prototype structures, then the average correlation between the typicality judgments of different judges should be greater than zero.

In exploring this issue, we have observed significant agreement in subjects' judgments of typicality across a wide variety of goal-derived categories under diverse task conditions. For example, Barsalou (1983, Experiment 2) observed agreement for prototype structure in ad hoc categories. In this particular study, the ad hoc categories were rather bizarre, such as ways to escape being killed by the Mafia and things that can fall on your head. Nevertheless, subjects exhibited clear and reliable agreement in their judgments of typicality. For subjects who rated typicality, the average correlation between subjects' ratings for the exemplars in an ad hoc category was .56. For subjects who ranked the exemplars according to
typicality, the average correlation between subjects' rankings was .54. Subjects performing both types of judgment agreed to a sizable extent in their assessments of prototype structure.

This agreement indicates that people construct similar prototype structures for a given ad hoc category. But because people rarely, if ever, consider these categories, how could they have acquired prototypical information for them? Moreover, why aren't these categories equivalence classes with respect to their associated goals? As we shall see in later sections, there is a single answer to both questions: People often establish goal-relevant information for these categories a priori that varies continuously across exemplars. In planning how to escape the Mafia, for example, people might reason that maximizing the geographic distance between themselves and the Mafia will optimize the chance of goal success. Because people derive this property a priori from background causal knowledge of the world, they do not have to experience exemplars to discover properties that define ways to escape the Mafia. Moreover, because geographic distance varies continuously, exemplars vary in how well they achieve the relevant goal (e.g., moving to South America is more optimal than moving to Wyoming, if one lives in Reno, Nevada). As an exemplar's geographic distance increases, its typicality and membership increase as well.

C. Stability of Prototype Structure in Common Taxonomic and Goal-Derived Categories

Earlier I suggested that the structures of common taxonomic and goal-derived categories should differ because they originate from different modes of category learning. But as we just saw, goal-derived categories exhibit the same prototype structure found in common taxonomic categories. This initial failure to identify a difference between these two category types led us to search further for differences. A second hypothesis we considered was that the prototype structures of common taxonomic categories are more stable than the prototype structures of goal-derived categories. Because lexemes such as apple, chair, and dog exist for common taxonomic categories, their meanings are conventional and impart a high degree of stability to prototype structure. Because goal-derived categories such as things to pack in a small suitcase arise idiosyncratically as individual persons pursue their daily goals, lexemes and conventional meanings do not develop for these categories, and their prototype structures vary widely across individuals and contexts.

In a number of studies, we have addressed the relative stability of prototype structures in common taxonomic and goal-derived categories (Barsalou, 1987, 1989; Barsalou, Sewell, & Ballato, 1986; also see Barsalou & Billman, 1989). Specifically, we have assessed the stability of between-subject agreement, within-subject agreement, and contextual shift. Because goal-derived categories are less conventional than common taxonomic categories, we expected the prototype structures of the former to exhibit less stability on all three measures. In performing these studies, we took care to sample a wide variety of categories, to sample exemplars representatively from categories, and to exhaust the range of typicality values within categories as much as possible. In general, the range of typicality values was the same for common taxonomic and goal-derived categories, such that differences in variability were not a factor. In addition, we assessed typicality with a variety of measures under a variety of task conditions, none of which altered our basic findings.

For between-subject agreement, we assessed the average correlation between all possible pairs of subjects in their judgments of typicality (as described in Section II.B). To the extent that subjects use the same prototypical information in judging typicality, correlations between subjects' judgments should be high. If the prototype structures of common taxonomic categories are more conventional than those of goal-derived categories, then between-subject agreement should be higher for common taxonomic categories. For within-subject agreement, subjects judged typicality in one session and returned 2 weeks later to judge typicality again for the same categories and exemplars. We then correlated each subject's judgments across the two sessions for each category to see how much their assessment of the category's prototype structure changed over time. To the extent that a subject uses the same prototypical information when judging typicality for a category on different occasions, the correlation between the subject's judgments in the two sessions should be high. If the prototype structures of common taxonomic categories are more stable than those of goal-derived categories, then within-subject agreement should be higher for common taxonomic categories.

To measure contextual shift, we had different subjects judge the typicality of the same categories in different contexts. In many of our experi-

4 Rosch (1975) and Armstrong et al. (1983) reported between-subject agreement over .90 for typicality, suggesting that people are nearly unanimous in their perception of prototype structure. But as Barsalou (1987) notes, these previous studies used inappropriate measures of agreement, which estimate the stability of means rather than agreement between judges. These extremely high levels of agreement simply indicate that sample sizes were sufficiently large to ensure that mean typicality judgments were stable—they provide no information about between-subject agreement.
ments, we manipulated context by asking subjects to adopt different points of view while judging typicality. For example, we asked some subjects to judge the typicality of birds from the point of view of the average American but asked other subjects to judge the typicality of birds from the point of view of the average Chinese citizen. Of interest was the extent to which a category's prototype structure shifted from context to context. To what extent are typical exemplars in one context atypical in another? Most importantly, do goal-derived categories exhibit more contextual shift than common taxonomic categories? If the prototype structures of common taxonomic categories are more stable than those of goal-derived categories, then less contextual shift should occur for common taxonomic categories. To measure contextual shift, we correlated the average typicality ratings for the same category in two different contexts, corrected for the unreliability of the means, and assessed the extent to which the adjusted correlation differed from the correlation that would occur if point of view had no effect (Barsalou & Sewell, 1984; Barsalou et al., 1986). Values of our contextual shift measure that deviate reliably from zero in the positive direction indicate that a contextual manipulation alters prototype structure.

Table I summarizes the results that we obtained for between-subject agreement, within-subject agreement, and contextual shift across a variety of experiments. As can be seen, common taxonomic and goal-derived categories exhibit roughly equivalent stability for all three measures. Occasionally, a reliable difference favors common taxonomic categories. But these reliable differences occur relatively infrequently and are quite small in magnitude. In a very different type of experiment, we actually found slightly higher agreement for the representations of goal-derived categories. In Barsalou, Spindler, Sewell, Ballato, and Gendel (1987, Experiment 1), we asked subjects to generate either average or ideal properties for common taxonomic and goal-derived categories. For example, subjects might generate round as an average property of fruit and sweet as an ideal. To measure between-subject agreement, we used the common element correlation to compute the average overlap in the properties that different subjects generated for the same category. The common element correlation is simply the number of properties common to two protocols divided by the geometric mean of the total properties in each (McNemar, 1969). To measure within-subject agreement, we used the common element correlation to compute the average overlap in the properties that the same subject generated for the same category on two different occasions. To measure contextual shift, we computed the difference in the common element correlations between subjects taking the same point of view versus subjects taking different points of view (again, larger values indicate more shift). Table II illustrates that goal-derived categories generally exhibit more stability than common taxonomic categories, although these differences are small in magnitude and only reliable in a few cases. The results from both sets of studies indicate that the category representations of goal-derived and common taxonomic categories do not vary noticeably in stability. When people judge typicality, the prototype structures that they produce for goal-derived categories are roughly as stable as those for common taxonomic categories. When people generate average and ideal information, they again exhibit equal stability. Contrary to our second hypothesis, the conventionality of common taxonomic categories does not make them more stable than goal-derived categories. At least two other factors may counteract conventionality. First, the causal principles that bear on goal achievement may often provide strong and salient constraints on the properties that can represent goal-derived categories. For example, causal principles relevant to human interactions specify that geographic distance is a relevant property for ways to escape being killed.

### Table I

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<tr>
<th>Experiment</th>
<th>Between-subject agreement</th>
<th>Within-subject agreement</th>
<th>Contextual shift</th>
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* Pairs of means indexed by the same superscript differ reliably at p < .05.
by the Mafia. Even though a given goal-derived category may only occur to a few people on a few occasions, the causal principles that constrain it may be obvious and well known, such that different people construct similar representations. Second, the wide variability of exemplars that different people experience for common taxonomic categories may decrease their stability. For example, if people experience different distributions of exemplars for furniture, their prototypical knowledge may vary. Barsalou and Billman (1989, pp.195–199) provide a more extensive list of factors that are likely to determine stability.

D. Determinants of Prototype Structure in Common Taxonomic and Goal-Derived Categories

Thus far, we have seen no differences between common taxonomic and goal-derived categories. Contrary to our original predictions, goal-derived categories possess prototype structures, which are just as stable as those in common taxonomic categories. However, equivalent stability does not entail that prototype structures be identical. For prototype structures to be identical, the same determinants must produce them. Perhaps the determinants of prototype structure that develop for common taxonomic categories during exemplar learning differ from the determinants of prototype structure that develop for goal-derived categories during conceptual combination. I next review work that bears on this issue.

1. Central Tendency

Following the classic work of Rosch and Mervis (1975), many researchers believe that similarity to central tendency constitutes the primary determinant of typicality in categories, where central tendency is the average or modal characteristics of a category’s exemplars. According to this view, central tendency information constitutes the content of prototypes. For example, the prototype of birds might contain modal properties such as small, flies, sings, and lives in trees. As exemplars approximate this modal information, they become increasingly typical. Because robin has all of these properties, it is typical. Because owl has two of these properties, it is less typical. Because ostrich has none of these properties, it is atypical. Proximity to central tendency is essentially the prototype view that has appeared in the categorization literature for the last 20 years: The closer an exemplar is to the central tendency of a category—the prototype—the more typical it is. Many investigators have indeed found that proximity to central tendency does determine prototype structure in common taxonomic and artificial categories (e.g., Hampton, 1979, 1987, 1988; Homa, 1984; Posner & Keele, 1968; Reed, 1972; Rosch & Mervis, 1975; Rosch, Simpson, & Miller, 1976; Smith & Medin, 1981).

Actually, Rosch and Mervis (1975) viewed the role of central tendency in typicality somewhat differently. Following Wittgenstein (1953), Rosch and Mervis argued that an exemplar’s family resemblance determines its typicality, where family resemblance is the average similarity of an exemplar to all other exemplars in the category. Some exemplar models of categorization account for prototype structure in this manner as well (e.g., Brooks, 1978, 1987; Estes, 1986; Hintzman, 1986; Medin & Schaffer, 1978; Nosofsky, 1984). For example, robin is typical of bird, because it has a high average similarity to all other birds, including sparrow, pigeon, dove, and so forth. In contrast, ostrich is atypical, because it has a low average similarity to all other birds. For most categories, an exemplar’s similarity to central tendency is at least roughly equivalent to its average similarity to all other exemplars (Barsalou, 1985). This is analogous to the difference between a number and the average of several other numbers being equivalent to the average difference between the number and these other numbers (e.g., the difference between 10 and (4 + 5 + 6)/3 is the same as the average of 10 – 4, 10 – 5, and 10 – 6). This equivalence becomes increasingly true for categories to the extent that a category’s central tendency contains average or modal information about property cooccurrence—not just independent properties (Barsalou, 1990b).

Exemplar learning is closely related to the role that central tendency plays in determining prototype structure. If central tendency determines the prototype structure of a category, it follows that people must have knowledge of the category’s central tendency in some form. Presumably, knowledge of central tendency often results from exemplar learning. In the process of experiencing a category’s exemplars and extracting their properties, people might compute average and modal information, which

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**TABLE II**

**AVERAGE MEASURES OF STABILITY FOR PROPERTY GENERATION**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Between-subject agreement</th>
<th>Within-subject agreement</th>
<th>Contextual shift</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Common taxonomic</td>
<td>Goal-derived</td>
<td>Common taxonomic</td>
</tr>
<tr>
<td>Average properties</td>
<td>.16</td>
<td>.18</td>
<td>.40</td>
</tr>
<tr>
<td>Ideal properties</td>
<td>.20&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.42&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* All entries in this table are reliably greater than zero at p < .05, including the measures of contextual shift. Pairs of means indexed by the same superscript differ reliably at p < .05. From Barsalou et al. (1987).
later represents the category and determines prototype structure. Alternatively, people may not compute central tendency information explicitly, but may rely on its implicit presence across exemplars (i.e., family resemblance in an exemplar model). Either way, exemplar learning is essential to central tendency determining prototype structure. Some exposure to exemplars is necessary for information about central tendency to develop.

People may often acquire central tendency information without encountering exemplars directly. For example, people have roughly accurate, central tendency information about the relative sizes of African animals, even though they have never been to Africa and have rarely been to a zoo. Frequently, people acquire central tendency information through hearsay, receiving it from conversations, books, and other media. Under such conditions, central tendency information is likely to be somewhat distorted and stereotypical, but it may nevertheless often be reasonably accurate. Most importantly, exemplar learning must have occurred at some point for central tendency information to be transmitted by hearsay. Some person must have experienced exemplars directly, such that he or she could convey reasonably accurate central tendency information to someone else later. As we shall see next, another very different kind of category information—ideals—doesn’t rely on exemplar learning either directly or through hearsay.

2. Ideals

Many researchers believe that central tendency is the exclusive determinant of prototype structure. Nevertheless, many other determinants are possible, such as ideals. An ideal is a characteristic that exemplars should have to serve a goal optimally. Consider the dimension of calories for the goal-derived category of foods to eat on a diet. Unfortunately for dieters, the central tendency of calories in this category is substantially higher than zero because most of its exemplars have a positive number of calories (e.g., one rice cake has 60 calories, one cup of nonfat yogurt has 130 calories). On the other hand, the ideal number of calories that exemplars should have is zero. The fewer calories a food has, the better it serves the goal of losing weight. Consequently, the central tendency and ideal value of calories differ for foods to eat on a diet. Most importantly, either could be prototypical. Exemplars could become increasingly typical as they approach the central tendency, the ideal, or both.

Whereas central tendency depends on exemplar learning, ideals do not. Instead, ideals arise from reasoning about categories with respect to goals. Consider the category of food. Outside the context of losing weight, zero calories does not become central to food through exemplar learning because few exemplars exhibit this property. Furthermore, zero calories is not an ideal but is instead a property of food to avoid, because people need calories to survive. But upon combining food with the goal of losing weight, zero calories acquires a new significance. Because zero calories epitomizes exemplars that enable weight loss, it becomes a salient ideal for the category. Frequently, ideals are central to category membership as well as to typicality. As exemplars approach the ideals of a category, they often become increasingly compelling category members.

Including ideals in prototypes extends prototypes in a nonstandard way because researchers typically assume that prototypes only contain central tendency information. But if a factor determines a category’s prototype structure, it must exist in the category’s representation. Consequently, ideals exist in the representations of categories whose prototype structures they predict (Medin & Barsalou, 1987). For this reason, assessing a category’s prototype structure is useful, because it provides a methodology for revealing the current content of a category’s representation (Barsalou, 1987, 1989). Further note that a prototype may contain multiple ideals that optimize multiple goals. For example, minimal calories, maximal nutrition, and maximal taste may exist simultaneously in the prototype for foods to eat on a diet, serving the goals of losing weight, staying healthy, and enjoying food.

3. Frequency

Most people who are not categorization experts believe intuitively that frequency determines prototype structure. According to this view, some exemplars are typical, because they occur frequently, whereas other exemplars are atypical, because they occur infrequently. In two studies, Rosch and her colleagues assessed the relationship between frequency and typicality and found none (Mervis, Catlin, & Rosch, 1976; Rosch, Simpson, & Miller, 1976). However, these tests of frequency were not strong, and subsequent researchers found effects of frequency on prototype structure, including Ashcraft (1978), Glass and Meany (1978), Hampton and Gardiner (1983), and Malt and Smith (1982). Consequently, frequency does contribute to prototype structure.

Two measures of frequency could determine prototype structure. First, an exemplar’s overall familiarity could determine its typicality. As people acquire increasing knowledge about an exemplar and encounter it more frequently, its typicality in any category increases. According to this measure, if people are more familiar with chairs than with logs, then chair should be more typical in any category that contains both (e.g., firewood). Second, an exemplar’s frequency of instantiation as a category member could determine its typicality. As people view an exemplar increasingly often as a member of a particular category, its typicality increases. Ac-
According to this measure, if people encounter log more often than chair as a member of firewood, then log should be more typical. Familiarity, frequency of instantiation, or both could determine an exemplar's typicality. Because people acquire familiarity and frequency of instantiation from experiencing exemplars (or from hearsay about other people's experiences with exemplars), both measures reflect exemplar learning.

4. Assessing the Determinants of Prototype Structure

To what extent do central tendency, ideals, familiarity, and frequency of instantiation determine the prototype structure of categories? Which of these factors is most important? Does each factor have a unique effect on prototype structure, or are these factors redundant? Most importantly, are the determinants of prototype structure the same for common taxonomic and goal-derived categories? Although prototype structure may be equally stable in both category types, its determinants may differ.

Barsalou (1981, 1985) assessed the determinants of prototype structure in common taxonomic and goal-derived categories. One group of subjects judged the typicality of exemplars in categories of each type. Four other groups of subjects provided independent information about central tendency, ideals, familiarity, and frequency of instantiation. For central tendency, subjects received all possible pairs of exemplars for each category and judged the similarity of the exemplars in each pair. The similarity ratings involving a given exemplar were then averaged to obtain its average similarity to all other exemplars. As noted earlier, this family resemblance measure is essentially the same as the similarity of each exemplar to the category's central tendency. For ideals, one ideal value was selected for each category (e.g., high calories for foods not to eat on a diet, tastes good for fruit). Subjects then rated exemplars according to their values on the corresponding dimensions (e.g., calories for foods not to eat on a diet, how much people like it for fruit). In all cases, the ideal value was an extreme value of the dimension. For familiarity, subjects rated each exemplar for how familiar they were with that kind of thing. For frequency of instantiation, subjects rated each exemplar for how often they encountered that type of thing as a category member.5

Table III summarizes the results from this experiment. As can be seen, this table contains the raw correlations between each possible determinant and typicality, as well as partial correlations that remove the contributions of other predictors. Before turning to the central results of this study, I first address several preliminary points. First, familiarity did not predict typicality. Nor did familiarity contribute to frequency of instantiation's ability to predict typicality. Consequently, frequency of instantiation appears to be the critical measure of frequency that determines typicality—not familiarity. Second, this study underestimates the predictive power of ideals. Because only one ideal was assessed for each category, ideals may account for substantially more variance when all relevant ideals are assessed. Investigators who have measured ideals more exhaustively generally find that ideals account for much more variance than central tendency (Borkenau, 1990; Chaplin, John, & Goldberg, 1988; Loken & Ward, 1990; Read, Jones, & Miller, 1990). Third, the pattern of predictors for specific categories varied considerably (see Table 3 in Barsalou, 1985). For example, central tendency and ideals predicted typicality in clothing, but frequency

5 Subjects who rated frequency of instantiation could have simply rated typicality. If so, the correlation between frequency of instantiation and typicality should have approached 1 (or, more realistically, the average reliability of the means for these two measures; see the shift score of Barsalou & Sewell, 1984). But because these correlations were considerably lower, the ratings for frequency of instantiation were not typicality judgments. Perusal of the means for these measures in the appendix of Barsalou (1985) further suggests that subjects were judging frequency of instantiation, given many sensible departures of this measure from typicality. Finally, much work on frequency estimates indicates that people are quite sensitive to the frequency of events and can rate frequency reliably (e.g., Hasher & Zacks, 1979; Hintzman, 1976).
of instantiation did not (partial correlations of .71, .81, and −.10). In contrast, all three factors predicted typicality in birds (partial correlations of .75, .42, and .78). Fourth, the determinants of a category’s prototype structure vary with context. Barsalou (1985, Experiment 2) found that central tendency determines the prototype structures of artificial categories in one context but that ideals determine them in another. As we saw earlier for contextual shift, the prototype structure of a category is highly malleable (Barsalou, 1987). Finally, these correlational studies must be interpreted with caution because correlations do not imply causation. However, additional research demonstrates that central tendency, ideals, and frequency causally determine prototype structure. Rosch and Mervis (1975, Experiments 5 and 6), Rosch, Simpson, and Miller (1976), Barsalou (1981, Experiment 3), and Barsalou (1985, Experiment 2) demonstrated that central tendency causally determines prototype structure in artificial categories. Barsalou (1985, Experiment 2) demonstrated that ideals causally determine prototype structure in artificial categories. Barsalou (1981, Experiment 3) and Nosofsky (1988) demonstrated that frequency causally determines prototype structure in artificial categories. As these experiments illustrate, all of these determinants bear a causal relation to prototype structure.

Turning to the results of primary interest, first consider the correlations in Table III for the common taxonomic categories. As can be seen, central tendency dominated the prediction of typicality, similar to the findings of Rosch and Mervis (1975). However, ideals and frequency of instantiation also accounted for unique typicality variance. By no means is central tendency the only determinant of prototype structure in common taxonomic categories. All factors together accounted for 64% of the typicality variance in common taxonomic categories.

In contrast, consider the results for the goal-derived categories in Table III. Ideals and frequency of instantiation each predicted typicality uniquely, with all factors together accounting for 69% of the typicality variance. Most importantly, central tendency accounted for no unique typicality variance in goal-derived categories. Although the raw correlation between central tendency and typicality was reliable, all of this variance was shared with ideals and frequency of instantiation. In Experiment 1 of Barsalou (1981), not even the raw correlation between central tendency and typicality exceeded zero for goal-derived categories (−.15). Here we have our first important difference between the two category types: Central tendency determines prototype structure in common taxonomic categories but not in goal-derived categories.

This difference indicates that exemplar learning is more central for common taxonomic categories than for goal-derived categories. Because exemplar learning is necessary for acquiring central tendency, and because central tendency determines the prototype structure of common taxonomic categories, exemplar learning is central to the acquisition of these categories. In contrast, exemplar learning is not as important to the acquisition of goal-derived categories because central tendency does not determine their prototype structures. Exemplar learning is of some importance to goal-derived categories because frequency of instantiation determines their prototype structures to a significant extent. Nevertheless, exemplar learning plays qualitatively different roles in common taxonomic and goal-derived categories: Whereas central tendency is by far the most significant determinant of prototype structures in common taxonomic categories, it plays no role in the prototype structures of goal-derived categories.

Interestingly, the importance of ideals for common taxonomic categories indicates that conceptual combination is important for these categories as well as for goal-derived categories. Consider the common taxonomic category of fruit. Because people eat fruit to achieve goals, ideals relevant to these goals become central to its representation (e.g., tastes good). Similarly, high enjoyability is an ideal for sports, and high destructiveness is an ideal for weapons. Other investigators have found much further evidence for the importance of ideals in category representations. Loken and Ward (1990) have found that ideals are far more important than central tendency in determining the prototype structures of consumer categories (e.g., shampoos, stereos). Researchers in social cognition have found that ideals are far more important than central tendency in determining the prototype structures of social categories (Borkenau, 1990; Chaplin et al., 1988; Read et al., 1990). Ideals are also important in the selection of names for cars, rock bands, and streets (Lehrer, in press). Lakoff (1987) reviews a variety of forms that ideals take in categories.

As these results illustrate, conceptual combination plays a central role in category formation. By no means does all category learning occur through the simple extraction of exemplar properties. Category representations not only contain exemplar properties; they also contain ideals derived through conceptual combination that serve goal achievement. As these results further illustrate, exemplar learning plays qualitatively different roles in common taxonomic and goal-derived categories. Whereas exemplar learning produces central tendency information for common taxonomic categories, it does not produce central tendency information for goal-derived categories. In the final section of this article, I return to this difference and propose that it reflects the different roles that common taxonomic and goal-derived categories play in the cognitive system. Whereas the role of common taxonomic categories requires that their...
representations contain central tendency information, the role of goal-derived categories does not. The role of a category in the cognitive system shapes the contents of its representation and therefore the determinants of its prototype structure.

III. Goal-Derived Categories in Planning

I turn next to a detailed analysis of the role that goal-derived categories play in the cognitive system. What specific functions do goal-derived categories serve in goal achievement? What is the nature of the conceptual combination the produces goal-derived categories during planning? What is the origin of the ideals that structure these categories? When Amy Rozett, Daniel Sewell, and I first considered these issues, we had few hypotheses about them. To gain an initial understanding, we performed exploratory studies to observe people's use of goal-derived categories. Because these categories appeared relevant to the plans that people construct for achieving goals, we asked subjects to plan various kinds of events, such as trips, purchases, repairs, and social gatherings. Typically, subjects spent anywhere from 5 to 15 min planning an event that would be plausible in the context of their lives. We tape recorded subjects' protocols and later performed coding analyses to identify the origins of goal-derived categories and the functions they serve. Table IV contains one subject's plan for a vacation.

In the remainder of this section, I review findings from these studies. I first describe the frames that guide planning and how people instantiate these frames to construct specific plans. I then describe how goal-derived categories provide sets of instantiations for frame attributes and how optimizations and constraints guide the selection of specific instantiations. As we shall see, optimizations produce the ideals that determine the prototype structures of goal-derived categories. Finally, I describe how people derive ad hoc categories from frames and how frames define large fields of categories relevant to achieving goals. Although I only describe people's plans for vacations from hereon, their plans for other types of events exhibit the same characteristics robustly. Barsalou, Usher, and Sewell (1985) and Barsalou and Hutchinson (1987) provide initial reports of this work.

A. Frame Instantiation

When beginning to plan a familiar type of event, such as a vacation, people retrieve a frame for it (see Barsalou, 1991-b, for a more thorough account

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TABLE IV

PROTOCOL OF A SUBJECT PLANNING A VACATION

Okay, well, given my monetary situation I think the first thing I would do is check how much money I have.

Just so I have a general feeling when planning whether I can afford anything at all.

Alright. Then, I think I would just sort of sit down . . . and think about the different places . . . I want to go.

There're obviously a lot of places I want to go to that I can't afford.

So . . . it'd have to be some place within a few hours of driving distance . . . from Atlanta.

That's the first thing.

So I'd just eliminate anything that I couldn't drive to in say . . . one day. Maybe eight or nine hours at the very most.

Alright, so, I'd have to drive.

And . . . if I wanted to relax, the only kind of vacation I could really relax on would be to get away from just about everybody I know here.

So, chances are I'd want to go alone, and just not . . . not go with anyone at all. So I'd probably just go by myself.

'Cause that's what I really need after being here for four months.

Um mm. And . . . so what would I do?

Well, I think . . . think I'd want to go camping.

Or go to some sort of rural or mountainous area.

Probably a park.

So probably . . . go to the library or book store and get books . . . and maps, guides to various parks and start reading about the different parks.

And what different, ah, facilities they have and what they're like.

And I'm not sure I'd know what I'd want, until I saw it. Just sort of looked through until I found something that looked good. Then I'd . . . then I'd pick that place to go.

After I picked what place I wanted to go to, then I'd have to think about what I was bringing.

Now, jumping back, I think I do know certain constraints that I would put on the place I go, like I'd probably want to go fishing.

I mean, that's something I really like to do.

So, I pick the place where I could go fishing.

And where there wasn't a lot of . . . sort of camping where people park their Winnebagos all over the place.

Some place where I could park but then, really in order to do any camping, you just have to hike a couple miles and just get away from anything.

So, and then I'd have to bring my fishing stuff.

And since it's really cold this time of year up in the mountains I'd have to bring a lot of really warm clothes.

And I'd have to bring my backpack and food, and this little Coleman stove I have . . . and probably . . . a book or two and some stuff to write with.

I'd just hike up into the mountains somewhere . . . find some place off in the middle of nowhere, go fishing all day, and sit around and read a book.

Although if it's really really cold (laugh) . . . I might not be able to read a book at all, because my hands will be so cold that . . . they'll freeze onto the pages and then I'd
TABLE IV (Continued)

just have to wrap myself up in about ten layers of clothing and just fish or shiver or something.

Attempt to write with ah . . . three gloves on my hands or something!

But that's . . . that's the general plan I'd have.

Now let me think. Is there anything else I'd want to do.

Oh, I know. Aha! Well, before I even went, I'd want to check my car since it's sort of dying anyway. As a matter of fact it's sort of in bad shape, so I wonder whether it would make it the whole way.

So I'd do, probably . . . probably do a complete checkup of the car and just figure whether it could make it on that distance trip.

And just check all the basic things like transmission fluid and oil and spark plugs and just everything.

Probably still something would go wrong, but (laugh) I'd check all those things . . . before I went.

And . . . hmm. Other than that . . . that's about it. I think I know exactly what I want.

It's so . . . that . . . that is what I'd do.

of frames). Consider the partial frame for vacation in Fig. 1. As can be seen, this frame contains attributes that take different values across different vacations. For example, the actors who take a vacation vary from plan to plan, as do vacation locations, things to take, and so forth. As can also be seen, attributes form clusters. For example, the expenses cluster contains more specific attributes, such as source of money (i.e., the person who will pay for the vacation) and total cost. Similarly, the activities cluster contains more specific attributes, such as preparations, not work (i.e., the work from which the planner is taking a vacation), not reside (i.e., the planner’s normal home), travel (i.e., transportation), reside (i.e., the vacation residence), and entertainment. Some of these more specific attributes constitute attribute clusters themselves. For example, the cluster for travel contains more specific attributes for major travel (e.g., flying from city to city), minor travel (e.g., getting from home to the airport), and at location (e.g., renting a car at the vacation location).

The nested sets of attributes in Fig. 1 form attribute taxonomies (Barsalou, in press-b). As the figure illustrates, the values of an attribute are often attributes themselves. For example, departure, duration, return, and schedule are all values of temporal parameters. But in turn, each of these values is an attribute that takes more specific values. For example, departure takes values such as December, Spring Break, Memorial Day weekend, and so forth. As each high-level attribute becomes increasingly differentiated in this manner, it forms an attribute taxonomy. Most of the highest level attributes in Fig. 1 occur across a wide variety of events. To a large extent, the attributes for actors, locations, temporal parameters, objects, and activities recur frequently across events, with values of these attributes distinguishing specific types of events (Barsalou, 1988; Barsalou & Billman, 1989). Interestingly, these same attributes also occur ubiquitously as thematic roles in verb syntax, further implicating their centrality in events (Carlson & Tanenhaus, 1988; Fillmore, 1968, 1977; Jackendoff, 1987; Wilkins, 1988).

The vacation frame in Fig. 1 excludes much important structure. First, this frame omits many attributes that subjects mentioned. For example, vacation location often had attributes of climate and health hazards, and companions often had attributes of convenient times for taking a vacation and preferred entertainment. Second, this frame omits many attribute values. For example, people know possible values of vacation location, such as Hawaii, Paris, and New York. Similarly, people know possible values of entertainment, such as swim, hike, and visit museums. Third, this frame omits relations between attributes. For example, people know
that actors cause travel to occur and that travel is typically from the home location to the vacation location. Fourth, this frame omits constraints between attribute values. For example, people know that if snow ski is the value of entertainment, then the value of vacation location must be a mountainous region. Similarly, people know that if the value of travel is drive, then the value of total cost is typically lower than if the value of travel is fly. Barsalou (in press-b) reviews the basic components of frames—attribute-value sets, relations between attributes, and constraints—and provides many examples of each, along with examples of other important properties of frames, especially recursion.

When people begin to construct a plan, they do not retrieve the entire event frame as a rigid structure in a single retrieval operation. We assumed in our analyses that subjects only considered a frame attribute in their plan if they mentioned it explicitly or implied its existence in a statement about some other attribute. On the basis of these criteria, no subject considered all of the attributes in the partial frame for vacation in Fig. 1. Instead, subjects varied in the attributes they considered, often failing to consider important attributes. For example, one subject failed to consider reside, companions, and things to bring back; whereas another subject failed to consider temporal parameters, expenses, and things to bring back. Subjects seemed aware of their failure to consider all attributes because they occasionally scanned the attributes that they had considered thus far, attempting to discover further attributes. Consider the following attribute scans:

Um... okay, so let’s see... um, have I planned everything? Where, when, who, money, what I’m gonna do...

Well, after we have figured out the location, the time, and if we can afford it, then we’d plan what we’re going to do.

Um... let’s see, so once I had a time and an agreed upon group, then we’d work on the specific location.

Um... we’d be all set for the plane, for places to stay, travel while we’re there, um... eating while we’re there, um... what else... where to go while we’re there... um... (whispered) God, I wonder if that’s all there is to it?

As these examples illustrate, subjects were aware of the attributes that they had already considered and of further attributes that remained. Further evidence that people do not retrieve frames rigidly comes from the orders in which subjects considered frame attributes. Subjects considered attributes in widely divergent orders. Although most subjects considered vacation location early in planning, the order in which they considered other attributes typically varied. For example, one subject considered source of money first, then vacation location, then travel, etc. Another subject considered actors first, then vacation location, then temporal parameters, etc. In addition, frame attributes sometimes appeared to be context-dependent. For example, subjects typically only considered health hazards when they had already selected a vacation location associated with health risks (e.g., tropical locations). For less risky vacation locations, subjects did not usually consider this attribute.

Because attributes are sometimes context-dependent, and because people vary in the attributes that they consider and in the order in which they consider them, frames are not rigid structures, as many theories in artificial intelligence assume (Barsalou, in press-b). Instead, frames are flexible, loosely organized bodies of knowledge. As Barsalou and Billman (1989) suggest, attributes vary in their likelihood of relevance for a frame across contexts, such that some attributes become more dominant than others. In the vacation frame, for example, vacation location appears more dominant than health hazards or things to bring back. In addition, a given attribute tends to covary with certain attributes and attribute values, such that relations and constraints develop between them. As a result, the activation of one part of a co-occurring pattern of attributes and values tends to activate the remaining parts of the pattern, similar to activation in a connectionist net (McClelland, Rumelhart, & the PDP Research Group, 1986; Rumelhart, McClelland, & the PDP Research Group, 1986).

As people retrieve a frame while planning, they begin to instantiate its attributes. By instantiation, I mean that people adopt particular values of an attribute for use in their current plan. When planning a vacation, for example, people consider values of vacation location and attempt to identify the specific location(s) that will instantiate this attribute. Similarly, vacation planners must instantiate other attributes, such as departure, things to take, entertainment, and so forth. This instantiation process appears to constitute the primary activity of early planning. Because our planners did not consider all attributes in the first 5–15 min of planning, many initial plans are probably quite sketchy. If people planned long enough, they might come closer to considering all relevant attributes. However, people often plan on instantiating some attributes during execution rather than during planning. For example, a planner might decide to instantiate things to bring back in an opportunistic manner once the vacation has begun (Hayes-Roth & Hayes-Roth, 1977). Nevertheless, planners often forget to instantiate key attributes in planning, such that minor and
When instantiating a frame's attributes, people do not proceed directly from considering an attribute to selecting a specific individual as its instantiation. For example, people often don't proceed directly from *vacation location* to the specific location that they plan to visit. Instead, people often focus their instantiations, beginning with a general class of instantiations and continually refining it down to more specific instantiations. For example, one subject's first instantiation of departure was *October*, followed later by *when the autumn leaves are at their peak* and then a *weekend*. Typically, but not always, each more specific focusing inherits the properties of the previous, more general instantiation. For example, this subject's final departure was a *weekend in October when the autumn leaves are at their peak*. As this example illustrates, conceptual combination is central to the process of focusing instantiations because planners combine increasingly specific properties with the existing attribute description. The nature of this conceptual combination is the topic of later sections on optimization, constraint, and the derivation of ad hoc categories.

Often people are unable to instantiate an attribute because they have limited knowledge of its possible instantiations. For example, a subject planning a vacation in Paris had no idea of instantiations for *lodging*. Similarly, people are often only able to instantiate an attribute generally, because they lack knowledge of specific instantiations. For example, the subject who planned the backpacking trip in Table IV had a general idea of the type of location he wanted but did not know specific locations with these properties. Finally, people often do not know whether enabling states for particular instantiations are met. For example, subjects sometimes selected particular instantiations of *vacation location* or *entertainment* but did not know if their companions would approve of these selections.

Because of subjects' frequent inability to instantiate attributes, they spent much time planning *preparations*, namely, activities that must be performed prior to instantiating an attribute either at all or completely. In one study, four important types of preparations accounted for 84% of those mentioned. The most frequent type of preparation was *obtaining things* (34%). For example, one subject needed to obtain a swimsuit before taking a vacation to the beach. The other three most frequent types of preparations were *seeking information* (25%), *making decisions* (15%), and *verifying states* (10%). For example, one subject planned to *seek information* about lodging and then *decide* which lodging was best at a later time. Another subject planned to *verify* that her passport was still current.

In general, preparations were oriented around the process of frame instantiation. Subjects realized that they couldn't instantiate an attribute completely during the current planning session and planned the necessary activities that would enable them to instantiate it later.\(^6\)

Finally, subjects performed little scheduling of actions. This is of interest because most theories of planning and problem solving in psychology and artificial intelligence assume that the primary process in these activities is constructing a sequence of operators (Hayes-Roth & Hayes-Roth, 1977; Newell & Simon, 1972; Sacerdoti, 1975, 1979). But we observed very little sequencing in our planning protocols. Instead, subjects' primary activity was to instantiate frames in an optimal and coherent manner (cf. Stefkik, 1981). Certainly, if subjects had planned long enough, they would have eventually planned sequences of actions necessary to preparing for their vacations and executing them. But this type of sequencing may often occur late in the planning process and during execution. In contrast, the early stages of planning focus primarily on frame instantiation. Much research on planning and problem solving finesses this phase because subjects or simulations receive fully instantiated frames prior to beginning the planning process. Because the actors, objects, locations, actions, and so forth are given in the problem statement, the only problem that remains is finding arrangements of them in time and space to achieve the goal.

### B. Role of Goal-Derived Categories in Frame Instantiation

Given that frame instantiation constitutes the primary activity in early planning, what role do goal-derived categories play? Essentially, these categories provide sets of instantiations for frame attributes. For example, when people instantiate the *location* attribute in the *vacation* frame, they typically have a category of *vacation locations* that they retrieve and consider. Similarly, when people instantiate *departure*, they typically have a category of *departure times* that they retrieve and evaluate. In this way, goal-derived categories support the instantiation of a frame's attributes during planning (cf. Byrne, 1977; Dougherty & Keller, 1985; Lucariello & Nelson, 1985).

Clearly, not all goal-derived categories exist prior to planning. Instead, many are ad hoc, being derived impromptu to instantiate an attribute in the plan for a novel goal. For example, people who work all of the time and never think about vacations, much less take one, may not have a well-established category of *vacation locations*. In attempting to instantiate this

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\(^6\) Preparations are similar to the procedural attachments in Winograd (1975).
attribute, these planners must derive an ad hoc category before they can consider and select instantiations. One strategy for constructing ad hoc categories under these conditions is the *generate-test procedure*. Using well-established knowledge of other categories, planners generate possible candidates for an ad hoc category and then test them for membership. For example, planners might generate candidates from their well-established knowledge of countries and continents, which they then test for the relevant properties of vacation locations. Later, we shall consider the processes that derive such categories in greater detail.

Once people derive an ad hoc category, they establish information about it in long-term memory. Because the processing that underlies the derivation of such categories is often deep, elaborative, and extended, information about them is likely to become transferred from working memory to a more permanent form of knowledge (cf. Crowder, 1976). If this same category is useful later for instantiating an attribute in another plan, planners may be able to retrieve it from long-term memory rather than having to construct it with the generate-test procedure in working memory. To the extent that the category receives frequent processing, it should become increasingly established, such that it is no longer ad hoc. As people become experts at planning a particular kind of event, the goal-derived categories that support frame instantiation become streamlined in memory. Rather than having to search for possible instantiations that are distributed throughout multiple sources of knowledge, people can retrieve a set of instantiations that have been stored together with the attribute as a byproduct of previous planning. Once planners have retrieved this set, they can search through it to find the most appropriate instantiations for the current plan. Depending on the familiarity of the planning situation, people may use either ad hoc or well-established goal-derived categories during frame instantiation.

C. **Factors that Guide the Selection of Instantiations**

Given that goal-derived categories provide sets of instantiation for frame attributes, how do people select particular exemplars from them to instantiate an attribute? Once people establish a goal-derived category of vacation locations—either ad hoc or well-established—how do they select specific exemplars for a particular vacation? Two important factors permeate people's selection of exemplars, as indicated by the ubiquitous discussion of these factors in subjects' planning protocols: optimization and constraint.

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1. **Optimization**

Across a wide variety of events, people generally try to optimize a recurring set of background goals. For example, people generally try to preserve their health, obtain maximum enjoyment, minimize wasted time, conserve money, maximize the quality of possessions, avoid losing possessions, and so forth. When people plan events, these background goals interact with the goal-derived categories that instantiate frame attributes. Specifically, background goals establish ideals in category representations, with these ideals being specific characteristics that exemplars should have to produce optimal goal achievement. For example, if conserving money is important to someone planning a vacation, this goal may establish an ideal of minimal cost for the goal-derived category of vacation lodgings. These ideals are essentially the same as those we considered earlier as determinants of prototype structure.

Once ideals become established in the representation of a goal-derived category, they guide the selection of exemplars during frame instantiation. Exemplars in a goal-derived category that approximate its ideals are optimal candidates for a plan. Exemplars far from these ideals are poor candidates. Similar to making typicality judgments, people prefer the exemplars of a goal-derived category to the extent that they approximate its ideals. People often optimize more than one ideal for a given category. For example, optimizing only cost for vacation lodgings might produce unpleasant and inappropriate accommodations. Instead, people often optimize multiple ideals, such as cost, facilities, and location.

For one set of protocols on vacation plans, we performed an extensive analysis of the optimizations that subjects mentioned. The 16 subjects in this study produced a total of 66 unique optimizations, with many optimizations being produced by more than one subject. Table V summarizes the optimizations that subjects produced and provides 10 specific examples. As can be seen, the 66 optimizations reflected four general types of goals that subjects were trying to optimize. Subjects frequently tried to optimize the achievements or gains of their actions, they frequently tried to preserve goals that they had already obtained, they frequently tried to conserve resources, and they frequently tried to optimize meta-planning. These four types of goals are essentially the union of those suggested by Schank and Abelson (1977) and Willensky (1983). Each example of an optimization in Table V specifies the type of goal being optimized, the goal-derived category being instantiated, and the specific optimization. For example, the first entry in Table V describes subjects who tried to achieve knowledge by selecting values of entertainment that maximized the ideal of educational value. Similarly, some subjects tried to preserve their achievements at work (i.e., an abandoned system) by selecting departures.
that minimized work disruption. Similarly, subjects sometimes tried to optimize their knowledge of vacation locations by planning to obtain as much knowledge about them as possible. As these examples illustrate, subjects considered a wide variety of optimizations instrumental to achieving a wide variety of goals. Much of the planning process centered around optimization, as subjects specified ideals for goal-derived categories and attempted to identify exemplars that approximated them.

2. Constraint

During frame instantiation, people frequently propagate constraints to ensure that the instantiations of different attributes are compatible. At most points in the planning process, planners have already determined instantiations of at least some frame attributes. When planners instantiate further attributes, they cannot ignore these prior instantiations. Imagine that earlier in planning, a planner decided that the instantiation of the activity attribute would be snow skiing. Further imagine that this planner is now trying to instantiate location. The planner can't select just any location, such as La Jolla, or the intended vacation might fail. Instead, the planner must select a location that is compatible with snow skiing.

TABLE V

<table>
<thead>
<tr>
<th>Type of goal</th>
<th>Goal-derived category</th>
<th>Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achievement</td>
<td>Entertainment</td>
<td>Maximize educational value</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>Location</td>
<td>Minimize crowdedness</td>
</tr>
<tr>
<td>Preservation</td>
<td>Abandoned system</td>
<td>Minimize work disruption</td>
</tr>
<tr>
<td></td>
<td>Departure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comfort</td>
<td>Optimize temperature</td>
</tr>
<tr>
<td></td>
<td>Vacation location</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Health</td>
<td>Maximize immunizations</td>
</tr>
<tr>
<td></td>
<td>Actors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal security</td>
<td>Maximize emergency phone numbers</td>
</tr>
<tr>
<td></td>
<td>Things to take</td>
<td></td>
</tr>
<tr>
<td>Resource</td>
<td>Money</td>
<td>Minimize cost</td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
<td>Minimize time to pack</td>
</tr>
<tr>
<td></td>
<td>Time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Things to take</td>
<td></td>
</tr>
<tr>
<td>Meta-planning</td>
<td>Knowledge</td>
<td>Maximize amount of knowledge</td>
</tr>
<tr>
<td></td>
<td>Vacation location</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adaptable</td>
<td>Maximize flexibility of schedule</td>
</tr>
<tr>
<td></td>
<td>Schedule</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preparations</td>
<td>Maximize timing of reservations</td>
</tr>
<tr>
<td></td>
<td>Lodging</td>
<td></td>
</tr>
</tbody>
</table>

For one set of protocols on vacation plans, we performed an extensive analysis of the constraints that subjects mentioned. The 16 subjects in this study produced a total of 78 unique constraints, with many constraints being produced by more than one subject. The six general relations that were sufficient to represent all 78 of the constraints were requires, disallows, enables, prevents, leaves, and co-occurs. Every constraint that subjects mentioned contained at least one of these relations and no others. The general relations are summarized below:

\[ a \text{ requires } b \]
\[ a \text{ disallows } \neg b \]
\[ a \text{ enables } b \]
\[ a \text{ prevents } b \]
\[ a \text{ leaves } \neg a \]
\[ a \leftrightarrow b \]

Figure 2 provides specific examples of constraints containing these relations. Note that the verbal descriptions of the constraints in Fig. 2 are not direct quotes from the protocols but instead are redescriptions that capture what the subject said plus the surrounding context. Consider the first example for requires. This subject stated that a requirement for one set of protocols on vacation plans, we performed an extensive analysis of the constraints that subjects mentioned. The 16 subjects in this study produced a total of 78 unique constraints, with many constraints being produced by more than one subject. The six general relations that were sufficient to represent all 78 of the constraints were requires, disallows, enables, prevents, leaves, and co-occurs. Every constraint that subjects mentioned contained at least one of these relations and no others. The general relations are summarized below:

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\[ a \leftrightarrow b \]
Requires
Possible companions must be able to take off from work at the time I can go.

\[ \text{time (departure (ex = my\_departure\_time)) -R-> actor (companion (work (vacation\_departure (ex = my\_departure\_time))))} \]

The amount of luggage I take depends on how I travel.

\[ \text{activity (travel (major (ex = X (max\_luggage = Y))) -R-> objects (things\_to\_take (amount \leq Y))} \]

Disallows
If my girlfriend goes with me (this requires romance with her), there can be no romances with strangers.

\[ \text{actor (self (goal = activity (entertainment (ex = romance (companion = girlfriend)))) & companion (ex = girlfriend)) -O-> activity (entertainment (ex = romance (companion = stranger))))} \]

If the vacation location is far (this requires long travel), I cannot drive.

\[ \text{location (vacation (ex = X (distance = far))) -D-> activity (travel (major (ex = car (rate = slow))))} \]

Enables
I can go on vacation when I have saved enough money.

\[ \text{expenses (source = self (time = X, savings = Y) \rightarrow expenses (total\_cost = Z)) -E-> time (departure (ex = X))} \]

Being at the vacation location will enable visiting friends who live there, assuming they're home.

\[ \text{time (schedule (loc = X, time = Y)) -E-> activity (entertainment (ex = visit (time = X, loc = Y, obj = friends (loc = X, time = Y))))} \]

Prevents
If I’m going to be flying, then I won’t have my car at the vacation location.

\[ \text{activity (travel (major (ex = fly))) -P-> activity (travel (at_loc (ex = my\_car)))} \]

If I’m only going to be there a short time, this makes renting a boat unfeasible.

\[ \text{time (duration (ex = X)) -P-> activity (entertainment (ex = rented\_boat (required duration = Y > X)))} \]

Leaves
Because I will be taking my car (this prevents distant vacation locations), I must go some place close to home.

\[ \text{activity (travel (major (ex = my\_car))) -L-> location (vacation (distance\_from\_home = close))} \]

Because I want to spend little money on accommodations (this prevents going at the peak season), I can only afford going in the off season.

\[ \text{location (vacation (accommodations (cost = low))) -L-> time (departure (ex = off\_season))} \]

Cooccurs
The amount of money I have available depends on the time of year.

\[ \text{expenses (source (ex = self (available\_money = X)) \rightarrow expenses (total\_cost = Z)) -C-> time (departure (ex = Y))} \]

The climate a person wants to escape to depends on their current climate.

\[ \text{actor (companion (ex = X like (obj = climate (ex = Y)))) \rightarrow actor (companion (ex = X (climate (ex = Z))}} \]

Fig. 2. Examples of constraints from subjects planning vacations. To verify attribute nestings, see the partial frame for vacation in Fig. 1. Note that verbal descriptions of the constraints are not direct quotes from the protocols. Instead they are redescriptions that capture the constraint directly and often incorporate surrounding context. In addition, these examples of primitive relations were sometimes extracted from constraint chains. Key: ex, exemplars; loc, location; obj, object.
Although many of the constraints that subjects mentioned only contained a single relation, many others were constraint chains, containing two or more relations. Of the 78 unique constraints that subjects mentioned, 17 were constraint chains of two relations, 3 were constraint chains of three relations, and 2 were constraint chains of four relations. On the surface, constraint chains often appear simple, stating only a single relation. For example, one subject noted that because he was going to the beach, he needed to take a swimsuit. But actually, he failed to state an intermediate step that is central to the pragmatic logic of this constraint: Going to the beach does not require taking a swimsuit. Instead, going to the beach enables going swimming, which in turn requires a swimsuit. Because people experience such patterns of constraint frequently, they streamline their knowledge about them. As a result, people quickly infer that taking a swimsuit is usually a good idea when going to the beach, without going through the intermediate step that concerns swimming. Figure 3 illustrates three of the more complex constraint chains in our data. Constraint chains reflect a mundane sort of domain-specific expertise about everyday events. As people become increasingly familiar with an activity, they compile repeated chains of constraints into simpler, more efficient rules (cf. Anderson, 1983).

D. Deriving Ad Hoc Categories

As we just saw, people use optimizations and constraints to select exemplars from goal-derived categories during frame instantiation. However, optimizations and constraints also play another important role in the planning process. Quite often, when people attempt to instantiate a particular attribute, they don't have any idea of the exemplars that could instantiate it. Planners don't know any exemplars for which optimizations and constraints could assist selection. Under these conditions, people often derive a conceptual description of the possible exemplars that could instantiate the attribute. In other words, they derive the description of an ad hoc category.

The protocol in Table IV provides an example of a subject deriving an ad hoc category in the absence of exemplars. Consider this subject's attempt to formulate his vacation location. At no point in this protocol does the subject ever specify particular exemplars that instantiate this attribute. But the subject does derive a description of this category. First, he notes that the vacation location must be affordable and within a few hours driving distance. Later he specifies that the vacation location must allow
cycling and be in a rural or mountainous park. Finally, he specifies that the vacation location must have fishing, must not be crowded with Winnebagos, and must enable backpacking. At this point the subject has derived the following ad hoc category:

vacation locations
that are affordable and within a few hours driving distance,
that are in an uncrowded rural or mountainous park with few Winnebagos,
that allow camping, backpacking, and fishing.

As this example illustrates, planners combine the attribute being instantiated with the optimizations and constraints that bear on it to derive an ad hoc category. The subject has the background goals of optimizing total cost (inexpensive), travel duration (short), and social isolation (high); and he establishes constraints for lodging (camping, backpacking) and entertainment (fishing). If the subject attempts to instantiate vacation location without taking these optimizations and constraints into account, his plan will probably not achieve his goals. For this reason, he combines the optimizations and constraints with the attribute and derives the description of an appropriate category.

Subjects frequently derive ad hoc categories in this manner while planning. Often subjects don’t know the possible instantiations of an attribute. Yet they do know the optimizations and constraints that bear on it. As an initial pass at instantiating the attribute, subjects combine it with relevant optimizations and constraints to derive a category description. This description serves subsequently to guide the search for exemplars that satisfy it and to select the best exemplar from those that do. Essentially, this description constitutes a prototype that produces prototype structure within the ad hoc category, as we saw in Section II. To the extent that exemplars approximate the description, they become increasingly typical and appropriate for the current plan. Table VI summarizes the process of deriving an ad hoc category.

The derivation of ad hoc categories from frames represents an extreme form of conceptual combination. People do not acquire these categories through exemplar learning because they do not know exemplars for them. Instead, people manipulate attributes, optimizations, and constraints in frames to derive novel conceptual combinations. It is unlikely that simple Boolean rules of intersection, union, and so forth account for step 5 of the derivation process in Table VI. Instead, the combination of attributes, optimizations, and constraints is likely to involve much background knowledge and proceed in complex manners. Frame modification, as discussed in Section III,F,3, appears to provide one workable account of this process (Barsalou, in press-a, Chaps. 7–9; Barsalou, in press-b; Murphy, 1988, 1990; Smith et al., 1988).

E. Fields of Goal-Derived Categories

Once exemplars of an ad hoc category are discovered, they are likely to become established in memory as a set. Consider the planner who produced the protocol in Table IV. If this subject pursued the planning process further, he would eventually identify specific exemplars of vacation locations that satisfy his optimizations and constraints. For example, this planner, who lived in Atlanta, might identify Smokey Mountains National Park, Joyce Kilmer Wilderness, and Blue Ridge Parkway as exemplars. As a result of the deep, elaborative, and extended processing that these exemplars receive, they are likely to develop representations in memory and become associated to the attribute for location in the vacation frame. Later, when attempting to plan another vacation, this subject might activate these exemplars when attempting to instantiate location again. Rather than having to derive an ad hoc category description and search for exemplars, the planner could instead examine previous exemplars and evaluate their appropriateness. To the extent that the current optimiza-

**TABLE VI**

<table>
<thead>
<tr>
<th>A General Procedure for Deriving an Ad Hoc Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Select a frame.</td>
</tr>
<tr>
<td>2. Select an attribute in a frame.</td>
</tr>
<tr>
<td>3. Identify optimizations that bear on the attribute</td>
</tr>
<tr>
<td>4. Identify constraints that bear on the attribute</td>
</tr>
<tr>
<td>5. Combine the attribute with the optimizations and constraints that bear on it to form a category description.</td>
</tr>
<tr>
<td>6. Search for exemplars that satisfy the category description.</td>
</tr>
<tr>
<td>7. Order exemplars according to how well they satisfy the category description, i.e., prototype structure.</td>
</tr>
<tr>
<td>8. Store information about the category.</td>
</tr>
</tbody>
</table>
tions and constraints are the same as before, this prestored category should be useful. As the planner continues to process vacation locations and its exemplars on future occasions, it will become increasingly established in memory. As a result, the category will lose its ad hoc status and become a well-established category that supports expert planning. Gentner (1989), Kolodner (1988), Ross (1989), and Schank (1982) address a variety of issues that bear on people’s use of previous plans to guide later planning by analogy.

### 1. Expert Planners

Imagine that a planner takes many vacations over the years that are of different types. In the process of planning this variety of vacations, she considers a disparate set of vacation locations. One possible account of her resulting representation for vacation locations is that all of the locations ever considered become associated with the location attribute in the vacation frame. As a result, this planner entertains the entire set of vacation locations every time she attempts to instantiate this attribute. Still more extremely, imagine that this planner eventually becomes an expert travel agent. From the process of planning several vacations a day for years, she develops an extensive set of exemplars associated with the location attribute in the vacation frame. To develop a vacation plan for a particular client, she might search through this set, attempting to find the most appropriate exemplars.

Simply associating exemplars with a frame attribute in this manner is actually an inefficient way to represent a goal-derived category. If this were how expert travel agents organized vacation locations, then every time they had to plan a vacation, they would have to search the entire category of vacation locations to find the appropriate exemplars for the current plan. One client might want to know about locations to snow ski in December, whereas another client might want to know about locations to snow ski in August. Similarly, another client might want to know about locations to sunbathe in December, whereas another might want to know about locations to sunbathe in August. In each case, the travel agent would have to search through the entire category of vacation locations to identify the relevant subset.

A much more efficient way for experts to organize their knowledge of vacation locations would be to form subcategories of locations that satisfy specific configurations of optimizations and constraints. If vacation locations were organized in this manner, then each request to plan a certain kind of vacation would access the relevant subset of vacation locations directly, assuming that the particular configuration of optimizations and constraints is familiar. For example, upon encountering a client who wanted to snow ski in August, a travel agent might immediately access a well-established, goal-derived category of locations to snow ski in August. Rather than having to derive an ad hoc category from vacation locations, the planner could access a well-established, goal-derived category directly, indexed by the current configuration of optimizations and constraints. Similarly, an expert might have well-established subcategories for locations to snow ski in December, locations to sunbathe in August, and locations to sunbathe in December. Once the attribute, optimizations, and constraints that define a subcategory are known, these cues converge directly on the relevant subset of vacation locations already established in memory. In a sense, this type of convergence is similar to constraint propagation in connectionist nets: Once part of a particular vacation pattern is known, the network fills in the rest of the pattern.

### 2. Frames as Specifying Fields of Goal-Derived Categories

We currently have no evidence that experts organize their goal-derived categories according to optimizations and constraints. But to the extent that this conjecture turns out to be true in future studies, the instantiations of a frame attribute would be organized as a conceptual field of goal-derived categories (Barsalou, in press-b). Specifically, optimizations and constraints serve as contrasts that provide the instantiations of a frame attribute with a field structure (Grandy, 1987; Kittay, 1987; Lehrer, 1974; Lyons, 1977; Miller & Johnson-Laird, 1976). In vacation locations, for example, optimizations of expensive and inexpensive contrast to form expensive vacation locations vs. inexpensive vacation locations. Similarly, the constraints of snow skiing and sunbathing contrast to form vacation locations for snow skiing vs. vacation locations for sun bathing. This is analogous to how the attributes of gender (male vs. female), age (child vs. adult), and species (e.g., human vs. equine) produce the well-known semantic field of animals (e.g., woman, boy, mare, colt). In each case, relatively orthogonal values on multiple attributes project a field structure onto a set of conceptually related entities.

Frames delimit the extent of these conceptual fields (Barsalou, in press-b). By specifying the possible contrasts within a field, a frame delimits the set of possible categories that can be derived within it. Consider the potential contrasts in the field for vacation locations in Fig. 4. As can be
seen, the activity attribute takes a variety of values, as does the departure attribute and the goal attribute of the actor. The values of these attributes, along with still other attributes not shown, specify the contrasts that can occur within the field for vacation locations. Values of goal contrast different subsets of vacation locations, such as locations that provide privacy vs. locations that provide aesthetic enjoyment. Similarly, values of activity and departure contrast other subsets, such as locations for fishing vs. locations for scuba diving. Each of these different location subsets constitutes a specific goal-derived category within the larger field.

The partial frame in Fig. 4 specifies a wide variety of possible goal-derived categories in the field for vacation locations. If only one value instantiates each attribute in a given plan, then combining all possible values across activity, departure, and goal produces 180 potential goal-derived categories (i.e., 6 activities × 6 departures × 5 goals). For example, one goal-derived category is locations for fishing at Spring Break that provide privacy. Another is locations for sunbathing on Memorial Day weekend that provide aesthetic enjoyment. By combining all possible constraints and optimizations in this manner, 180 such goal-derived categories result. If multiple values of an attribute can occur (or none at all), still more goal-derived categories are possible, including locations for fishing and hiking. Because Fig. 4 contains only four of the potential attributes for vacation as well as only a small subset of their potential values, 180 goal-derived categories greatly underestimates the number possible in the field for vacation locations. Because of the combinatorics involved, an indefinitely large number of goal-derived categories, well beyond the billions, is possible within this field. Most importantly, the frame for vacation—to the extent it can be fixed—specifies the space of possible categories. If the optimizations and constraints are known that bear on a field of goal-derived categories, they specify the categories within the field completely.

Clearly, not all possible combinations of optimizations and constraints are likely or even possible within a field (Barsalou, in press-b). For many combinations, the value of an attribute may not be optimal with respect to a background goal (e.g., wanting to save money and vacationing at the French Riviera). Similarly, many combinations of values do not satisfy constraints (e.g., snow skiing at La Jolla). In these ways, optimizations and constraints produce "conceptual gaps" in the field structure, namely, goal-derived categories that are unlikely to occur. Nevertheless, the number of feasible goal-derived categories is typically tremendous. Although we have only considered examples for the location attribute in the vacation frame, the same potential structure exists for any attribute in any frame.

3. Contextualization

As just noted, all possible optimizations and constraints specify all possible goal-derived categories within the field for a frame attribute. Conversely, a specific configuration of optimizations and constraints defines
one particular goal-derived category within a field. For a given plan, existing optimizations and constraints contextualize a frame attribute by converging on a single goal-derived category. The contextualization of a frame attribute is essentially the derivation of an ad hoc category, as summarized in Table VI. In this section, I illustrate how frame modification underlies this process.

Consider the contextualization of the location attribute in Fig. 5. As can be seen, the optimizations projecting from goal to location are privacy and aesthetic enjoyment. Similarly, the constraints projecting from activity and departure to location are snow skiing and July, respectively. As Fig. 5 illustrates, these optimizations and constraints modify the location frame by setting values for its attributes. For example, the attribute of hemisphere is likely to be southern, the terrain must be mountainous, the climate must be cold, and so forth. As this example illustrates, optimizations and constraints contextualize location by setting values for attributes in its frame. Once these settings exist, they guide the subsequent search for possible exemplars and provide criteria for preferring one exemplar over another (i.e., the category’s prototype structure).

If the optimizations and constraints in Fig. 5 were to change, they would contextualize the location frame differently. For example, if departure were December, the value for hemisphere might be northern, and exemplars of the category might be United States, Canada, and France. Similarly, if the activity were sunbathing and the departure were December, the values for most of the attributes in the location frame would be set differently, thereby producing another set of exemplars. As these examples illustrate, the current optimizations and constraints in a situation contextualize a frame attribute by modifying the attribute’s frame, which in turn specifies a compatible set of category members. As optimizations and constraints change, the contextualization of the frame attribute and its accompanying goal-derived category change as well.

Before leaving this topic, it is worth noting that common taxonomic categories often appear to be contextualized in much the same manner. The only people who regularly consider categories like clothing, fruit, and furniture in their abstract, decontextualized senses may be categorization researchers! Under more normal conditions, people may typically contextualize these categories. For example, people usually think about clothing with respect to particular contexts, such that optimizations and constraints bear on it. Clearly, the optimizations and constraints that bear on clothing in the context of taking a walk on a Maine beach are very different from those in the context of taking a business trip to Tucson. In each context, attributes in the frame for clothing take different values, and the resulting exemplars vary. Contextualization—not decontextualization—may be the norm for categories of all types. People may even contextualize categories in minimally specified, laboratory contexts, thereby producing category representations that vary widely between and within individuals (Barsalou & Billman, 1989; Barsalou & Medin, 1986).

IV. Roles of Common Taxonomic and Goal-Derived Categories in the Cognitive System

In this section, I examine further differences and relations between common taxonomic and goal-derived categories. First, I explore the roles of
common taxonomic and goal-derived categories in the time course of categorization. Whereas common taxonomic categories provide the primary categorizations of entities, goal-derived categories provide secondary categorizations. Second, I explore the relation between lexicalization and the time course of categorization. Because primary categories convey normative information that is relevant across contexts, lexemes develop for referring to this stable information. Because secondary categorizations convey goal-specific information that varies widely across contexts, too many lexemes would be needed to represent all possible categories. Instead, productive linguistic mechanisms generate complex phrasal constructions for goal-derived categories as needed. Finally, I propose a general framework for representing knowledge, in which common taxonomic categories compose world models, and goal-derived categories interface world models with event frames.

### A. Time Course of Categorization: Primary vs. Secondary Categorizations

Whereas a *primary categorization* is a person’s initial categorization of an entity, a *secondary categorization* is any subsequent categorization. For example, people might categorize something as a *chair* initially (the primary categorization) and later categorize it as *something to stand on to change a light bulb* (a secondary categorization).

People generally appear to use basic level categories and subordinate categories—two types of common taxonomic categories—for initial categorizations (Joliceur, Gluck, & Kosslyn, 1984; Murphy & Smith, 1982; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Tversky and Hemenway (1985) and Biederman (1987) suggest that this preference for basic level categories results from the diagnosticity of *shape* as a category cue, where shape refers more specifically to an entity’s spatial configuration of physical parts. Because most members of a basic level category share a common shape, and because this shape does not occur in other categories, it provides a highly diagnostic cue for the category (Rosch, Mervis et al., 1976). Consider *chairs*. Because the shape of the average chair occurs for most chairs, and because this shape generally does not occur for other categories, an entity’s possession of this shape strongly predicts that it is a chair. In contrast, shape is not a diagnostic cue for superordinate categories, because no shape is common to all category members (e.g., *animals*). Nor is shape a diagnostic cue for most subordinate categories, because different subordinate categories share the same global shape (e.g., *poodle, collie*).

The visual system’s rapid analysis of shape information contributes further to the use of basic level categories as primary categorizations. Because the visual system extracts the low spatial frequency information for global shape faster than the high spatial frequency information for detailed stimulus properties, categories defined by shape are often the first to become available. In contrast, the information that specifies other categories is extracted more slowly, such that these categories are less likely to become available initially. For example, people categorize most kinds of birds initially as *bird*—not as *animal, robin, falcon, cardinal, blue jay*, etc.—because the shape information extracted from these entities accesses *bird* more rapidly than any other category. Because shape information is diagnostic for basic level categories, and because it becomes available so rapidly, these categories are more likely to be primary than other categories.

Interestingly, when an entity does not share the shape of its fellow exemplars in a basic level category, its subordinate category provides the primary categorization (Biederman, 1987; Joliceur et al., 1984; Murphy & Brownell, 1985). For example, people do not categorize chickens as *bird* initially because chickens do not share the common shape for *bird*. Instead, the shape of chickens is diagnostic for *chicken*, such that *chicken* is the primary categorization. Because shape is such a potent cue in initial categorization, categories for which shape is a diagnostic property provide primary categorizations. In other domains, such as audition, primary categorizations are likely to reflect whatever diagnostic information is extracted initially.\(^{10}\)

In contrast, goal-derived categories generally appear to provide secondary categorizations. Once people categorize an entity with a basic level or subordinate category, they may categorize it subsequently in ways that are relevant to current goals. For example, someone might first categorize an entity as a *chair* but then categorize it subsequently into *things that can be stood on to change a light bulb*.

Goal-derived categories are not the only source of secondary categorizations. Many taxonomic superordinates, such as *furniture, animal,* and *clothing,* appear to provide secondary categorizations as well. First, some superordinates organize collections of basic level and subordinate entities in a particular context (Markman, 1979, 1989). For example, *furniture* might provide a secondary categorization for a collection of entities in a

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\(^{10}\) This account differs from the view of Rosch, Mervis et al. (1976), who argued that informativeness determines the basic level. Barsalou and Billman (1989, pp. 175–179) suggest that there may be multiple basic levels that operate in different task contexts. Specifically, a perceptual basic level may rely heavily on shape to produce primary categorizations during perception; whereas an informational basic level may provide secondary categorizations that carry optimal information during reasoning and communication.
particular room, including some chairs, a table, and a sofa. Similarly, \textit{tools} might provide a secondary categorization for a collection of entities in a particular closet. Second, natural kind superordinates often integrate lower level categories that share a common intuitive theory (Barsalou \\
& Billman, 1989, pp. 190–192). For example, \textit{animal} is associated with an intuitive causal theory about certain categories of living things, specifying information about genes, birth, and so forth. Similarly, \textit{fruit} represents an intuitive theory about other categories of living things, specifying information about plant growth and reproduction. These superordinates may provide secondary categorizations when achieving a goal requires understanding the underlying physical principles of a natural kind entity. Third, artifact superordinates often constitute goal-derived categories, containing instantiations of an attribute in an event frame (Barsalou \\
& Billman, 1989, pp. 190–192). For example, \textit{clothing} contains values of the \textit{object} attribute in the frame for \textit{wear}. Similarly, \textit{tool} contains values of the \textit{instrument} attribute in the frame for \textit{make}. As these examples illustrate, superordinates play a variety of roles as secondary categorizations.

It is unlikely that people use goal-derived categories or superordinates without having made a basic or subordinate level categorization first. For example, it is unlikely that people would categorize a chair directly into things that can be \textit{stood on} \textit{to change a light bulb} without categorizing it first as a \textit{chair}. Because the shape information that specifies \textit{chair} is probably available before the information that specifies \textit{things that can be \textit{stood on} \textit{to change a light bulb}}, it is likely that \textit{chair} is the initial categorization. Even though primary categorizations may be irrelevant in goal contexts, the automatic application of basic and subordinate categories may be obligatory, given the consistent mappings of these categories and their associated shapes over extended experience (Schneider \\
& Shiffrin, 1977; Shiffrin \\
& Schiffrin, 1977). Moreover, primary categories may remain active as secondary categorizations are made, because they carry important information. For example, remembering an entity simply as \textit{something to \textit{stand on} \textit{to change a light bulb}} loses important information about its other properties. Remembering it as a \textit{chair} carries important information that may be useful for achieving later goals.

As I have noted, the early availability of shape information constitutes one important reason why basic and subordinate level categories provide primary categorizations. A second reason is that these categories typically convey correlated patterns of physical properties that are informative across a wide range of contexts (Billman \\
& Heit, 1988; Rosch, Mervis et al., 1976). In contrast, goal-derived categories typically do not carry as much information about physical structure (Barsalou, 1983, 1985). To see this difference, imagine that a speaker says her garage contains a \textit{chair}.

The listener can draw a wide variety of inferences about the entity's physical structure from the correlated properties that typically occur for \textit{chair}. For example, the referent of \textit{chair} is likely to have \textit{legs}, a \textit{seat}, and a \textit{back} of certain sizes and in a particular configuration. Knowing these physical properties of the referent is relevant in a wide variety of contexts because these properties support a wide variety of goals (e.g., the entity has a flat horizontal surface that could support a can of paint; the entity has a flat vertical surface to which a paper sign could be attached; the entity has four supports that could penetrate through a coarse grate in the floor).

On the other hand, imagine that the speaker says her garage contains \textit{something to \textit{stand on} \textit{to change a light bulb}}. The listener can draw many fewer inferences about the entity from this categorization than from \textit{chair}. This categorization only tells the listener that the entity is capable of supporting heavy weight at a certain height. Only physical properties relevant to the goal that the category serves are inferable. Much additional physical information about the parts of the entity and their configuration is not. Some inferences are possible, such as the entity being heavy enough to hold down a tarp. But because the categorization is so specific to the goal, drawing inferences beyond this context is limited.

A third reason that common taxonomic categories may be primary is that they convey information about standard functions (Rosch, Mervis et al., 1976). If a speaker says that she received a \textit{chair} for her birthday, the listener can infer that the speaker will use it typically for sitting. Not only does \textit{chair} convey information about correlated physical properties, it also conveys related information about the entity's standard function and the actions that people perform to achieve it. From knowing that the entity is a \textit{chair}, the listener can infer what its standard function will be on many future occasions. The ideals associated with common taxonomic categories may often be associated with these standard functions (e.g., comfortable for \textit{chair}).

Conversely, goal-derived categories do not typically specify the standard functions of their exemplars. If the speaker says that she received \textit{something to \textit{stand on} \textit{to change a light bulb}} for her birthday, it is not safe for the listener to infer that this function will be the primary use of the entity. Instead, the entity is likely to have some more typical function that the listener cannot ascertain. From knowing this categorization, the listener has very limited knowledge of the entity's function.

The correlated physical properties of a category, along with its standard function, constitute central tendency information because they are the properties most likely to occur across exemplars. As we saw in Section II.D, central tendency information dominates the prototype structure of common taxonomic categories but plays no role in the prototype structure
of goal-derived categories. Central tendency information may be central for common taxonomic categories because it enables them to provide maximal information about an entity following a primary categorization. Once the entity disappears from view, central tendency information associated with the primary categorization provides the best possible guess of what the entity’s properties were. Any other information associated with the primary categorization would provide less accurate information on the average, by definition. Because common taxonomic categories provide the primary categorizations of entities, it is not surprising that central tendency represents them. By simply storing the basic or subordinate category of a perceived entity, and later retrieving the central tendency information for this category, a perceiver can retain maximal information about the entity without storing a detailed perceptual record of it or after forgetting it.

In contrast, central tendency should not be as important for secondary categorizations. Because secondary categorizations serve to categorize an entity with respect to particular goals, they do not need to convey central tendency information about their members. Instead, these categories must convey ideals that are relevant for achieving their associated goals. Whereas primary categorizations store normative information for an entity, secondary categorizations add information relevant to goals in particular contexts.

B. Lexicalization and the Time Course of Categorization

Typically, people refer to common taxonomic categories with lexemes, namely, a word or a short phrase that constitutes a conventional unit of vocabulary. For example, cat, blue jay, kitten, and tom cat are lexemes that refer to common taxonomic categories. In contrast, people typically refer to goal-derived categories with complex phrasal expressions, such as expensive vacations that are relaxing and inexpensive vacations to go hiking. As we saw in Section III,E, the linguistic mechanisms that produce these expressions are highly productive and contrastive, being capable of expressing tremendous numbers of goal-derived categories within a field.

In the remainder of this section, I examine reasons for this difference between common taxonomic and goal-derived categories. As we shall see, this difference is closely related to the time course of categorization.

Before proceeding further, it is important to note that not all taxonomic categories are lexicalized and that some goal-derived categories are. As much work has illustrated, common taxonomic categories typically exhibit a field structure (Grandy, 1987; Kittay, 1987; Lehrer, 1974; Lyons, 1977; Miller & Johnson-Laird, 1976). Sometimes this field structure takes a matrix form, when various attributes are orthogonal to one another. For example, the orthogonal attributes of gender, age, and species provide a matrix structure in animals. Sometimes a field’s structure takes a more hierarchical form, exhibiting superordinate, basic, and subordinate levels (Rosch, Mervis et al., 1976). For example, fruit descends into apple, orange, melon, and so forth, each of which may descend further (e.g., apple descends into Granny Smith, Macintosh, etc.). Within these field structures, lexical gaps exist at various intersections of attribute values.

For example, the lack of lexemes for neutered male cat and adult male robin constitute lexical gaps in the field for animal. When taxonomic categories are rarely relevant to human activity, lexemes do not develop for them, and people must refer to them with complex phrasal constructions.

Conversely, some goal-derived categories are lexicalized, such as buyer, payment, donor, and gift. Each of these lexicalized goal-derived categories contains the instantiations of a frame attribute. Consider payment. This category contains instantiations of the instrument attribute in the frame for buy, including cash, credit card, and loan. Consider gifts. This category contains instantiations of the object attribute in the frame for give, including flowers, clothing, and jewelry. Certain goal-derived categories probably become lexicalized because they contain instantiations of frame attributes frequently relevant to human activity and communication.

Lexicalized goal-derived categories vary in the extent to which they are contextualized. Gifts is a contextualized form of the object attribute in the give frame because it does not contain all possible instantiations of the object attribute. When the agent of give is police officer, a parking ticket as the object is certainly not a gift. Instead, gift is a contextualized version of object, derived from optimizations and constraints in the give frame. When gift specifies the object of the give frame, the value of time is often special occasion, the value of goal is provide unexpected pleasure to the recipient, and so forth. In contrast, payment is a noncontextualized form of the instrument attribute in the buy frame. Any possible instrument for buy would also be a payment.

A surprising number of lexemes refer to goal-derived categories. One heuristic for generating these lexemes is as follows: Select a common verb and consider each of its central attributes, such as agent, object, instrument, location, time, and so forth. For each such attribute, search for a lexeme that refers to all of its instantiations or to a contextualized subset. Consider eat. Food is the object, utensil is the instrument, and diner is the actor contextualized by the constraint of restaurant for location. Consider farm. Farmer is the agent, and crop is the object. Consider wear. Clothing is a contextualized form of object, and model is a contextualized form of agent.
Even though some common taxonomic categories are not lexicalized and some goal-derived categories are, lexicalization appears closely related to the time course of categorization. Typically, lexicalized categories provide primary categorizations, whereas nonlexicalized categories provide secondary categorizations. For example, people might initially categorize an entity as a chair (lexeme) and later as something that can be stood on to change a light bulb (complex phrasal construction). Similarly, someone might initially categorize an entity as celery and later as food to eat on a diet. As we just saw, lexicalized goal-derived categories sometimes provide secondary categorizations, such as categorizing something initially as a sweater and then as a gift. But in general, lexicalized categories seem much more likely to provide primary categorizations.

The normativeness of primary categorizations vs. the goal-relevance of secondary categorizations may underlie this relation between lexicalization and the time course of categorization. Because the same primary category is used across a wide range of goal contexts, a single lexeme can convey its central tendency information in each. Even though chairs may occur in many goal contexts, such as changing light bulbs and holding doors open, the lexeme for chair conveys the same central tendency information across all of them. Because the purpose of primary categorizations is to provide the same central tendency information in all situations, a single lexeme can develop to convey this information.

In contrast, secondary categorizations of the same entity vary widely with context, such that no single linguistic expression can convey all of them. Instead, a different linguistic expression is necessary for each. To the extent that a particular secondary categorization occurs frequently, it may develop a lexeme (e.g., gift). But because most secondary categorizations only occur occasionally, their lexicalization would be inefficient. Too many lexemes would develop. Instead, it makes much more sense to allow the productive mechanisms of a language to express these categorizations in complex phrasal constructions. Although more cumbersome expressions result, people do not have to learn thousands of lexemes that they would use rarely.

In addition, it is necessary to have productive linguistic abilities that can express ad hoc categories the first time they become relevant. People could not refer to such categories with lexemes the first time they derive them because such lexemes would be unknown to listeners. For example, if someone referred to a newly constructed ad hoc category as daxes, it would be impossible to determine that it refers to gifts for my granddaughter’s birthday party. Instead, the complex phrasal construction gifts for my granddaughter’s birthday party is necessary. Conceivably, a culture could attempt to lexicalize this category. But doing so would be predicated on the belief that this category is important sufficiently often as a secondary categorization to warrant a lexical entry in the language. Most importantly, such lexicalization would typically occur after the use of a more complex, phrasal construction beforehand, when the category was derived initially. Even though some secondary categorizations become lexicalized, a language must still have productive mechanisms for expressing new categories.

C. GOAL-DERIVED CATEGORIES AS THE INTERFACE BETWEEN EVENT FRAMES AND WORLD MODELS

In this final section, I propose a framework for knowledge that integrates findings from the previous sections. According to this framework, common taxonomic and goal-derived categories play different but complementary roles in the cognitive system. Whereas common taxonomic categories provide building blocks for world models, goal-derived categories provide interfaces between world models and event frames for achieving goals.

I define world model as a person’s knowledge of locations in the environment, together with knowledge of the entities and activities that exist currently in these locations. A world model begins with a person’s knowledge of his or her current location and of the entities and activities present. For example, someone’s world model might represent that she is currently in her garage at home, between her car and the work bench, with a stack of boxes on the floor in front of her, and a dog sleeping behind her. A world model contains further knowledge about the current existence of locations, entities, and activities that are not immediately present. If people are at home, they know about locations, entities, and activities at work. If people are at work, they know about locations, entities, and activities in their home. Not only do world models contain information idiosyncratic to a particular individual, they also contain much culturally shared information, such as knowledge about neighborhoods, schools, parks, and rivers. In general, people have a tremendous amount of knowledge about the current state of the world, both immediately and more distantly.

By world model I do not mean general knowledge about the kinds of things in the world. For example, I do not mean people’s general knowledge about garages, cars, dogs, schools, parks, and so forth. Instead, I mean specific knowledge and beliefs about the current state of the world. An extensive system of spatial frames for locations underlies a world model. As Minsky (1977) suggests, people have extensive systems for representing positions in space, which contain the specific entities and activities whose current positions are known. As entities and activities move about in the world, people move representations of them to new
positions in their world models. Other transformations occur in world models as well, such as changes in the state of an entity (e.g., a car becomes broken, a roof develops a leak). To the extent that people are aware of changes in the world, their world model changes correspondingly. Researchers in artificial intelligence have often worried about world models in the context of the frame problem, truth maintenance systems, and nonmonotonic logics: Once a given change occurs in a data base, to what extent do other changes take place in the data base as well (e.g., Brown, 1987; Hayes, 1985; McCarthy & Hayes, 1969)? Little if any study has addressed the nature of world models in cognitive psychology. However, increasing work addresses the much more specific notion of situation models and their important roles in various tasks (e.g., Greeno, 1989; Johnson-Laird, 1983; Morrow, Bower, & Greenspan, 1989; van Dijk & Kintsch, 1983).

World models also provide natural representations of the past and the future. On this view, the system of spatial frames that organizes a world model also organizes long-term memory. To represent past events, previous states in a world model remain associated with the locations of their occurrence. To represent future events, envisioned states in a world model are similarly associated with their predicted locations. As the representation of an event unfolds over time within a world model, representations of its successive states become associated with the locations containing them. Not only do world models represent the present, they also represent the past and the future.

I propose that common taxonomic categories constitute the building blocks of world models. Upon perceiving an entity or activity in the environment, people categorize it with a basic level or subordinate category, storing this categorization at the position of the entity in their spatial reference system. For example, when people represent where things are in their homes, they represent the locations of particular chairs, skirts, cups, apples, cats, and so forth. People may generally use common taxonomic categories to construct world models because these categories describe entities independent of idiosyncratic goals. People often do not know what particular goals will become relevant to the entities that they encounter in the environment. They may therefore try to capture as much "objective" information as possible in primary categorizations to support a wide variety of idiosyncratic goals later.

Because common taxonomic categories maintain central tendency information about physical structure (Section IV, A), using them to build world models captures information about entities that is useful for achieving unanticipated goals. Imagine that a person's world model contains a desk at a location in an office building. Central tendency information about the physical structure of desks allows using this particular desk in a wide variety of unexpected ways. For example, if a person needs to blockade a door, he might consider this desk as a possible blockade because it is likely to have the size, weight, and mobility typical of desks. On another occasion, if this person needs to hide a birthday gift for a coworker, he might consider this desk as a possible hiding place because it is likely to have the drawers typically found in a desk. By building world models with common taxonomic categories, people establish central tendency information that supports achieving unanticipated goals as they arise.

Event frames complement world models, integrating the information that people must have to achieve familiar goals. When people want to buy groceries, their frame for buy must specify the relevant attributes that need to be instantiated. People must find a location that sells groceries, they must select a time to go shopping, they must have some form of payment, they must have a means of traveling to the grocery store, and so forth. As we saw earlier, knowledge about the attributes relevant to achieving goals resides in event frames. For each goal, an event frame specifies the particular attributes that must be instantiated to ensure successful goal achievement. Without knowledge of these attributes, planners would not know how to begin achieving the goal. Knowledge about optimizations and constraints in frames is also essential for successful goal achievement.

Successful goal achievement further requires a satisfactory interface between an event frame and a world model. If people cannot map the attributes in an event frame into their world models, they cannot achieve the respective goal. For example, if people need to buy groceries, the buy frame specifies that they must consider location, payment, temporal parameters, and so forth. But to actually achieve the goal, people must be able map these frame attributes into a world model. For example, people must be able to map the location attribute into particular locations in their world model that sell groceries. People must be able to map the payment attribute into the types of payment that they possess and that are acceptable at grocery stores. Knowing an event frame and having a world model is not enough. Instead, successful goal achievement requires an interface between these two systems of knowledge.

Mapping different event frames into the same world model defines different partitions on entities in the world model. Consider all of the geographic locations in a world model. Each event frame maps its location attribute into a different partition of geographic locations. To instantiate the location attribute in the vacation frame, people must partition geographic locations in their world model into vacation locations and non-vacation locations. In contrast, to instantiate the location attribute in the buy frame, when groceries is the value of merchandise, people must
partition geographic locations quite differently. Vacation locations and locations for buying groceries constitute very different partitions on geographic locations in a world model. Similarly, as the value of merchandise in the buy frame varies from groceries, to clothing, to cars, the relevant partition of geographic locations continues to change.

Other frame attributes besides location must similarly map into world models for goals to succeed. Object attributes in frames must map into appropriate objects in world models, as must agent attributes, instrument attributes, time attributes, and so forth. Moreover, the partitions that these attributes produce on a world model change from frame to frame and from context to context. For example, the object attribute in the frame for eat produces a very different partition of objects in a world model than the object attribute in the frame for wear (i.e., food vs. clothing). Similarly, the object attribute for eat produces different partitions on objects as the agent of eat varies (e.g., lions vs. birds).

Essentially, each of these partitions constitutes a goal-derived category. For each attribute in each event frame, a goal-derived category contains the entities in the world model that can instantiate it. As people become familiar with achieving a particular type of goal, partitions on world models become increasingly established in memory. For example, when groceries instantiates merchandise in the buy frame, most people can immediately access a relevant partition on locations in their world model. Because people frequently process the location attribute in conjunction with particular grocery stores, the mapping between them becomes well established in memory as a goal-derived category. Similarly, when planning to see a movie, many people can immediately access a different partition on locations in their world model. As people become increasingly familiar with an activity, they develop direct mappings from frame attributes into world models, enabling the rapid retrieval of satisfactory instantiations. Without such interfaces between event frames and world models, goal pursuit would often be difficult, unsuccessful, and nonoptimal when successful. With such interfaces, people can quickly discover the parts of their world model relevant to a current goal. They do not need to perform the time- and resource-consuming operations that compute these mappings. Nor do they run the risk of miscalculating them.

As we saw earlier, expertise in planning develops as these mappings become sensitive to particular configurations of optimizations and constraints. Experts may often be able to use the optimizations and constraints in a situation to specify highly specialized partitions in their world model. In contrast, novices may often have trouble using optimizations and constraints to specify partitions. Instead, novices may use rigid partitions across contexts that ignore the full set of optimizations and constraints in a given context. Consequently, expertise at performing an activity may reflect a wide variety of mappings from frame attributes into a world model, each indexed by a different configuration of optimizations and constraints.

To the extent that this account is correct, common taxonomic and goal-derived categories play fundamentally different but complementary roles in the cognitive system. In perceiving the world and storing information about it, people use common taxonomic categories for primary categorizations, as they build and update their world models. These categories form the building blocks of world models because they specify central tendency information about entities that is useful across many contexts. Following primary categorizations, people use goal-derived categories for secondary categorizations that specify the relevance of entities to particular goals. By linking entities in a world model to attributes in event frames, people store information that will later facilitate their ability to construct plans. Because common taxonomic and goal-derived categories play these very different roles in the cognitive system, the information that develops to represent them adapts to these functions. Central tendency information becomes established for common taxonomic categories to optimize the applicability of information in world models, whereas ideals become established for goal-derived categories to support frame instantiation during goal achievement. Similarly, ideals become established for common taxonomic categories to support the optimization of their standard functions, and frequency of instantiation becomes established for goal-derived categories to provide base rates about the previous use of particular exemplars for achieving goals. As this analysis of common taxonomic and goal-derived categories illustrates, understanding the nature of categories depends on understanding their roles in the overall activity of the cognitive system.

V. Conclusion

Much work on categorization focuses on the issue of access: Given a featural description of an entity, how does an intelligent system access a correct category in memory? Prototype models, exemplar models, and connectionist models are all attempts to address this issue. Certainly, the issue of access is important and challenging, and solving it will have significant implications for both theoretical and applied research.

Yet much of the work on access fails to consider why access is important (Barsalou, 1990a). Why would an intelligent system want to know the category of an unfamiliar entity? Sometimes models of categorization
seem to view categorization as an end in itself. Yet clearly, the purpose of categorization is not to know an entity’s category. Instead, the purpose of categorization is to identify information in memory that provides useful inferences. Upon accessing a category for an entity, a tremendous amount of knowledge becomes available that is useful in a variety of ways. This knowledge may specify the origins of the entity, its physical structure, its probable behavior, its implications for the perceiver’s goals, or actions for interacting with it successfully. Accessing a category is not an end in itself but is instead the gateway to knowledge for understanding an entity and interacting with it appropriately.

I have focused on the roles that categories play in the cognitive system following their access. For example, I have proposed that goal-derived categories provide sets of instantiations for frame attributes during planning and that common taxonomic categories constitute the building blocks of world models. Much of the evidence I present is not as rigorous as experimental psychologists prefer, and some of my proposals do not rest on any sort of systematic data collection. Moreover, the framework I present is far from being a fully developed formal or computational theory. Nevertheless, one should not be afraid to ask new questions for fear of being unable to utilize methodological tools of the utmost technical sophistication. Otherwise, the science of categorization has little hope for initiating progress on numerous daunting issues that dwarf those we understand currently. To make significant progress, it will be necessary to explore important issues for which meticulous answers do not exist initially but exist eventually.

ACKNOWLEDGMENTS

Work on this chapter was supported by National Science Foundation Grant IRI-8609187 and Army Research Institute Contract MDA903-90-K-0112. I am grateful to Gordon Bower for the opportunity to write this article and am deeply indebted to him for his contributions to my career. I am also grateful to Boaz Keysar, Barbara Malt, Robert McCauley, Douglas Medin, Gregory Murphy, and Brian Ross for helpful comments and discussion regarding this chapter.

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