Concepts and conceptual development: Ecological and intellectual factors in categorization

Edited by

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The instability of graded structure: implications for the nature of concepts

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After a brief introduction to graded structure, this chapter reviews empirical findings showing that the graded structure of a category is unstable, varying widely across contexts. Implications of these findings for theories of categorization are discussed, and it is concluded that graded structures do not represent invariant structural characteristics of categories. Instead it is proposed that instability in graded structure occurs because different concepts temporarily represent the same category in working memory on different occasions. Rather than being retrieved as static units from memory to represent categories, concepts originate in a highly flexible process that retrieves generic and episodic information from long-term memory to construct temporary concepts in working memory. Because this concept construction process is highly constrained by goals, context, and recent experience, the same concept is rarely if ever constructed for a category. A theory of concept construction is presented, and the relations of this theory to dreaming (Foulkes 1985), conceptual combination (Hampton in press a,b; Smith & Osherson 1984), exemplar theories (Brooks 1978; Jacoby & Brooks 1984; Medin & Schaeffer 1978), norm theory (Kahneman & Miller, 1986), and parallel distributed processing (McClelland & Rumelhart 1986; Rumelhart & McClelland, 1986) are discussed.

Definition of graded structure

A central theme in categorization research for the last decade has been that categories possess graded structure. Instead of being equivalent, the members of a category vary in how good an example (or in how typical) they are of their category (Rips, Shoben, & Smith 1973; Rosch 1973). In the category of *birds*, for example, American college students generally agree that *robin* is very typical, *pigeon* is moderately typical, and *ostrich* is atypical. In addition, nonmembers of a category vary in how good a nonmember they are of the category (Barsalou 1983). With respect to *birds, chair* is a better nonmember than is *butterfly*. Typicality for nonmembers is analogous to the relatedness effect for nonmembers that has been well-documented in the category verification literature (Smith 1978).

Graded structure refers to this continuum of category representativeness, beginning with the most typical members of a category and continuing through its atypical members to those nonmembers least similar to category members. Although the focus of this chapter will be on graded structure within categories, much of what will be said may also apply to graded structure outside categories.

It should be noted that "graded structure" in this section and the following section does *not* refer to cognitive structure. Instead it simply refers to behavior, that is, to how people order exemplars in categories according to typicality. In this sense, the graded structure for *birds* is simply the rank ordering of *birds* from most to least typical and does not carry any representational assumptions. Various interpretations of these orderings will be considered later in this chapter.

Generality of graded structure

Because every category observed so far has been found to have graded structure, it appears that graded structure is a universal property of categories. Seminal work by Rosch, Smith, and their colleagues found that common taxonomic categories such as *fruit* and *furniture* all have graded structure (e.g., Rips et al. 1973; Rosch 1973, 1975, 1978; Rosch & Mervis 1975; Smith, Shoben, & Rips 1974). Subsequent studies have found graded structure in a wide range of category types. Armstrong, Gleitman, and Gleitman (1983) found graded structure in formal categories such as *odd numbers* and *squares*. Lakoff (1986) reviews evidence for there being graded structure in linguistic categories for phones, phonemes, and syntactic categories. Barsalou (1985) found graded structure in categories people construct to serve goals, what will be referred to as *goal-derived categories* (e.g., *things to eat on a diet, things to pack in a suitcase*). Barsalou (1983) found graded structure in categories people have rarely if ever thought of, what will be referred to as *ad hoc categories* (e.g., *ways to escape being killed by the Mafia, things that could fall on your head*). Ad hoc categories are goal-derived categories that are not well-established in memory but are instead created to achieve a novel goal.

Importance of graded structure

Besides appearing to be universally true of categories, graded structure appears to be the most important variable in predicting performance on a wide range of categorization tasks. Graded structure is central to predicting how long it takes someone to classify something as a category member, with typical exemplars being identified faster than atypical exemplars (e.g., McCloskey & Glucksberg 1979; Smith 1978). Graded structure is central to predicting the frequency with which people generate members of categories, with typical exemplars being generated more often than atypical exemplars (e.g., Barsalou 1983, 1985; Barsalou & Sewell 1985; Mervis, Catlin, & Rosch 1976). Graded structure is central to predicting ease of category learning, with typical exemplars being easier to acquire than atypical exemplars (e.g., Mervis & Pani 1980; Rosch, Simpson, & Miller 1976). In addition, graded structure is central to how people make decisions, with the typicality of exemplars often having substantial effects on decision making (Cherniak 1984; Rips 1975; Rosch 1983). Mervis and Rosch (1981), Medin and Smith (1984), and Smith and Medin (1981) further review the roles of graded structure in categorization tasks.

Preview

Given the ubiquity and predictive power of graded structure, it is important to identify its basic empirical properties and to understand its origins in the human cognitive system. The next section reviews research aimed at identifying basic empirical properties of graded structure. The remaining sections explore implications of these properties for cognitive interpretations of graded structure and for how the cognitive system produces concepts.

Before proceeding, however, it is first necessary to discuss common taxonomic and goal-derived categories in a little more detail, since they will be referred to frequently. Examples of common taxonomic categories are *birds, fruit, furniture,* and *vehicles*. Examples of goal-derived categories are *things to eat on a diet, places to vacation, birthday presents,* and *things to pack in a suitcase.* Although it has not been possible so far to define these two category types – and it may not ever be possible – each appears to have characteristic properties. First, common taxonomic categories are usually highly familiar biological and artifactual categories that are culturally transmitted, whereas goal-derived categories generally appear to be less familiar and to be less central to cultural knowledge. Second, common taxonomic categories generally reflect the correlational structure of the environment such that they form salient groups of entities (Rosch & Mervis 1975), whereas goal-derived categories generally form much less salient groups of entities because they do not reflect correlational structure (Barsalou, 1983, 1985). Third, common taxonomic categories often serve the purpose of representing kinds of things in the environment, whereas goal-derived categories often serve people's goals. Fourth, common taxonomic categories (especially basic-level categories) are often used for classifying entities in the environment, whereas goal-derived categories are often used for instantiating schema variables during planning. Further discussion of the differences between common taxonomic and goal-derived categories can be found in Barsalou (1983, 1985; Barsalou, Usher, & Sewell 1985).

The instability of graded structure

The empirical properties of graded structure to be discussed in this section can be viewed in two ways: Pessimistically, they can be viewed as showing that graded structure is unreliable and meaningless. Optimistically, they can be viewed as showing that graded structure is highly flexible, with this flexibility being a fundamental property of the human cognitive system.

Determinants of graded structure

As discussed earlier, graded structure appears to be a universal property of categories. Yet what determines whether exemplars are typical or atypical? Assuming that exemplars usually differ from each other in many ways (e.g., *familiarity, value, size, shape*), and assuming that people use one or more of these differences to order exemplars by typicality, which particular difference or differences do they use? For example, people could use differences between exemplars in familiarity such that exemplars become more typical as they become more familiar.

It appears that people use a variety of differences between exemplars when judging typicality. Instead of there being any single determinant or invariant set of determinants responsible for typicality, there appears to be a large class of determinants that is impossible to specify completely and that depends to some extent on the category and on the context in which it is perceived.

One factor that has been shown to play an important role in determining typicality is a category's *central tendency*, namely, information that is prototypical or representative of a category's members. Central tendency information can be construed as modal or average properties abstracted from exemplars, as one very representative exemplar, as several very representative exemplars, as modal correlations of properties, or as various other forms (see Smith & Medin 1981). It turns out that most major accounts of graded structure have proposed that an exemplar's similarity to the central tendency of its category determines its typicality. Smith et al. (1974) argued that exemplars are typical to the extent they

possess the characteristic properties of their categories. Hampton (1979) made a similar proposal. Rosch and Mervis (1975), Rosch et al. (1976), and A. Tversky (1977) argued that an exemplar's family resemblance determines its typicality, where "family resemblance" is a particular form of similarity to central tendency.[1]

While there appears to be widespread acceptance that similarity to central tendency is responsible for graded structure, its importance appears to have been overestimated. As found by Hampton (1981), similarity to central tendency does not predict graded structure in some abstract categories. As found by Barsalou (1985), similarity to central tendency does not predict graded structure in goal-derived categories. Similarity to central tendency by no means determines the graded structure of every category.

A second factor that determines an exemplar's typicality is how similar it is to ideals associated with its category, where ideals are properties that exemplars should have if they are to best serve goals associated with their category. For example, *zero calories* is an ideal associated with *foods to eat on a diet*, since exemplars with decreasing numbers of calories are increasingly conducive to the goal of *losing weight*. As found by Barsalou (1985), exemplars of both common taxonomic and goal-derived categories become increasingly typical as they approximate *ideals* associated with their category.

A third factor that determines an exemplar's typicality is how frequently it is perceived as instantiating its category. As found by Barsalou (1985), exemplars become more typical in both common taxonomic and goal-derived categories as their frequency of instantiation increases. Barsalou (1985) also assessed the role of familiarity in predicting graded structure and found that it accounted for no unique typicality variance. More specifically, its weak correlations with typicality were completely the result of variance it shared with frequency of instantiation. People's perceptions of how frequently exemplars instantiate their category, rather than people's familiarity with exemplars, appears to be the measure of frequency that is most central to graded structure.

It should be noted that each of the factors discussed so far – central tendency, ideals, and frequency of instantiation – accounts for *unique* typicality variance. Each predicts typicality to a substantial extent after effects of other possible determinants have been partialed out.

Lakoff (1986, Chapter 4, this volume) reviews a number of additional factors that also determine graded structure. It is safe to say that there are many reasons why exemplars are typical and that no single factor or invariant set of factors is solely responsible. As found by Barsalou (1985), categories vary widely in the factors that determine their graded structure, with there being no invariant pattern of determinants. In addition, several factors may together determine a category's graded structure. In several of the categories studied by Barsalou (1985), central tendency, ideals, and frequency of instantiation each accounted for unique typicality variance in the same category; various pairs of these factors each accounted for unique typicality variance in a number of other categories. It appears that the determination of graded structure is a highly flexible phenomenon. There is no single determinant such as similarity to central tendency that is universally responsible for graded structure.

Effects of context

Different determinants in different contexts. Not only do categories vary in what determines their graded structure, different factors determine the graded structure of the *same* category in different contexts. In an experiment with artificial categories, Barsalou (1985: Experiment 2) found that subjects used central tendency to determine a category's graded structure in one context, but used ideals to determine its graded structure in another. This suggests that almost any difference between a category's exemplars could be used to order them by typicality, given the appropriate context.

Linguistic contexts. As shown by Roth and Shoben (1983), a category's graded structure can shift as a function of its linguistic context; that is, different linguistic contexts result in different orderings of exemplars by typicality within the same category. For example, when *animals* is processed in the context of milking, *cow* and *goat* are more typical than *horse* and *mule*. But when *animals* is processed in the context of riding, *horse* and *mule* are more typical than *cow* and *goat*. Roth and Shoben not only found that linguistic context affected typicality judgments, but also found that it affected time to access exemplars. Typicality as determined in the absence of explicit context was unrelated to performance measures in context.

Point of view. As shown by Barsalou and Sewell (1984), a category's graded structure can also shift as a function of the point of view from which it is perceived. In one set of experiments, subjects judged typicality from one of several international points of view (i.e., from the point of view of the average American, African, Chinese, or French citizen) or from one of several domestic points of view (i.e., from the point of view of the average businessman, housewife, hippie, or redneck).[2]

An average graded structure was obtained for each category from each point of view by averaging the rankings for each exemplar in each category from each point of view. Correlations were then computed between the average graded structures for the same category from different points of view. Groups of subjects taking different points of view generated substantially different graded structures for the same category. In *birds,* for example, *robin* and *eagle* were typical from the American point of view, whereas *swan* and *peacock* were typical from the Chinese point of view. In many cases, the ways in which different points of view ordered exemplars for the same category were uncorrelated or inversely related. Such effects occurred for both goal-derived and common taxonomic categories. In fact, context generally affected both category types to a large and equal extent.

In another experiment from Barsalou and Sewell (1984), Emory faculty generated graded structures from their own point of view, and Emory undergraduates generated graded structures from their own point of view. Other faculty generated graded structures from the undergraduate point of view, and other undergraduates generated graded structures from the faculty point of view. Across categories, the average correlation between faculty taking their own point of view and undergraduates taking their own point of view was .23, indicating that different populations of subjects may perceive very different graded structures in the same categories. Given this substantial difference, we were surprised to find that undergraduates generated graded structures from the faculty's point of view that were *identical* to those generated by faculty taking their own point of view. In addition, faculty taking the undergraduate point of view generated graded structures that were very close to those generated by undergraduates taking their own point of view, although faculty were off by a very small amount. Graduate students also participated in this study and were perfect at taking the points of view of both faculty and undergraduates.

It should be noted that these results do not indicate how well *specific individuals* from these different populations take each others' points of view. Instead these results only show that, *on the average,* different populations can be very accurate at taking each others' point of view. Work addressing the ability of specific individuals to take each others' points of view is discussed later.

Summary. The graded structures within categories do not remain stable across situations. Instead a category's graded structure can shift substantially with changes in context. This suggests that graded structures do not reflect invariant properties of categories but instead are highly dependent on constraints inherent in specific situations.

Between-subject reliability

How much do people agree with each other when they order exemplars by typicality? Previous attempts to address this issue have been highly misleading, primarily because of inappropriate statistical analyses. For example, Rosch (1975) and Armstrong et al. (1983) reported values over .9 for agreement, the implication being that subjects agree substantially on graded structure. Unfortunately the statistics used to obtain these estimates (measures of group reliability such as split-half correlation) are directly related to sample size. Depending on the number of subjects run, it is possible to obtain just about any level of agreement, with increasing numbers of subjects resulting in increasing levels of agreement. Instead of measuring how well subjects agree with each other, these statistics measure the stability of the *mean* typicality ratings for a sample (see Barsalou & Sewell, 1984, for further discussion).

More desirably, agreement should be measured by statistics that estimate the average correlation between all possible pairs of subjects in a sample and whose mean values are not influenced by sample size. Such measures exist (see Barsalou & Sewell 1984; Guilford & Fruchter 1973), and when they are used, values of subject agreement for typicality generally average around .45. This means that a given person's graded structure will correlate about .45 on the average with another person's graded structure. We have assessed subject agreement in over 20 groups of subjects over the last eight years, and we have always obtained average values across categories of around .50, with these averages generally ranging from around .30 to .60 (Barsalou 1983; unpublished values for Barsalou 1985; Barsalou & Sewell 1984; Barsalou, Sewell, & Ballato 1985). We have obtained average values of this magnitude for common taxonomic, goal-derived, and ad hoc categories; across a wide range of points of view that people take while judging typicality; for subjects from specific populations (e.g., Emory faculty, Emory graduate students); for categories of different sizes; for different sets of exemplars from the same category; and for ratings and rankings. In addition, Galambos and Rips (1982) obtained values of this magnitude for the centrality of actions in scripts, which is somewhat analogous to the typicality of exemplars in categories (Barsalou & Sewell 1985).

It should be noted that this level of agreement has generally been obtained with subjects from a fairly homogeneous population (i.e., American undergraduates). It would not be surprising if agreement dropped substantially when samples are more heterogeneous in their composition. Conversely, it is possible that certain conditions may result in higher levels of agreement. As discussed later, certain kinds of contexts may cause people to perceive categories more similarly. On the basis of results from Sewell (1985), however, it does not appear that agreement increases substantially as subjects within a sample become more homogeneous. For example, Sewell (1985) found between-subject agreement of .46 for Emory graduate students in psychology taking the American point of view. Sewell also found that between-subject agreement for close friends, each taking their own point of view (.47), was not significantly higher than agreement for superficial acquaintances, each taking their own point of view (.40).

Clearly this .50 level of between-subject agreement indicates that people differ substantially in how they perceive the graded structure of a given category. On the average, knowing one individual's typicality rankings for a category will predict about 25 percent of the variance in another person's typicality rankings (i.e., assuming an average correlation of .50 between individuals). Across individuals, graded structure is relatively unstable.

Taking the points of view of specific individuals

Between-subject reliability can be viewed as how well strangers agree with each other when they judge typicality. A related issue is how good people are at judging typicality from the points of view of their close acquaintances. It seems reasonable that getting to know someone may result in acquiring knowledge of how they view the world. As a result, people may be able to generate graded structures from the points of view of their close acquaintances that are very similar to the graded structures perceived by close acquaintances from their own points of view.

It was reported earlier that Emory undergraduates, graduates, and faculty were excellent at taking each others' point of view. As noted in that discussion, however, those results only demonstrate that populations *on the average* can in some cases generate graded structures that are identical to the *average* graded structures of another population. Because that experiment dealt with average graded structures, it doesn't really bear on how well a given individual can take the point of view of another individual.

In an unpublished study of people's ability to take individual points of view, 10 subjects judged typicality from the point of view of a close friend for the 20 common taxonomic categories and 20 goal-derived categories in Barsalou and Sewell (1984). Each subject also judged typicality for these categories from the point of view of a casual acquaintance. Each close friend and casual acquaintance also judged typicality while taking his or her own point of view. For each category, each subject's rankings from the point of view of his or her close friend were correlated with the rankings generated by that friend. Similarly, each subject's rankings from the point of view of a casual acquaintance were correlated with the rankings generated by that friend. Across subjects and categories, the average correlation between the rankings of a subject taking the point of view of his or her close friend and the rankings of that close friend was .45 for common taxonomic categories and .43 for goal-derived categories. The average correlation between the rankings of a subject taking the point of view of a casual acquaintance and the rankings of that acquaintance was .51 for common taxonomic categories and .43 for goal-derived categories.

These results indicate that people are not very good at taking the points of view of their close friends when judging typicality. Nor are people any better at taking the points of view of close friends than they are at taking the points of view of casual acquaintances, at least in the context of judging graded structure. It is interesting to note that the level of agreement in this study is about the same as that found for between-subject reliability.

To more carefully examine people's ability to take the point of view of specific individuals, Sewell (1985) had subjects take the points of view of close friends and casual acquaintances while making judgments for categories that friends are likely to share knowledge about. For example, subjects ranked how well they thought their friends liked various *kinds of food* (e.g., *Italian, Chinese*), how often they thought their friends performed various *entertainment activities* (e.g., *go to movies, go out to eat*), and so on. Each close friend and casual acquaintance also performed these judgments while taking his or her own point of view. Across subjects and categories, the average correlation between a subject and a close friend was .57, whereas the average correlation between a subject and a casual acquaintance was .45, this difference being significant. From these correlations, it follows that the rankings generated by someone from a friend's point of view only accounts for between 20 and 32 percent of the variance in the rankings generated by the friend himself. These results indicate that people do acquire some knowledge about close friends such that they can view categories from their points of view. Still, people are far from being able to do so perfectly.

Sewell (1985) also asked subjects to judge typicality from their own point of view and from various stereotypes that fit their friends (e.g., *adult black female, graduate student in clinical psychology*). Using regression analyses, he found that subjects' own points of view and their stereotypes were the best predictors of the rankings they generated from their friends' points of view. Most importantly, these two factors were generally better predictors of how a subject perceived a friend's point of view than the rankings generated by the friend from the friend's own point of view. When people perceive categories from the points of view of their friends, they often may not use (or have available) much objective knowledge about whom they are judging. As a result, they project their own point of view and use stereotypes when taking their friends' points of view.

In summary, people's ability to construct graded structures from the points of view of their friends is relatively poor. In fact the values obtained in these studies are not much higher than the values obtained for between-subject agreement for strangers. Even under advantageous circumstances, people do not agree substantially on graded structure.

Within-subject reliability

Given that between-subject reliability is much lower than has been previously believed, it is of interest to determine how stable graded structures are *within* particular individuals; that is, how well does a given subject agree with him- or herself over time. To explore this, Barsalou et al. (1986) had 36 subjects judge typicality for exemplars from 20 common taxonomic categories and 20 goal-derived categories twice, once on each of two days a month apart. Subjects received the same categories and the same exemplars from each category in different random orders on the two days. Half the subjects were asked to take the point of view of the average American on both days, and half were asked to take their own point of view.

Of primary interest was how well a given subject's rankings for the same category correlated across sessions. We had initially expected to observe within-subject agreement of .9 or higher. Although the graded structures of different individuals vary substantially, it seemed to us that particular individuals would be highly stable. For goal-derived categories, however, the average within-subject agreement was .75 from the American point of view and .76 from the subjects' own point of view. For common taxonomic categories, the average within-subject agreement was .82 from the American point of view and .80 from the subjects' own point of view. From these correlations, it follows that the rankings generated by someone on one day only account for between 56 and 67 percent of the variance in the rankings generated by the same subject a month later.

In another experiment, Barsalou et al. (1986) manipulated the delay between subjects' two sets of judgments from one hour to four weeks. In addition, half the subjects received exemplars in the same order on both days, whereas the other subjects received them in different orders. Within-subject reliability decreased from around .92 at a delay of one hour, to around .87 at a delay of one day, and to around .80 at delays of one, two, and four weeks, which did not differ. Order had no effect. In a third experiment, Barsalou et al. (1985) had subjects take either the redneck, the housewife, or their own point of view, while judging either typicality or exemplar goodness, on two days separated by a three-week delay. Subjects showed approximately a .80 level of agreement for all points of view and for both types of judgment.

The above experiments also observed whether highly typical, moderately typical, or atypical exemplars showed the most stability across the two days on which subjects judged typicality. All three experiments found that the rankings of highly typical exemplars and atypical exemplars were least likely (and equally likely) to change from day one to day two, whereas the rankings of moderately typical exemplars were most likely to change. All three experiments also found that when an exemplar's ranking did change from day one to day two the average distance it moved in its graded structure was lowest for highly typical and for atypical exemplars; it was highest for moderately typical exemplars (after correcting for potential amount of movement possible). Highly typical and atypical exemplars were most stable across time, whereas moderately typical exemplars were least stable.

In general these experiments show that there is substantial instability in the graded structures of particular subjects. Although subjects show reasonably high reliability after an hour, reliability drops substantially after a day and levels out at around .80 after a week. In terms of percent variance accounted for, subjects' initial judgments accounted for around 85 percent of the variance in their judgments an hour later, with this value dropping to around 75 percent after a day, and to around 65 percent after a week. Interestingly, when subjects took unusual points of view, reliability was approximately the same as when they took their own point of view, even though graded structures from the different points of view differed substantially. Finally, changes in the typicality of moderately typical exemplars played the largest role in the instability of graded structure, although there were also sizable changes in the typicality of both highly typical and atypical exemplars.

A finding from McCloskey and Glucksberg (1978) further indicates that the information used to judge category membership varies within individuals over time. McCloskey and Glucksberg found that individuals often changed their minds across a one-month period about whether an item did or did not belong to a category. For example, individuals often changed their minds about whether *yeast* belongs to *animals*. This further indicates that category representations are less stable than might be expected.

Production

So far, most of the results reported have been based on judgments of typicality. It appears, however, that production data also possess a high degree of instability. Bellezza (1984a) had subjects generate exemplars from the same common taxonomic categories in two sessions one week apart. He found that the average correlation between different subjects on a given day for the exemplars generated from a particular category was .44.[3] He also found that the average correlation within a subject for the exemplars generated on two days a week apart was .69. These values are remarkably similar to those reported earlier for the between- and within-subject reliability of typicality judgments. In a related study, Bellezza (1984c) had subjects provide definitions for various kinds of words in two sessions a week apart (i.e., concrete nouns, abstract nouns, and superordinate category names). Each definition generated by a subject was broken down into a set of propositions. The average between-subject agreement on a given day for the propositions generated for a word was .22. The average within-subject agreement across a week was .48. In a third study, Bellezza (1984b) asked subjects to produce information about famous people and about people they knew well in two sessions a week apart. The average between-subject reliability on a given day for famous people was .21 (this could not be computed for people subjects knew well because each subject knew a different person). The average within-subject reliability for famous people across a week was .55 and for people subjects knew well was .38.

These production data corroborate the typicality judgment data discussed earlier, namely, the way in which a particular category is represented varies widely both between and within individuals. It would not be surprising if production, similar to typicality, also varied substantially with changes in context.

Summary

As this review demonstrates, graded structure is a highly flexible and unstable phenomenon. A wide range of determinants is responsible for graded structure, and different determinants can be responsible for a category's graded structure in different contexts. A category's graded structure can vary substantially with changes in linguistic context and with changes in point of view. Different people do not agree very highly in the graded structures they generate for the same category. When people take the points of view of specific individuals, they are still not very accurate, even for close friends. Specific individuals are surprisingly inconsistent over time in the graded structures they generate for the same category. Furthermore, high variability occurs, both between and within subjects, when subjects produce information from conceptual representations, as well as when they judge typicality.

Implications for the nature of concepts

What conclusions should we draw from these data on graded structure? As was suggested earlier, a pessimist might conclude that graded structure is a useless phenomenon. Because it has so many determinants, because it is so easily affected by context, and because it is so unstable between and within individuals, one could argue that it is has little if any potential for informing us about people's representations of categories. This view, however, assumes that there are invariant cognitive structures associated with categories that we should be trying to discover. According to this view, people's representations of categories exist in some clear-cut way, and our job as cognitive scientists is, first, to develop empirical means for identifying these structures and, second, to develop theoretical means for discussing them. The remainder of this chapter argues that this view is fundamentally wrong. Invariant representations of categories do not exist in human cognitive systems. Instead, invariant representations of categories are analytic fictions created by those who study them.

Sources of graded structure

How then can we interpret results that show graded structure to be a highly dynamic and unstable phenomenon? What implications do these results have for theories of categorization? The following sections discuss several possibilities.

Memory. One possibility is that representations of graded structures are explicitly stored in long-term memory. According to this view (e.g., Glass and Holyoak 1975), associative strength underlies graded structure, with typical exemplars being highly associated to their category in long-term memory and atypical exemplars being weakly associated. In other words, a category's graded structure is represented by the associative strengths between the category and its exemplars in long-term memory. When judging typicality, people assess the strength of these associative relations and assign higher typicality values to higher strengths.

This view seems implausible for a number of reasons. First, it requires that there be a very large number of graded structures stored in long-term memory for each category. A category would need graded structures for all the possible points of view and contexts a person could possibly encounter. Second, people appear able to generate graded structures in novel contexts for which they do not have prestored graded structures. It is unlikely that subjects in our point-of-view experiments had previously constructed graded structures for all 40 categories from the Chinese point of view, the redneck point of view, and so on. Third, people appear able to generate graded structures for ad hoc categories such as *things that could fall on your head,* which are not well established in memory (Barsalou 1983). Fourth, this account does not explain how graded structures for well-established categories get constructed in the first place. Fifth, how readily an exemplar is generated during production – a measure of how strongly it is associated with its category – is far from being a perfect predictor of how typical it is. As found by Barsalou (1981: Experiment 1) and Barsalou and Sewell (1985), the order in which individual subjects generate exemplars only correlates .27 with their individual typicality judgments. In general, it seems implausible that the wide range of graded structures we observe in our experiments are all stored in long-term memory.

Similar problems exist for purely extensional approaches to fuzzy-set theory, which generally propose that exemplars have values between zero and 1 associated with them that indicate their degree of category membership (Zadeh 1965). It seems implausible that people store many such values for each exemplar to represent its degree of membership in every possible context. In addition, this theory does not explain how these values are obtained in the first place, how people obtain values for familiar categories in new contexts, or how people obtain values for ad hoc categories. As noted shortly, more intensional approaches to fuzzy-set theory (e.g., Zadeh 1982) are better suited to handle these problems.

The environment. A second account of graded structure is that it reflects the structure of the environment (Rosch 1978; Rosch & Mervis 1975). According to this view, categories originate in the correlational structure of the environment, and the typicality of exemplars reflects the extent to which they possess the pattern of correlations characteristic of their category. There are a number of problems with this view. First, it does not account for graded structure in categories that do not reflect correlational structure (e.g., goal-derived categories). Second, it provides no explanation of why graded structure varies so much with context. Third, it has no way of accounting for the importance of ideals in graded structure. People's goals appear extremely important to the organization of categories, and a complete theory of graded structure must account for them (cf. Murphy & Medin 1985).

Although the environment may not explain everything about graded structure, it probably plays an important role in people's knowledge and use of categories. There certainly seems to be structure in the environment, and people certainly appear sensitive to this structure (Neisser, Chapter 2, this volume; Rosch & Mervis 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem 1976). Although people's knowledge may reflect environmental structure to some extent, it appears that their ability to manipulate knowledge allows them to construct representations that go far beyond those that reflect this structure.

Comparison of exemplar and category concepts in working memory. A third explanation of graded structure – and the one that seems best able to account for its flexibility – is that graded structure reflects a similarity comparison process that operates on exemplar and category concepts in working memory (Barsalou 1983, 1985; Hampton 1979; Smith et al. 1974; Zadeh 1982).

Before going into this account, it is first necessary to specify what will be meant by *concept* in this and the remaining sections. Although *concept* has typically been equated with the *definition* or *membership criteria* for a category (e.g., Armstrong et al. 1983), it will not be used as such here. Instead *concept* will refer to the particular information used to represent a category (or exemplar) on a particular occasion. More specifically, it will be assumed that the concept used to represent a category on a particular occasion contains (1) information that provides relevant expectations about the category in *that* context, and (2) information that provides relevant expectations when interacting with the category in *most* contexts. These two kinds of information correspond to context-dependent and context-independent information (Barsalou 1982), which are discussed later.

Barsalou and Medin (1986) review a number of arguments for viewing concepts in this way. For example, it is difficult, if not impossible, to find definitions for many categories. Even when such definitions exist, they often do not appear central to people's representations of categories. Instead prototypical, ideal, and context-relevant information (none of which may be definitional) generally appear most important, perhaps because they provide people with a rich source of expectations that facilitate successful interactions with category members. According to this argument, definitional information is only used to represent categories in contexts for which such information is relevant (e.g., when the payoffs for correct categorizations are high).

Returning to the issue of what determines graded structure, the comparison view proposes that the graded structure of a particular category in a particular context results from the following three steps: First, a concept is established in working memory to represent the category

(what will be referred to as a *category concept*). Second, concepts for exemplars (*exemplar concepts*) are compared to the current category concept. Third, exemplars are judged as typical to the extent that they are similar to the current category concept. Highly similar exemplars are atypical, moderately similar exemplars are moderately typical, and weakly similar exemplars are atypical.

According to this account, graded structure changes across contexts because different category concepts are used in different contexts for the same category. Consider *animals* from the housewife and redneck points of view. When taking the housewife point of view, people might use a concept for *animals* that includes information about animals being small and domesticated; but when taking the redneck point of view, people might use a concept that includes information about animals being large and wild. Different graded structures would occur for *animals* because small and domesticated animals are similar to the housewife concept for *animals*, whereas large and wild animals are similar to the redneck concept for *animals*. According to this view, changes in graded structure for the same category reflect changes in the concept currently representing the category.

Exemplar concepts may also vary across contexts. For example, when judging how typical *dog* is in *animals*, the concept for *dog* from the housewife and redneck points of view may vary substantially. By affecting the similarity between exemplar and category concepts, changes in exemplar concepts may also play a role in causing graded structures to shift across contexts.

A third factor that may cause shifts in graded structure is frequency of instantiation. As suggested by Barsalou (1985), information about how frequently exemplars occur in various contexts may be stored with exemplars. When subjects judge an exemplar's typicality, frequency-related information relevant to the current context may be accessed as part of the exemplar concept and enter into the typicality judgment. Exemplars occurring frequently in that context are typical, whereas infrequent exemplars are atypical. To the extent that frequency of instantiation varies across contexts, it could also play a role in the instability of graded structure.[4]

It should be noted that this account of graded structure is *not* intended as an account of how people determine category membership. The substantial changes observed by McCloskey and Glucksberg (1978) in people's assignments of category membership across a one-month period suggest, however, that the information individuals use to determine membership also varies across occasions. Although the concepts people use for judging typicality and for determining membership may often be similar, it would not be surprising if the concepts used to represent a category vary somewhat as a function of the current task. Along these lines, Gluck (1985) has found that people represent categories with highly discriminative properties when classifying exemplars, but represent them with highly probable properties when drawing inferences about exemplars.

Sources of concepts

Assuming that graded structure largely results from a similarity comparison process in working memory, how do people obtain the concepts that enter into this process? To simplify matters, only category concepts will be considered in the remainder of this chapter, although what is said also applies to exemplar concepts.

Memory. One possibility is that concepts are stored in long-term memory and retrieved when needed. This account, however, runs into the same problems noted earlier for storage views of graded structure. It seems implausible that people have a category concept stored in long-term memory for every possible context in which they might use a category or for every possible ad hoc category.

Constructed in working memory. A more plausible alternative is that people have the ability to construct a wide range of concepts in working memory for the same category. Depending on the context, people incorporate different information from long-term memory into the current concept that they construct for a category.

People have in fact been shown to incorporate different information into their concept for a category on different occasions. As discussed earlier, Bellezza (1984c) found that the propositions comprising an individual's definition of a word only correlated .48 on the average with the propositions comprising their definition a week later. This suggests that the information an individual incorporates into a concept can vary substantially from occasion to occasion. Explicitly manipulating the context in which people produce definitions (e.g., changing their point of view) would probably result in even larger variability.

The conclusion that people construct different concepts for the same category on different occasions explains the various context effects discussed earlier. When people only incorporate ideals into category concepts, only ideals determine graded structure; when people only incorporate central tendency information into category concepts, only central tendency determines graded structure; and when both are incorporated, they determine graded structure together. In different linguistic contexts and for different points of view, people construct somewhat novel concepts for familiar categories that result in different graded structures. When using ad hoc categories, people construct new concepts that can be used to generate graded structures (see Barsalou 1983:225).

This account explains variability between and within subjects. Between-subject variability results from different subjects incorporating different information into the concept for the same category. Within-subject variability results from a given individual incorporating different information on different occasions. Between and within individuals, the concepts constructed for a given category may vary widely and may rarely be the same.

By assuming that concepts are constructed when needed, it is not necessary to assume that a large number of concepts are stored in long-term memory for a particular category. Instead the large number of concepts associated with a category simply reflects a process capable of constructing a wide variety of concepts in working memory from a constantly changing knowledge base in long-term memory. In this sense, people's conceptual ability is highly productive.

It should be noted that concepts constructed in working memory are probably not simple bundles or lists of independent properties. Instead, the properties that comprise concepts are probably highly integrated by various kinds of relations, such as those discussed by Medin (Chapter 3, this volume), Murphy & Medin (1985), and Lakoff (Chapter 4, this volume, 1986). Changes in concepts across contexts may reflect changes both in the properties comprising concepts and in the relations that structure them.

In addition, the kind of information retrieved from memory to construct concepts may take many forms. Such information may often be central tendency information that has been abstracted from specific episodes; it may be ideals specified by problem-solving processes; it may be specific episodes or fragments of specific episodes (Brooks 1978; Medin & Schaeffer 1978); or it may be generic properties summarized online from previous episodes (Kahneman & Miller 1986). In principle, a given concept in working memory could contain a variety of information, and the kind of information incorporated into concepts for the same category could vary widely across contexts.

Invariant concepts as analytic fictions. Many theorists seem to assume that there are invariant concepts in long-term memory that we should be trying to discover. When investigators collect property listings for concepts, they are trying to determine what information comprises these concepts in long-term memory. When investigators use linguistic analysis to determine prototypes, definitions, and idealized cognitive models, they appear to assume that there are invariant concepts in long-term memory that need to be fully characterized. We often seem to assume that people store invariant concepts, retrieve them under appropriate conditions, and apply them to current situations.

Yet, on the basis of the findings reviewed here, different people seem to have different concepts for the same category, and the same individual seems to have different concepts for the same category in different contexts. Consequently, the concepts that theorists "discover" for categories may never be identical to an actual concept that someone uses. Instead, they may be analytic fictions that are central tendencies or idealizations of actual concepts. Although such theoretical abstractions may be useful or sufficient for certain scientific purposes, it may be more fruitful and accurate to describe the variety of concepts that can be constructed for a category and to understand the process that generates them.

It should be noted that this argument is *not* meant to imply that there is *no* stable knowledge in long-term memory. Instead, the point is that the same exact representation does not appear to represent a category on every occasion in working memory. As discussed in the following section, it is entirely possible for there to be relatively stable knowledge in long-term memory, but for it rarely to be the case that the same information is retrieved from this knowledge to represent a category.

A theory of concept construction

Concepts as constructs

Instead of viewing long-term memory as being divided into invariant concepts, it may make more sense to view long-term memory as containing large amounts of highly interrelated and "continuous" knowledge that is used to construct concepts in working memory. Instead of viewing concepts as invariant structures that are retrieved intact from long-term memory when needed, it may make more sense to view concepts as temporary constructs in working memory that are tailored to current situations. According to this view, long-term memory contains the knowledge from which concepts in working memory are constructed rather than containing invariant concepts that are used to represent categories across all possible situations.

The structure of knowledge in long-term memory

Although the concepts people use to represent categories may not exist as invariant structures, it by no means follows that categories are not associated with stable and highly articulated knowledge in long-term memory. Loosely speaking, the knowledge associated with a category in long-term memory can be viewed as the union of many possible concepts that could represent the category in working memory. It follows that long-term memory contains concepts for categories, but in the sense that the knowledge for a particular category contains many, many concepts. On a given occasion, the concept that is constructed to represent a category only traces out a small subset of all the knowledge available in long-term memory for representing the category.

The following six sections each discuss a way in which knowledge in long-term memory might be structured so as to result in highly variable concepts for the same category across situations.[5]

Continuity. The knowledge in long-term memory from which concepts are constructed for a particular category may generally not have clear boundaries. Instead, knowledge for a particular category may share much structure with knowledge for other categories, and various kinds of knowledge may have dense relations with one another. This becomes evident when trying to compile property norms for categories on the basis of information provided by subjects. More specifically, it is often difficult to decide if certain information that subjects generate for a category really belongs to the category. Consider a few examples from norms collected in our laboratory. Although subjects generated *chased by cats* as a property of *birds,* it could just as easily be construed as a property of *cats,* and in some sense it does not seem to be a property of either. Although subjects generated *the reason for building scarecrows* as a property of *birds,* it seems more related to knowledge about farming and scarecrows. Although subjects generated *played while sitting, requires lessons, makes music for dancing, rewarding to learn,* and *requires care* as properties of *musical instruments,* each is highly related to another knowledge domain (i.e., performing, learning, dancing, self-satisfaction, and maintenance, respectively). These properties are not a few isolated examples, but instead represent a large proportion of those generated.

The fact that many of the properties generated for categories cannot be neatly assigned to a single knowledge domain suggests that the knowledge in long-term memory from which concepts are constructed is relatively undifferentiated or continuous – it does not appear to be divided into packets of knowledge associated with particular categories. In general, it may be extremely difficult, if not impossible, to identify where the knowledge for a particular category in long-term memory begins and ends. To the extent this is true, it is hard to imagine how there could be invariant representations for categories stored in long-term memory.

Mutual exclusivity. A common feature of nearly every theory of representation is the presence of variables that are bound with different instantiations in different contexts. Representations of *birds,* for example, contain variables for *color, size, eating habits,* and so on that are bound with different instantiations for different birds. Whereas these variables are bound with instantiations of *red, medium-sized,* and *eats seeds* for *cardinal,* they are bound with instantiations of *black, large,* and *eats carrion* for *vulture.*

Variables associated with a category often exhibit the property of *mutual exclusivity* and, as a result, insure instability of concepts. Mutual exclusivity holds for a variable when only one of its instantiations is typically incorporated into the concept for a category on a given occasion. Consider the variables of *size* and *ferocity* for *animals.* When taking the point of view of a forest ranger, a person might construct a concept for *animals* that contains instantiations of *large* and *wild* for these variables. In contrast, when taking the point of view of a pet store owner, a person might instantiate these variables with *small* and *tame.* For either variable, only one instantiation typically ever occurs in a concept at a particular time, and all others are excluded.

An implication of mutual exclusivity is that much of the knowledge for a category may not be included in a given concept because it has been precluded by mutually exclusive instantiations. Mutual exclusivity results in instability because the instantiations of variables vary widely across contexts. Most importantly, mutual exclusivity insures that there are no invariant representations of categories, since it is impossible for all of the knowledge associated with a category to represent the category on a single occasion.

It should be noted that multiple instantiations of a variable do occur under certain conditions. For example, when people construct disjunctive concepts, they may bind certain variables with multiple instantiations. In *physical events not well-described by Newtonian mechanics,* the variable, *size of the event,* is instantiated by both *very, very small* and *very, very large.* In addition, certain variables may normally be bound with multiple instantiations (e.g., the variable of *hobbies* for the concept of *person*). The point is, however, that those variables typically exhibiting mutual exclusivity insure that not all of the knowledge for a category represents the category on a given occasion. Categories are not associated with invariant concepts.

Accessibility. The knowledge associated with a category appears to vary substantially in its accessibility. One way to view accessibility is in terms of a distinction between context-independent and context-dependent information (Barsalou 1982). Context-independent information automatically comes to mind on every occasion in which a concept is constructed for a particular category. Several independent programs of research have shown that the activation of this information is *obligatory,*

namely, there is no way of preventing its retrieval when a concept is constructed (Barsalou 1982; Barsalou & Ross 1986; Conrad 1978; Gildea & Glucksberg 1984; Greenspan 1984; Whitney, McKay, & Kellas 1985). For example, whenever people construct a concept for *skunk,* the activation of *smells* is obligatory; whenever people construct a concept for *diamond,* the activation of *valuable* is obligatory.

In contrast, context-dependent information only comes to mind in relevant contexts, thereby causing instability of concepts. Numerous studies (cited in Barsalou 1982) have shown that such information is typically inactive for a category, except when it is relevant to the current situation. For example, *floats* is typically inactive when people construct concepts for *basketball,* except in situations involving water. Upon hearing that someone used a *basketball* for a life preserver, *floats* becomes activated.[6]

As discussed by Barsalou (1982), the distinction between context-independent and context-dependent information is orthogonal to the distinction between generic and episodic information. For example, a generic property for *smells* may be context-independent for *skunk,* whereas a generic property for *floats* may be context-dependent for *basketball.* Similarly, an episode involving being bitten by a dog may have been rehearsed so often with *dog* that is has become context-independent, whereas other episodes that have not been rehearsed are context-dependent. As argued by Barsalou and Bower (1980), a property or episode only becomes context-independent after it has been incorporated into a concept on many occasions. It follows that what is context-independent for a concept may vary widely both between and within individuals as a function of their experience with a category.

This distinction between context-independent and context-dependent information may help account for the stability, as well as the instability, of graded structure. Although graded structure can clearly vary substantially, some agreement is generally observed both between and within subjects. Subjects from the same population generally correlate around .50 with each other; when individuals take the points of view of close friends, this correlation increases to around .6; and across situations, individuals generally correlate around .8 with themselves. Although agreement is generally low, it exists and must be accounted for.

That there is any agreement at all within and between subjects may be a consequence of context-independent information, although this remains to be shown empirically. Assuming that the same context-independent information is activated for the same person across situations, there should be some stability within individuals. Assuming that different individuals share at least some context-independent information, there should be some stability between individuals. Context-independent information shared by individuals may represent the properties and episodes most central to the conventional use of concepts. For example, most people may immediately think of *robins* as *red-breasted* and of *rattlesnakes* as *poisonous* because these properties represent widely shared beliefs about these categories. Similarly, the episode in which four people were shot on a New York subway may be context-independent for most people's concept of Bernard Goetz because it has become part of shared cultural knowledge.

In contrast, the large amount of disagreement both between and within individuals may be a consequence of context-dependent information. To the extent that much of the context-dependent information comprising concepts changes across situations – both between and within individuals – concepts should be unstable. Disagreement may also reflect differences between individuals in their context-independent information for the same category. For example, *bites* may be context-independent in *dog* for someone who has been bitten many times, whereas *bites* may not be context-independent for someone else who has had more positive experiences.

Correlated properties. Another way in which knowledge associated with categories may be structured is that properties may be integrated with one another. Instead of being represented independently in long-term memory, properties that co-occur and properties that are meaningfully related may be associated. Because correlations between properties vary between individuals, as well as within individuals over time, they provide another source of instability in the knowledge used to construct concepts.

Recent work by Medin and his colleagues provides evidence for correlated properties (e.g., Medin & Schaeffer 1978). Although this work is often interpreted as showing that people represent categories with exemplars, it does not rule out *all* prototype models (see Medin & Schaeffer 1978:231–232). Instead, this work demonstrates that *independent cue models* do not account for classification performance. Instead of accessing properties of a category independently of one another, people appear to access *correlations of properties*. Thus these findings could either indicate that people are accessing correlated properties that comprise individual exemplars, or it could indicate that people are accessing correlations of properties that have been abstracted from exemplars into prototypes (as in Reitman & Bower 1973). Both forms of correlated properties probably exist in people's knowledge (e.g., Malt & Smith 1984; Medin, Altom, Edelson, & Freko 1982).

As suggested by Medin (Chapter 3, this volume) and Murphy and Medin (1985), people may often interpret correlations between properties in terms of their theories about the world. These theories may explain correlations that actually exist between properties (e.g., why *cars* have both *gasoline* and *spark plugs*) and may cause people to perceive correlations that don't exist (Chapman & Chapman 1969).

Global organization. Similar to there being relations between properties, there are also probably higher-order relations between clusters of properties. Such organization may in some cases be metonymic or radial, as suggested by Lakoff (Chapter 4, this volume; 1986); and it may also take other forms such as schemas (e.g., Rumelhart & Ortony 1977), frames (Minsky 1975), scripts (Schank & Abelson 1977), and memory organization packets (MOPs) (Schank 1982).

Although there may be global structures in memory, it by no means follows that these structures form invariant units that are always retrieved intact into working memory when necessary. Instead, the representations of a particular global structure in working memory may vary widely across contexts. Along these lines, Barsalou, Usher, and Sewell (1985) have found that the variables active for a schema vary across contexts in which the schema is used – a schema does not appear to have an invariant set of variables relevant to every context. Similarly, the different tracks that people construct for scripts (Schank & Abelson 1977) appear to vary widely across contexts. One reason it may be so difficult to identify all the possible tracks of a script is because many of them only exist as temporary constructs in working memory rather than as invariant structures in long-term memory. In this sense, the representations of scripts are no different from the representations of categories.

Episodic organization. Representations of exemplars and episodes in long-term memory may be integrated with the generic knowledge they instantiate. A number of recent findings suggest the presence of such organization. Ross (1984) found that specific characteristics of a current learning episode function to cue previous learning episodes that share those characteristics. Kahneman and Miller (1986) review many cases of social decision making in which specific characteristics of a current experience function to cue related episodes. Schank (1982) provides many examples of how a current episode may remind someone of related episodes instantiating the same generic structure. Because episodes vary widely between individuals, as well as within individuals over time, episodic information provides another source of instability in the knowledge used to construct concepts.[7]

Summary. The knowledge from which concepts are constructed appears to exhibit the following properties: Knowledge associated with categories is continuous in the sense that it is not well-bounded; such knowledge contains variables, some of which may exhibit mutual exclusivity and thereby insure instability; information may vary substantially in accessibility, from being context-independent to context-dependent; information may be richly interrelated, typically being retrieved in meaningful clusters as opposed to being retrieved independently; clusters of information may be interrelated by various kinds of global structures; and exemplars and episodes may be organized by generic knowledge. Further characteristics of knowledge structures are discussed in Graesser and Clark (1985).

The process that constructs concepts

What is the nature of the mechanism that pieces together information from long-term memory to construct highly idiosyncratic concepts in working memory that are relevant to current situations? The following five sections suggest several possible characteristics of this process.

Incorporates context-independent properties. Because it is so accessible, the context-independent information associated with a category may automatically be incorporated into all concepts constructed for it. This would result in there being cores for concepts that lead them to be somewhat stable over time. As argued by Barsalou and Medin (1986), such cores are very different from those postulated by Armstrong et al. (1983), Osherson and Smith (1981, 1982), and others who take the core-plus-identification view of concepts. Instead of being definitional, as in the core-plus-identification view, context-independent cores are *experiential.* They do not represent necessary and sufficient conditions for category membership but instead represent information that has frequently been relevant in a person's experience with exemplars of the category. Consequently, these experiential cores may vary widely between individuals as a result of different experience and may vary within an individual over time as a result of changing experience. Such cores provide an individual with expectations that are useful for interacting with a category in most contexts.

As discussed by Barsalou (1982), if context-independent information turns out to be irrelevant in a particular situation, it may subsequently be inhibited by conscious processing. For example, although *sour* and *juicy* may be context-independent for *lemon,* these properties may eventually become inhibited for someone working on an arrangement of plastic lemons.

Incorporates correlated properties and episodes. When a given property is retrieved and incorporated into a concept, correlated properties may also be incorporated. In addition, properties incorporated into concepts may also cause fragments of associated episodes to be incorporated.

Correlated properties also appear to play an important role in variable instantiation. As found by Barsalou et al. (1985), the way in which a variable is instantiated in a particular concept affects how other variables are instantiated. Consider concepts for *vacation.* If *beach* instantiates *location* and *summer* instantiates *time,* then *swimming* is much more likely to instantiate *activities* than is *sledding.* The opposite is true, however, when *mountains* and *winter* instantiate *location* and *time.* Relations between the instantiations of different variables appear to play important roles in the construction of concepts.

Incorporates goal-related information. People are almost always in the process of achieving goals. Consequently, information about current goals may often be temporarily stored in working memory. When concepts are constructed for categories, the goal-related information currently in working memory may serve to cue related information from long-term memory that becomes incorporated into current category concepts. This enables people to construct concepts for categories that are tailored to current goals. For example, if someone needs something to stand on while changing a light bulb, and if he or she considers the possibility of using a chair, the goal of finding support may cause properties such as *sturdy, easy to move,* and *not too fancy* to be retrieved from knowledge in long-term memory and be incorporated into the current concept for *chair.*

Incorporates information relevant to current exemplars and to other aspects of the current context. Particular exemplars of a category are often present when concepts are being constructed for it. For example, when arranging furniture, particular exemplars of *furniture* are physically present. Similar to current goals, current exemplars may also cue relevant context-dependent information from long-term memory that becomes incorporated into the current concept. This enables people to construct concepts that are tailored to the exemplars with which they are currently interacting. For example, if all of the furniture being arranged is *expensive* and *fragile,* these properties may be incorporated into the current category concept.

Similar to current exemplars, other aspects of the current context may cue relevant information from memory that becomes incorporated into concepts. For example, the *current place* may retrieve information that was incorporated into concepts constructed in that place on previous occasions. So if someone once had overcooked pasta at a restaurant, the next time he or she eats there, *overcooked* may be retrieved by being in the same place, and this property may be incorporated into the concept for *pasta.* Other contextual information such as *time of day, participants, mood,* and so on may cue relevant information in a similar manner.

Incorporates recently activated information. There are obvious advantages of a system that can tailor concepts to particular situations. It may also be advantageous for concepts to be stable under certain circumstances. For example, it would be useful if the concept for a category remained fairly stable over a time period in which someone was pursuing the same goal with the same exemplars. One way this may work is that information used on recent occasions to construct a concept for a category may have a high likelihood of being accessed on subsequent occasions in which concepts are constructed. As a result, some stability can be maintained in the concepts constructed for a category over a short time period. An advantage of this recency bias is that people would not always have to use goal and exemplar information in working memory to construct a concept relevant to the current situation. By simply making recently used information highly accessible, the process of constructing concepts that are tailored to the current situation becomes temporarily automated.

Evidence that recent experience with exemplars biases people's representations of categories has been provided by a number of experiments on perceptual priming (Brooks, Chapter 6, this volume; Jacoby & Brooks 1984). Further evidence comes from Barsalou et al. (1985). As discussed earlier, they found that within-subject reliability dropped from .92 after an hour, to .87 after a day, to .80 after a week, with no further decreases occurring after two and four weeks. These results can be interpreted as a recency bias for concepts that dissipates over a day and that is gone after a week.

This recency bias may play a substantial role in the instability of graded structure. Low between-subject reliability for a category may partially reflect the fact that different people have had different recent experiences with the category (e.g., having recently pursued different goals and having recently encountered different exemplars). Similarly, low within-subject reliability for a category may partially reflect the fact that an individual's recent experience with a category may vary substantially over a given period of time. Higher agreement might be found both between and within individuals when recent experience with a category is held constant.

Finally, this recency bias may result in subjects appearing to have invariant concepts in laboratory experiments on categorization. Since subjects in such experiments typically pursue the same goal and interact with the same exemplars over a short time period, they may temporarily develop highly stable concepts for these categories. If their concepts for these categories were observed over longer periods of time with changing goals and exemplars, less stability might be observed.

Summary. The process that constructs concepts may exhibit stability for the following four reasons: First, by incorporating context-independent information, this process may generally retrieve information that provides some stability both between and within individuals. Second, when goals are the same, either between or within individuals, they may cue the same information from memory such that concepts are stable. Third, when exemplars and other aspects of the current context are the same, they may similarly result in stable concepts. Fourth, by incorporating recently activated information, this process may construct concepts that are temporarily stable.

The process that constructs concepts may exhibit instability for the following five reasons: First, different experience both between and within individuals may result in their having different generic and episodic knowledge from which concepts can be constructed. Second, correlations within this information may vary, such that the incorporation of particular information into a concept causes different information that is correlated to be included. Third, people's concepts for a category may vary with different goals. Fourth, people's concepts for a category may vary as current exemplars and other aspects of the current context vary. Fifth, people's concepts for a category may change as their recent experience changes.

The representation of properties

Implicit in this theory of concept construction has been the assumption that only concepts vary and that the generic properties partially comprising concepts (along with exemplars, episodes, and so on) are invariant representational units. Nevertheless, there is no reason to believe that properties are associated with invariant representations any more than are concepts, since many properties are concepts themselves (e.g., *wheel* for *car, wing* for *bird*). Consequently, what was said earlier about concepts being constructed in working memory probably also applies to many properties. The representation of many properties in working memory may typically vary widely as a function of goals, current context, and recent experience.

This raises an old and difficult problem: Are there any fundamental units used to build property and concept representations that remain invariant across contexts? While certain innate perceptual primitives (and possibly certain innate conceptual primitives) may have physiological bases that correspond to invariant representational units, it is also possible that there are no invariant primitives at all. Instead, instability may generally characterize the circuitry of the nervous system, with there being *no* pattern of neuronal firing that remains invariant across contexts. If this is true, then there is a substantial problem in describing the knowledge in long-term memory from which properties, concepts, and episodes are constructed. As noted by McCauley (Chapter 11, this volume), it is not clear what the basic units of knowledge in long-term memory would be. One possible solution is provided by theories of parallel distributed processing, which will be discussed in the next section. Related discussion can also be found in Bechtel (1985).

Relation to other theories

Recent work in a number of areas appears to be converging on the view that representations should not be viewed as invariant structures but should instead be viewed as dynamic structures that vary widely across contexts. The following sections briefly discuss five such areas.

Dreaming

One way to view dreams is as representations that are constructed from knowledge in memory by the same processes that construct representations during alert activity. This assumption is the basis of a cognitive theory of dreaming proposed by Foulkes (1985), who reviews a number of striking similarities among various cognitive states (e.g., alert activity, dreaming while asleep, daydreaming). For example, dreams generally appear to be structured by the kinds of rules that structure text (e.g., as in story grammars), dreams often follow the same scripts that structure everyday activities, and mental imagery plays a central role in both alert activity and dreaming.

Analogous to the thesis of this chapter, Foulkes (1985) suggests that a constructive approach to representation is a natural way to account for the creativity and unusualness of dreams. Instead of viewing dreams as invariant representations that are retrieved from memory, it makes much more sense to view them as representations that are constructed by the same processes responsible for cognition during alert activity. In fact, the extent to which dreams are unusual may represent the extent to which the human conceptual ability is constructive. Dreams may often contain unusual assemblages of information simply because the perceptual input that normally serves to constrain construction during alert activity is relatively absent during dreaming.

To the extent that the same processes are responsible for cognition during both dreaming and alert activity, we have further reason to believe that the representations people use during alert activity are not retrieved

as invariant structures. The processes responsible for the creativity of dreams may also be responsible for the instability of concepts.

Conceptual combination

Much of the recent work on graded structure has addressed the determinants of graded structure for combinations of concepts (Cohen & Murphy 1984; Jones 1982; Hampton in press a, b; Osherson & Smith 1981, 1982; Smith & Osherson 1984). When the concepts for *pet* and *fish* are combined, for example, what determines graded structure in *pet fish*? Although this work generally assumes that the structures for constituent concepts such as *pet* and *fish* are invariant, it acknowledges the importance of people's ability to construct novel concepts from existing knowledge.

As shown by Osherson and Smith (1981, 1982) and Hampton (in press a,b) extensional approaches to fuzzy-set theory have difficulty in accounting for the graded structure of combined concepts. Consequently, alternative attempts to account for the graded structures of these concepts have been more intensional, proposing that the representations of new concepts are formed by integrating the representations of preexisting concepts. These new representations then become comparison standards by which typicality in their respective categories is judged (Cohen & Murphy 1984; Hampton in press a,b; Smith & Osherson 1984).

These intensional approaches can account to some extent for the instability of graded structure reviewed earlier. Context effects can be accounted for by assuming that representations of categories and contexts are combined to form new representations that are used to judge typicality. For example, Roth and Shoben's (1983) finding that typicality in *animals* depends on whether animals are processed in the context of riding or milking can be accounted for by assuming that the concept for animals is combined with the concepts for riding and milking. Similarly, Barsalou and Sewell's (1984) point-of-view effects can be accounted for by assuming that the concept for a category is combined with a concept for a point of view (e.g., *birds* with the *Chinese point of view*).[8]

Although intensional approaches to conceptual combination have not been oriented toward accounting for between- and within-subject instability in graded structure, they can easily be adapted to do so. For example, the Smith and Osherson (1984) approach basically assumes that concepts are represented by sets of values on dimensions. By assuming that the salience of dimensions and values for a category vary between individuals and within individuals over time, it becomes possible for different concepts to result in different graded structures between and within individuals. By additionally assuming that different dimensions can be active on different occasions, further flexibility becomes possible.

In general, intensional theories of conceptual combination are highly sympathetic to the view that people are constantly in the process of using old knowledge in new ways. These theories also provide an interesting way of viewing the construction and use of ad hoc categories (Barsalou, 1983; Barsalou, Sewell, & Usher 1985). As noted earlier, these theories primarily differ from the position being taken here in their assumption that invariant representations are associated with the categories used to form new categories.

Exemplar theories

Brooks (1978) and Medin and Schaeffer (1978) have proposed that people use exemplars instead of generic prototypes as the basis of classification. Although this approach has not yet been oriented toward accounting for the instability of graded structure, it has potential for doing so. For example, between-subject instability could result from different individuals experiencing different exemplars, and within-subjects instability may result from the same individual experiencing different exemplars over time. Similarly, context effects may result from different cues in different contexts retrieving different exemplars. In general, what seems typical to a particular person on a particular occasion may reflect the exemplars that are readily available.

Related work on perceptual priming has shown that people's ability to classify stimuli is biased toward exemplars similar to those that have been recently encountered (Brooks, Chapter 6, this volume; Jacoby & Brooks 1984). Consistent with the theory of concept construction presented earlier, and consistent with McCloskey and Glucksberg (1978), it appears that people's classification standards are unstable and vary as a function of recent experience.

Norm theory

Kahneman and Miller (1986) propose that a current experience recruits previous episodes stored in memory that are similar to it in specific ways. As these episodes are retrieved, they are compiled into a norm that summarizes them. The current experience is then compared to the norm just constructed in working memory, and on the basis of their similarity, various kinds of inferences and judgments are made. According to this theory, experiences typically do not retrieve precomputed

norms that have been abstracted from previous experience. Instead, each experience engenders a somewhat unique norm that is used to evaluate it. Such norms are constructed in an ad hoc fashion and are highly constrained by the current situation.

This account of how episodes are compiled into summary representations is highly compatible with the theory of concept construction presented earlier. In fact, Kahneman and Miller also propose that concept norms are generally constructed in much the same way as experience norms. Norm theory goes further in making an intriguing suggestion regarding the construction of representations in working memory. Earlier, when discussing how a concept is formed in working memory, it was implicitly assumed that pieces of information are retrieved from long-term memory and then combined together as parts of the concept. More specifically, it was assumed that these parts do not receive much processing between being retrieved and being incorporated into the concept. In contrast, Kahneman and Miller assume that what is retrieved from long-term memory does not actually appear in working memory. Instead, the episodes that are retrieved from memory are summarized into a norm, which is then what appears in working memory. This suggests that there are important ways in which information from long-term memory is transformed in the process of being used to construct representations.

In taking norm theory (and exemplar theories) to the limit, one could argue that there are no generic representations at all in memory. Instead, memory only contains episodic information, and all generic representations are the products of an online summarization process that constructs generic representations as they are needed. While this is possible, there is no a priori reason why only episodes and not generic representations should become transferred into long-term memory after being processed in working memory. It is widely believed that information in working memory is transferred to long-term memory to the extent it is deeply processed and to the extent it is processed for a long time (e.g., Craik & Watkins 1973; Glenberg, Smith, & Green 1977). Therefore, to the extent a constructed representation is processed deeply for a long time in working memory, it should be transferred into long-term memory, although what is transferred may not be a perfect replica of what existed in working memory. Once such transfer of a generic representation has occurred, it may later be retrieved and be incorporated into a new concept. Only parts of it may be retrieved, however, and other information may also be incorporated into the current concept, as a result of context and recent experience. To the extent a generic representation is frequently incorporated into a particular concept, it may become highly accessible to the point of being context-independent. In addition, the degree to which such information is transformed in the process of being recruited and incorporated into concepts may decrease such that the form it takes in concepts becomes relatively invariant.

Parallel distributed processing

As reviewed in McClelland and Rumelhart (1986) and Rumelhart and McClelland (1986), many theorists have adopted an architecture for cognition that is fundamentally different from the one traditionally employed by cognitive psychologists. Traditional approaches have assumed that the representation of a specific entity (e.g., for a concept or a property) exists as an invariant component in memory that is retrieved from a specific memory location when needed (e.g., as in many network theories, feature theories, and production systems). On the other hand, parallel distributed processing (PDP) theories assume that the representation of an entity is distributed throughout the entire memory system, or at least throughout a large part of it. Instead of being represented by a unique part of memory, the representation of a specific entity exists as a particular *state* of activation defined over the entire memory system. Representations of different entities correspond to different states of activation in the same memory system. In addition, no component of the memory system corresponds to a particular property or concept. Instead, both properties and concepts are defined as states of activation over all components.

Central to PDP theories are the assumptions that a range of similar states represents the same concept and that these states vary as a function of context. More specifically, various aspects of the current context combine to drive a PDP system into a unique state each time a concept is represented. Consequently, instability of concepts is a natural consequence of the basis PDP architecture. Instability of properties falls out of the basic PDP architecture in a similar manner. Such flexibility makes PDP systems consistent with the empirical findings reported earlier for instability of graded structure. In general, these findings suggest that highly dynamic accounts such as PDP theories will be necessary to account for the full flexibility of cognition.

The theory of concept construction presented earlier appears on the surface to be quite different in architecture than PDP theories. Whereas the theory presented earlier follows traditional architecture in assuming that only a subset of information in long-term memory is ever active in working memory to represent a concept, PDP theories assume that all of long-term memory represents each concept. As discussed by McClelland and Rumelhart (1986) and Rumelhart and McClelland (1986), however, traditional theories and PDP theories are not necessarily mutually exclusive. Instead traditional theories may to *some* extent be higher-level descriptions of the behavior of PDP systems in some cases. Proposing that concepts are constructed in working memory from unique sets of information in long-term memory, for example, may be roughly isomorphic to proposing that unique patterns of activation occur when PDP systems represent concepts. While it may ultimately be more accurate to view knowledge in the framework of PDP systems, highly flexible traditional approaches may capture the essence of PDP systems but be easier to work with.

Conclusion

Standard views of cognition assume that long-term memory contains invariant representations of categories. When exemplars of these categories are encountered, or when it becomes necessary to think about them, invariant category concepts are retrieved from long-term memory into working memory for representational purposes. When these representations are no longer needed, they become inactive, perhaps being slightly altered by that processing experience.

In contrast, alternative views propose in various ways that knowledge in long-term memory is not clearly differentiated into invariant concepts. Instead, the concepts that people use are constructed in working memory from knowledge in long-term memory by a process sensitive to context and recent experience. Concepts in working memory may be stable under some conditions, however, concepts typically appear to vary widely as a function of goals, current context, and recent experience. Although theoretical abstractions that correspond to invariant concepts may serve some useful theoretical and empirical purposes, it may generally be more useful and more accurate to view concepts as temporary constructs in working memory.

NOTES

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1. More specifically, an exemplar's family resemblance is a function of how similar it is to other category members on the average and of how dissimilar it

is to members of contrast categories on the average. As discussed by Barsalou (1983, 1985), how similar an exemplar is to other category members on the average is at least roughly equivalent to how similar it is to the central tendency of the category. This is analogous to the average difference between a number and several other numbers being the same as the difference between the first number and the average of the others. An analogous relationship exists between an exemplar's average dissimilarity to members of contrast categories and its dissimilarity to the central tendencies of contrast categories. Consequently, family resemblance is a measure of similarity to central tendency.

2. Although people make extensive use of stereotypes such as *hippie* and *redneck*, and even though such stereotypes may lead to accurate inferences on some occasions, they more often lead to inaccurate inferences and offer a narrow and prejudiced view of the world. The discussion of stereotypes in this chapter, therefore, is not meant to condone them. Instead we have chosen to study stereotypes because of the extensive role they appear to play in cognition (Fiske & Taylor 1984).
3. These correlations were measured using the *common element correlation* (Deese 1965; McNemar 1969:145–146). To compute the common element correlation between the items generated in two protocols, the number of items occurring in both is divided by the geometric mean of the total number of items occurring in each. This measure ranges from zero, when no item occurs in both protocols, to one, when all items occur in both protocols.
4. It should be noted that information pertaining to frequency of instantiation may take a number of forms. In some cases, people may have acquired frequency information from direct experience about how often exemplars have instantiated a category in a particular context. In many other cases, people may not have had such experience and may instead employ various inference procedures to obtain information about frequency. For example, most Americans have not visited Africa and so do not have direct experience about how often various exemplars of *animals* occur from that point of view. On the other hand, Americans readily make inferences about the frequency of animals in Africa based on their exposure to media and hearsay.
5. McCauley (Chapter 11, this volume) notes that my account of knowledge in long-term memory does not include intuitive theories. I do not consider them here because they are not directly relevant to the issues at hand. The focus on the role of goals in categorization in my previous work (Barsalou 1983, 1985) certainly reflects the importance of such theories. Murphy and Medin (1985) cite this work as evidence for the centrality of intuitive knowledge.
6. As pointed out by Barsalou (1982), context-independent and context-dependent information fall at the upper and lower ends of a continuum of accessibility. Consequently, there are other kinds of information that fall somewhere between being context-independent and context-dependent (e.g., the senses of ambiguous words). In addition, there are differences within the information that is context-independent and within the information that is context-dependent. For example, context-dependent information includes properties that are not stored in long-term memory at all but that are computed when necessary, as well as low accessibility properties that are actually stored in memory (Barsalou 1982:87–88).
7. It should be noted that episodes may not be stored with generic knowledge and may not be organized by generic knowledge, as just discussed. Instead, episodes could be stored separately from generic knowledge and could be unorganized (or could be organized in some other way, such as by temporal sequence). A cluster of related episodes could be retrieved together when a concept is constructed simply because of there being a retrieval process capable of cuing related episodes simultaneously.
8. It is probably stretching things somewhat to assume that people have a single concept for *Chinese point of view* that can be combined with other concepts. As suggested by Barsalou and Sewell (1984), point-of-view effects may result from processing knowledge for categories in the context of a large knowledge base associated with a point of view. Instead of combining these two representations, the knowledge associated with the point of view may be used to cue and interpret relevant information from knowledge associated with the category.

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