Preservation of Specific Experiences in the Representation of General Knowledge

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Dissociations between tests of memory have prompted both dual-memory accounts, suggesting independent representation of episodic and abstract information, and single-memory accounts, emphasizing variability of encoding and specificity of retrieval. Similarly, prototype theories of concept representation emphasize abstraction of class-level information, whereas episodic accounts assume retention of particular experiences. In eight experiments, the representation of pseudoword categories was inferred from the relative perceptibility of probes. When typicality was unconfounded from similarity to previous instances, performance depended on the latter, even when category structure was made explicit and members of a category were massed. Moreover, alteration of the encoding task reversed the relative perceptibility of probes. Although difficult to explain through abstraction of category structure, these results are predictable if events are encoded as experienced and retrieved in parallel. It was concluded that dual-memory accounts assuming automatic, stable abstraction are less powerful than episodic accounts assuming encoding variability and specificity of retrieval to the conditions of encoding.

Certain phenomena of memory seem to require dual-memory systems, differing in the abstractness of the information they retain. An example is the dissociation between tasks requiring deliberate use of memory, such as recognition and recall, and tasks for which memory is apparently incidental, such as the identification of degraded stimuli. Commonly found in amnesics (e.g., Cohen & Squire, 1980; Jacoby & Witherspoon, 1982; Wickelgren, 1979), the dissociation consists of loss of subjective familiarity of recent events coupled with preserved influence of the experience in nonreflective tasks. A similar dissociation has been demonstrated in normal subjects, consisting of independent effects of encoding variables on recognition and perception of briefly presented items (e.g., Carroll, Byrne, & Kirsner, 1985; Jacoby, 1983a, 1983b; Jacoby & Dallas, 1981).

Numerous accounts explain the dissociation by assuming two memory systems retaining different aspects of experience (Moscovitch, 1981, provides a review). For example, the semantic–episodic theory suggests that decontextualized, general information and information about specific events are retained in separate memory systems (e.g., Kinsbourne & Wood, 1975; Tulving, 1972, 1983). The dissociation can thus be explained as a result of differential effects of encoding variables on the accumulation of different forms of knowledge and of differential access to these knowledge systems in reflective and nonreflective tasks. However, other researchers have suggested that a distinction between abstract and event-specific knowledge does not adequately capture differences in the involvement of memory in the two types of task. For example, Jacoby and Witherspoon (1982) demonstrated that performance on items in each of the dissociated tasks is specific to the contexts in which items were previously encountered, suggesting that memory for particular events is involved in both tasks. They argued that the dissociation is based on differences in retrieval cues offered by the tasks, rather than on separate stores retaining general and specific knowledge.

The central issue of this debate is how general characteristics of the world influence memory and how representations arising from experiences of specific events enable us to react to abstract properties of classes of events. This is also the central question of concept formation. Starting from observations of generalization rather than from task dissociations, theories of conceptual representation have developed in parallel with the hypotheses that have been outlined. Like the semantic–episodic hypothesis, prototype theories of concept formation (e.g., Rosch, 1977) suggest that general information about classes is summarized across experiences and may be accessed directly in conceptual tasks, which are free of episodic reference. In contrast, instance theories (e.g., Brooks, 1978; Medin & Schaffer, 1978) parallel an episodic hypothesis, suggesting that class knowledge is represented in distributed fashion through retention of particular ex-
periences, and may be accessed through parallel activation of traces of specific events.

Despite this mutual concern about representation of general knowledge, memory and concept formation have been largely treated as separate issues (see, e.g., almost any undergraduate text). Memory research has made little use of evidence about representation derived from "concept" studies that examine generalization from sets of events of known class structure to novel events of controlled similarity. In turn, studies of concept formation have traditionally relied on analyses of classification performance, to the exclusion of evidence offered by "memory" tasks such as recognition, item completion, and perceptual identification. However, questions about the representations underlying concepts are memory questions, and statements about the representation of general information imply theories of concept formation. This identity is exploited ahead by employing strategies and tasks from both areas to address the common issue of the representation of general knowledge. Specifically, the representation of categorical events is investigated by observing patterns of generalization in a memory-guided perceptual task. Because the stimuli used are categorically related, assumptions from theories of concept formation are used to guide the discussion, but the fundamental issues concern the nature of memory.

**Strategies and Tasks**

It has been frequently observed that the speed, accuracy, and confidence of judging members of many natural and artificial categories covaries with the typicality of the members within their categories (e.g., Armstrong, Gleitman, & Gleitman, 1983; Rips, Shoben, & Smith, 1973). Because typicality is a characteristic of classes rather than individual events, this finding has been interpreted to suggest that class-level information must be abstracted and retained, in addition to information about particular events, as in a semantic–episodic model. Prototype theories (e.g., Rosch, 1977) suggest that the learner abstracts typical aspects of category members, thus forming a summary representation, or category prototype. Judgments about subsequent members are made on the basis of their typicality (similarity to the prototype). Greater typicality permits judgments to be made with greater speed, accuracy, and confidence, which accounts for the correlation of responses with the typicality of the items judged. Thus, this system explains the apparent influence of class-level information on generalization through direct representation of that information.

In contrast, instance models (e.g., Brooks, 1978; Hintzman & Ludlam, 1980; Medin & Schaffer, 1978) assume that only the particular events encountered are represented directly. However, they can also explain the correlation of generalization with typicality (Brooks, Jacoby, & Whittlesea, 1984; Busemeyer, Dewey, & Medin, 1984; Jacoby & Brooks, 1984; Medin & Schwanenflugel, 1981). For some stimuli to be more typical than others, the stimulus space must be clustered (nonuniform). In such spaces, areas containing more instances carry more weight in defining typicality. Thus, a highly typical probe is likely to be very similar to at least one instance in memory, whereas an atypical probe is less likely to be close to any encoded instance. If probe items are classified on the basis of their similarity to the most similar instance previously encountered (Reed, 1972), a correlation of typicality with speed, accuracy, and confidence of classification will result. However, in this case the influence of class-level properties is mediated by a memory system retaining only details of particular events.

Thus, the observation of judgments correlated with typicality is insufficient to determine the form of representation underlying generalization. However, these accounts assume that category members are distributed in a particular way, roughly multidimensional normal, so that their density is correlated with their typicality (i.e., the most typical member has more and closer neighbors than any other member; very atypical items are few and far apart). This type of distribution is probably common in natural categories (Fried & Holyoak, 1984; Rosch, 1973, 1977), and has been generally employed in tests of prototype theory (e.g., Homa, Sterling, & Trepel, 1981; Posner & Keele, 1968). However, such a distribution is not a necessary condition for either type of account. This is demonstrated in the experiments ahead, which employ a variety of distributions of training instances and probes. These distributions are selected so that the similarity of probe to particular instances is unconfounded from their similarity to a prototype based on those instances. To a great degree, this strategy permits evaluation of whether general stimulus characteristics influence behavior through a general or specific representation.

Although classification is the most widely used task in investigations of concept formation, perceptual tasks may also offer valuable evidence regarding conceptual representation. Because experience may influence the perception of complex stimuli, the manner in which the experience is represented can be inferred from differences in the perceptibility of critical items (cf. Neisser, 1967). In the studies reported ahead, predictions about the relative ease of perceiving selected category members are generated on the basis of various general and specific representation assumptions. These predictions are compared to patterns of performance in a perceptual identification task, in which subjects are required to identify briefly presented stimuli. Although unusual in concept research, this strategy has been used to study analogous problems such as the representation of speech (Miller & Isard, 1963), words (Johnston & McClelland, 1974), and schemas (Friedman, 1979), as well as its use in the issue of multiple memory systems (Jacoby & Witherspoon, 1982) described already.

Because perceptual identification is explicitly concerned with the identities of items as individuals rather than as members of categories, its use in the study of concept formation may be surprising. However, it is irrelevant to the task whether an item is identified because it is specifically familiar or generally similar to many items seen before. Thus, like categorization, it is a task in which summary information may be expected to demonstrate an influence. However, it differs from classification in other ways that make it a valuable additional tool. First, because subjects are required to produce components of stimuli rather than simply a class label, the perceptual task permits identification of compounds of stimulus components used to judge items (Feustel, Shiffrin, & Salasoo, 1983; Murrell & Morton, 1974). The stability of these units is an important aspect of the representation issue, as discussed later. Second, because the category membership of an item is incidental to the task, it is likely that
the influence of past experience is the major factor determining performance. In contrast, because classification explicitly demands that an item be treated as an instance of a concept, it may additionally reflect deliberate, active problem-solving strategies invoked at the time of test.

Deliberate strategies may also affect the course of category learning and representation. The training phase of many concept experiments makes clear to subjects that they will later be required to classify the stimuli. The development of conceptual structure when learning is not deliberate has received less attention, although demonstrations of incidental learning having effects on explicit (e.g., Craik & Tulving, 1975) and incidental (e.g., Jacoby, 1983b) tests of retention are common in the memory literature. Nonetheless, many theories of concept formation have proposed that abstraction of category structure occurs independent of any requirement or intention to abstract. This issue is important in evaluating the nature of representation systems. If abstraction is automatic, then it is reasonable to focus on differences in the information stored to explain differences in performance, as in a dual-memory account. However, if abstraction occurs only under task demand or conscious control, then it may be better to think of the nature of the representation as a by-product of stimulus processing, and to concentrate on differences in encoding and retrieval conditions as the locus of differences in performance.

Mechanisms have been described whereby stimuli could be organized into clusters without conscious effort, such as cue validity (Beach, 1964a, 1964b), diagnosticity (Tversky, 1977), or likelihood ratio (Fried & Holyoak, 1984). Other authors have proposed that abstraction of some kind of class-level information is automatic, such as prototypes (e.g., Homa et al., 1981; Rosch, 1977), the variability of stimulus dimensions (Fried & Holyoak, 1984), or frequency of combinations of features (e.g., Elio & Anderson, 1981; Hayes-Roth & Hayes-Roth, 1977). In contrast, some evidence has been presented that abstraction does not occur if idiosyncratic information is emphasized (Medin, Dewey, & Murphy, 1983). Automaticity of abstraction is assessed later through comparisons of performance when the categorical nature of stimuli is explicit and central to the task, explicit but incidental, or implicit in the encoding task.

Experiment 1

Rosch (1975, 1977) and her associates (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) have pointed out that properties of natural categories tend to be correlated. As a result, the categories possess graded internal structure, consisting of differences in the typicality of items. However, although prototype representation is made possible by the correlation of properties, it is frequently assumed that subjects forming a prototype do not abstract this information. Prototype theories in general (e.g., Homa et al., 1981; Posner & Keele, 1968; Rosch & Mervis, 1975) assume that typicality information is abstracted independently for each dimension (Malt & Smith, 1984; Medin & Schwanenflugel, 1981). In contrast, feature-frequency models (e.g., Elio & Anderson, 1981; Hayes-Roth & Hayes-Roth, 1977; Neumann, 1977) count the frequencies of all possible levels of feature compounds, thus retaining information about dependence of features between dimensions.

Experiment 1 was designed to test two accounts assuming that only class-level information (semantic memory) determines judgments about categorical events. Both assume independent abstraction of information. They differ in assuming that only features typical of a dimension are retained, or that information about how features vary within dimensions is also abstracted, referred to ahead as simple and complex representation, respectively. Models assuming simple independent representation propose that only the highest frequency features or the average dimensional values are retained and that correlations of values on different dimensions are not. Essentially, the prototype is assumed to be the multidimensional mean or mode of the category. The most popular prototype models, which share the idea that the prototype is an ideal category member (Rosch, 1977), fall into this class. Under these assumptions, the effective typicality of a probe (its similarity to the prototype) can be computed simply as the sum of features shared between the probe and prototype pattern.

In contrast, complex independent models assume that memory abstracts and retains variability information such as the identities and frequencies of atypical features, or the range or variance of dimensional values, although it does not retain information about covariation of features. Some prototype variants (e.g., Homa & Vosburgh, 1976) fall into this class, as do first-order feature-frequency models (e.g., Neumann, 1974) and distribution-abstraction models (Fried & Holyoak, 1984). Family resemblance models (Rosch & Mervis, 1975) also fit this class inasmuch as they code the dispersion of features by means of differential frequency counts for features. Under these assumptions, the effective typicality of a probe may be rated by taking into account the proportional frequency of occurrence of each of its features or in dimensional terms by weighting each stimulus value by its proximity to the mean value for the dimension.

The two classes of simple and complex independent models are representative of the majority of accounts assuming that purely semantic information is accessed in judging members of categories. Later experiments assess models assuming that both semantic and episodic information is employed.

Experiment 1 also provided an opportunity to test a form of episodic account, the nearest neighbor model (Nahinsky & Morgan, 1983; Reed, 1972). In contrast to the category-level representation assumed by semantic-memory accounts, this model proposes that experience of category members results in retention of the instances themselves. It further assumes that probes are processed with reference to the most similar trace, receiving facilitation in proportion to their similarity. In common with prototype models, the similarity between a probe and trace is assumed to be a linear function of the number of features they share.

Method

Subjects. A total of 15 undergraduate students, participating for course credit, were used in each condition of Experiment 1.

Stimuli. A stimulus domain consisting of two categories of CV/CVC pseudowords was created as a common pool for all of the experiments in this article. Each experimental condition employed a selected subset of this pool, using some items from both categories as training items
Table 1

<table>
<thead>
<tr>
<th>Stimulus type</th>
<th>II,</th>
<th>IIa</th>
<th>IIb</th>
<th>III</th>
<th>IV</th>
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</tr>
</tbody>
</table>

Note. Roman numerals denote deviations from prototype; alpha subscripts denote sets of equal typicity. The letters T, E, K, Y, and P do not discriminate between categories.

and some as target items in a transfer task. Table 1 shows the entire domain from which stimuli were drawn.

Each category was constructed by generating sets of deviations from a prototypical item (e.g., FUGI), under the constraint that the prototype remained the multidimensional mode of the resultant set (e.g., the set FURG, FURII, FURIT, and FURII). The letters used to create distortions (P, E, K, E, and T) were applied symmetrically to both prototypes, so that these letters did not distinguish the category to which the resultant items belonged. Three such sets were generated, all items within a set differing from their prototype by one, two, or three elements. These sets are referred to below in terms of the number of deviating elements. For example, a type II item like FEKIG differs from its prototype FUGI by two elements (see Table 1). Although the structure of the stimuli remained constant between subjects, the letters constituting items were counterbalanced.

In addition, alternate sets of items were generated at the one- and two-deviation levels. These alternate sets deviated from their prototype to the same degree as the original sets, but each item of an alternate set differed from the most similar item in the original set by exactly one or exactly two elements. These alternate sets are distinguished by means of a subscript. Thus, for example, II, items (e.g., FEKIG) all differ from the prototype (FUGI) by two elements; IIb items (FYKIG) do also, but, in addition, each differs from the closest II, item by one element, whereas II, items (FUKIG) differ from both the prototype and the closest II, item by two elements.

Two further sets of items were created for Experiments 1a and 1b by reversing type I, or type II, items, respectively. These sets, called type IV, differed from the prototype pattern by at least four elements.

Procedure. The subject's task consisted of three phases. First, in a pretest the subject was exposed to a set of 30 stimuli, presented tachistoscopically on a Zenith monitor driven by an Apple IIe. Each trial exposed one stimulus for 30 ms, immediately followed by a pattern mask. Directly after each exposure, the subject was required to reproduce on paper the five letters of the stimulus, in the correct position, guessing if necessary. Trials were initiated by the subject when he or she was ready. In Experiment 1a the 30 presentations consisted of the 10 IV, 10, and 10 IV, items, and in Experiment 1b, which was a near replication of Experiment 1a, they consisted of the 10 II, II, and IV, items.

A training phase followed, in which subjects were required to copy 30 stimuli, which remained on the screen until they were terminated by the subject. In Experiment 1a the training set consisted of the 10 IV, items (5 from each of two categories) presented three times, each in random order. The training set for Experiment 1b consisted of the 10 IV, items. Subjects were not informed that they were in a concept task, nor that there were two categories of items. The stimuli presented in the training phase are called old, reflecting the fact that the subject has had a good opportunity to look at them; these items are indicated in text by a subscript O (e.g., I0, IV0). Last, a posttest was conducted, identical in all respects to the pretest.

If abstraction of general information is automatic, subjects would be expected to develop a summary representation despite the lack of instruction about category structure. The summaries should conform to the definitional categories, because cue validity was maximal for those categories. On the assumption that the feature is the single letter in position (in keeping with Rosch, Simpson, & Miller, 1976), the average cue validity of training stimuli for the definitional categories of Experiment 1a was .9 and represented higher cue validity than any other way of organizing training items into any number of categories. In Experiment 1b the average cue validity of training stimuli was .8, again maximal for the domain.

Data scoring. Each production in the pre- and posttest phases was scored for the number of elements correct in position. The pretest score for each item was subtracted from its posttest score to give a gain score for each item. These gain scores were averaged over the 10 items of each type, yielding an index of the gain in perceptibility for each type of item.

The relative values of posttest scores obtained without taking a baseline could be contaminated by differential preexperimental perceptibility of the item sets. However, the baseline measure permits detection of preexperimental inequalities among the stimulus types, and if the baselines are approximately equal, there is no reason to expect that either preexperimental perceptibility or experience of items in the pretest will differentially affect gain scores. As a result, the relative magnitudes of gain scores was interpreted as due to an alternation of the processing system during the training phase.

Results and Discussion

Eight experimental conditions are discussed in this article, differing primarily in the type of training items used and in the distribution of transfer items. To assist the reader in comparing the patterns of relative perceptual gain obtained in various conditions, Table 2 summarizes the training and transfer stimuli for all conditions and reports transfer scores for each.

Mean pretest scores could range from zero through five letters correct in position per item. For Experiment 1a they were I0, 2.66; I1, 2.78; and IV, 3.01, and did not differ significantly (within-subject analyses of variance (ANOVA), F(2, 28) = 1.36). Mean pretest scores from Experiment 1b were II0, 2.10; II1, 2.19; and IV, 2.29, again not differing significantly, F(2, 28) = 1.27. Thus, prior to training, the various types were about equally perceptible. However, because old items were identified least well in both cases, their relative gain would be spuriously large if ceiling effects limited the possible gains. However, posttest scores in both studies were actually in reverse order from pretest scores, and no scores were near ceiling. Mean posttest scores from Experiment 1a were I0, 4.02; I1, 3.56; and IV, 3.18; and from Experiment 1b, II0, 3.59; II1, 2.94; and IV, 2.42. Thus, it is unlikely that ceiling effects contributed significantly to differential gains.

The obtained mean gain scores for Experiment 1a were I0, 1.36; I1, 0.78; and IV, 0.17. These means were significantly
Table 2  
Training Stimuli, Transfer Scores, and Predictions of the Episode Model for all Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Training stimuli</th>
<th>Transfer scores</th>
<th>Predictions (episode model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>I₄</td>
<td>I₄: 1.36</td>
<td>I₄: 1.87</td>
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<tr>
<td></td>
<td>I₆</td>
<td>I₆: 0.78</td>
<td>I₆: 1.38</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>IV: 0.17</td>
<td>IV: 0.03</td>
</tr>
<tr>
<td>1b</td>
<td>II₄</td>
<td>II₄: 1.49</td>
<td>II₄: 1.21</td>
</tr>
<tr>
<td></td>
<td>II₆</td>
<td>II₆: 0.75</td>
<td>II₆: 0.58</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>IV: 0.13</td>
<td>IV: 0.14</td>
</tr>
<tr>
<td>2</td>
<td>II₄</td>
<td>II₄: 1.07</td>
<td>II₄: 1.21</td>
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<tr>
<td></td>
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<td></td>
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<td>II₈: 0.58</td>
</tr>
<tr>
<td>3</td>
<td>II₄</td>
<td>II₄: 0.95</td>
<td>II₄: 0.93</td>
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<tr>
<td></td>
<td>III</td>
<td>III: 1.13</td>
<td>III: 0.75</td>
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<tr>
<td></td>
<td>II₆</td>
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<td>III: 0.24</td>
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<td>II₄: 0.80</td>
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<td></td>
<td>II₆</td>
<td>II₆: 0.34</td>
<td>II₆: 0.60</td>
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<td></td>
<td>III</td>
<td>III: 0.11</td>
<td>III: 0.40</td>
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</table>

Note. Relative facilitation scores predicted by the episode model are made under \( r = 3 \) for Experiments 1–6 and \( r = 1 \) for Experiments 7 and 8.

Different (within-subjects ANOVA, \( F[2, 28] = 23.64, p < .01 \); all pairwise comparisons differ \( p < .01 \) by Newman-Keuls a posteriori test). The obtained mean gain scores for Experiment 1b were II₄ = 1.49; II₆ = 0.75; and IV = 0.13, \( (F[2, 28] = 33.62, p < .01\); all differences between means significant at \( p < .01 \). Thus, in both experiments, old items are best perceived, followed by novel items equally close to the category center, followed by items far from the center.

These results are consistent with the predictions of the nearest neighbor model because it suggests that the accuracy of perception will covary with the number of features shared between the probe and the closest training instance. For Experiment 1a the model predicts that I₄ probes, each identical to a member of the training set, should be most accurately perceived, followed by I₆, each differing by one feature from the closest instance, followed by type IV items, sharing only one feature with the most similar instance. Similarly, in Experiment 1b the II₄ probes, identical to the training instances, are predicted to be best perceived, followed by II₆ (less similar), followed by IV (least overlap with training items).

The predictions of the first semantic-memory model, assuming simple independent representation, are disconfirmed. This account suggests that subjects will abstract the multidimensional mode of each category (e.g., FURIG) and that similarity to this mode, measured in features shared, will predict perceptual facilitation. Because the I₄₀ (e.g., FUKIG) and I₆₀ (e.g., FUTIG) items are equally similar to the mode, they should be perceived with equal accuracy, despite I₄ items being old and I₆, novel. Similarly, in Experiment 1b the II₄₀ (e.g., FEKIG) and II₆ (e.g., FUKIP) items are equally similar to the prototype and should be equally perceived. Both of these predictions are contradicted.

The second semantic-memory model, assuming complex independent representation, correctly predicts the results of Experiment 1a. This account predicts a difference in performance on old and novel items because it assumes that both modal features (F,U,R,I,G) and features deviating from the mode (P,Y,K,E,T) are represented in memory. Thus, each component of a I₄₀ item like FUKIG matches a component of the complex prototype. However, when a I₄₀ item like FUTIG is presented, the deviation component T (presented in the third position), fails to match the representation, because T was only presented in the fifth position in training items (e.g., in the I₄₀ item, FURIT). As a result, complex independent models predict poorer performance on I₄₀ than on II₄₀ items.

However, this account cannot explain the results of Experiment 1b. The training items in this condition each possessed two deviation components. Each particular deviation element appeared in two training (I₄) items (see Table 1). When used in novel (II₄) items, they were presented in exactly the same positions. Thus, the deviation components P and Y in the training item PURYG occur in the same position in the novel items FUTIG and FURYT. As a result, complex independent representation incorrectly predicts that II₄₀ and II₆₀ items should be equally perceived.

In fact, II₄₀ and II₆₀ items differ only in the combination of components. As a result, each feature of II₄₀ items is presented in a totally familiar context, whereas the context of features in II₆₀ items is to some extent novel. Because II₄₀ items are better perceived than II₆₀ items, it appears that the familiarity of the context in which a feature occurs affects its identification. Because this context consists of the identities of other features, it appears that the identification of a feature depends on the reinstatement of other features with which it was originally processed.

This conclusion contradicts an assumption of both simple and complex independent versions of semantic representation, that features of items are processed independently. Table 3 permits analysis of these competing hypotheses, presenting probabilities of identification of both modal components (e.g., F,U,R,I,G) and components deviating from the mode (e.g., T,E,K,Y,P), tabulated separately for each type of item in Experiment 1a. The various types of items restate to differing degrees the context(s) in which a particular feature was presented in the training task, thus permitting an evaluation of the effects of context on perception.

The first column of Table 3 presents the pretest probability of identifying a particular modal or deviation component in a I₄₀, I₆₀, or IV item. The second column gives similar data for the posttest. The third column gives the difference between the first two and represents the gain for a particular type of component
Table 3

Letter-by-Letter Probabilities for Experiment 1a

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Gain</th>
<th>Total gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>I₀ O modal</td>
<td>.55</td>
<td>.82</td>
<td>.27</td>
<td>1.08</td>
</tr>
<tr>
<td>I₀ O deviation</td>
<td>.46</td>
<td>.71</td>
<td>.26</td>
<td>1.02</td>
</tr>
<tr>
<td>I₀ modal</td>
<td>.57</td>
<td>.77</td>
<td>.20</td>
<td>1.00</td>
</tr>
<tr>
<td>I₀ deviation</td>
<td>.50</td>
<td>.48</td>
<td>-0.02</td>
<td>1.00</td>
</tr>
<tr>
<td>IV modal</td>
<td>.62</td>
<td>.64</td>
<td>0.02</td>
<td>1.08</td>
</tr>
<tr>
<td>IV deviation</td>
<td>.53</td>
<td>.50</td>
<td>-0.03</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Note. Gains represent the increased probability of identifying a letter after training.

Table 4 presents corresponding data from Experiment 1b. Deviation components of II items, gaining a total of 0.18 letters per item, contribute less than deviations in I₀O items, gaining 0.46 letters per item (p < .01). Because both deviations are presented in their original position, the complex independent hypothesis is again contradicted. Table 4 also illustrates that, as in Experiment 1a, a modal component is better perceived in an old item (gaining 1.08 in I₀O items) than in a novel item (gaining 0.63 in II items, or 0.12 in IV items; p < .01, for both comparisons), although the only difference among these three presentations is the degree to which neighboring elements are reinstated. Both findings again suggest that perception of any component is dependent on prior experience of that component in its present context. (Two-way within-subjects ANOVA; stimulus type, F[2, 28] = 29.9, p < .01; modal deviation, F[1, 14] = 14.9, p < .01; interaction, F[2, 28] = 2.3, p > .05. Significance levels of effects were determined by means of posteriori tests of simple effects.)

Prototype models in general, which assume that the similarity of a probe to the representation is the sum of independently coded features shared between the two, have difficulty in explaining why performance on particular features depends on their context. Yet the assumption of independence is not an arbitrary one. Although the frequency of particular features across a set of items is evidently class-level information, the frequency of joint occurrences is less obviously so. In the extreme, the joint occurrence of n features defines particular items, and the frequency of the n-tuple defines the frequency of presentation of a particular instance. Thus, evidence of dependent processing of features at least demonstrates that an extreme form of the semantic–episodic hypothesis, employing only semantic information to predict performance in a nonreflective task, is inadequate.

Experiment 2

Posner and Keele (1968), finding that items presented a second time were classified more accurately than equally typical novel items, concluded that typicality was insufficient to account for performance and that memory for individual instances must also affect categorical judgments. To explain these results, they proposed two hybrid representation systems involving both episodic and semantic memory. In one variant, called a weak-hybrid model, both types of memory are assumed to influence performance on all category members, whether

Table 4

Letter-by-Letter Probabilities for Experiment 1b

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Gain</th>
<th>Total gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>I₀ O modal</td>
<td>.40</td>
<td>.75</td>
<td>.35</td>
<td>1.08</td>
</tr>
<tr>
<td>I₀ O deviation</td>
<td>.45</td>
<td>.68</td>
<td>.23</td>
<td>0.46</td>
</tr>
<tr>
<td>I₀ modal</td>
<td>.43</td>
<td>.64</td>
<td>.21</td>
<td>0.63</td>
</tr>
<tr>
<td>I₀ deviation</td>
<td>.45</td>
<td>.54</td>
<td>0.09</td>
<td>0.18</td>
</tr>
<tr>
<td>IV modal</td>
<td>.47</td>
<td>.51</td>
<td>0.04</td>
<td>0.12</td>
</tr>
<tr>
<td>IV deviation</td>
<td>.44</td>
<td>.47</td>
<td>0.03</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Note. Gains represent the increased probability of identifying a letter after training.
novel or old. However, Posner and Keele, followed by Homa et al. (1981), argued for strong-hybrid representation, suggesting that memory for particular items only facilitates recurrences of those items, whereas abstracted typicality information influences performance on all items. Experiment 2 was designed to test this strong-hybrid assumption.

Method

Subjects. Thirty undergraduate students participated for course credit in this and in all subsequent experiments.

Procedure. The procedure was the same as in Experiment 1, with the exception that in Experiment 2 the \( I_0 \) items (e.g., \( \text{FEKIG} \)) were used in training, and the stimulus set \( II_0 \), \( \Pi_0 \), and \( \Pi_1 \) were used in transfer (e.g., \( \text{FEKIG, FYKIG, FUKIP} \)). All of these stimuli differ from the modal stimulus (\( \text{PURIG} \)) by exactly two features, but differ from the nearest training instance by zero, one, or two features. The average cue validity of the training items for the definitional categories was 0.8, which is maximal for the space.

Predictions. The strong-hybrid model, like an instance model, predicts that \( II_0 \) items will be better perceived than either type of novel items, by virtue of having been encoded during training. The interest in this condition centers on the relative perceptibility of the two classes of novel items, \( II_0 \) and \( II_1 \). The strong-hybrid model predicts that these two types will be perceived about equally because they are equally typical under either simple or complex independent assumptions of typicality and because both are novel and so should be perceived with assistance only from the prototype. By contrast, the nearest neighbor instance model predicts that \( II_0 \) items will be better perceived than \( II_1 \) items because \( II_0 \) items are each more similar to a training item.

Results and Discussion

Baseline accuracy scores were \( II_0 = 2.32; II_1 = 2.25; \) and \( II_0 = 2.43. \) There were no significant differences among these scores (within-subjects ANOVA, \( F[2, 58] = 1.42 \)). The obtained mean gain scores were \( II_0 = 1.07; II_1 = 0.80; \) and \( II_1 = 0.51 \) \((F[2, 58] = 14.06, p < .01) \); pairwise, \( II_0 \) items gained more than \( II_1 \) items \((p < .01) \) by Neuman-Keuls, and \( II_0 \) items gained more than \( II_1 \) items \((p < .05) \). When tested nonparametrically by Wilcoxon, both differences are significant at \( p < .01 \).

These results indicate that \( II_0 \) novel items are better perceived than \( II_1 \) novel items, contrary to the predictions of strong-hybrid representation. However, this conclusion does not deny that typicality may play a role in the perception of novel items. To test the weak form of hybrid model, which suggests that both typicality and similarity to instances exercise an effect on perception of novel items, one must examine stimulus sets in which distance to old items is held constant and distance to the prototype is manipulated. Experiments 5 and 6 present evidence relevant to this issue.

The results of the present experiment, like those of Experiment 1, are consistent with the predictions of the nearest neighbor model. However, these studies were designed primarily to test assumptions about representation systems involving semantic memory alone or in combination with episodic memory. Experiment 3 examines some implications of purely episodic systems.

Experiment 3

The deterministic nearest neighbor model, which is the one usually contrasted to abstractive models (e.g., Hayes-Roth & Hayes-Roth, 1977; Homa et al., 1981; Reed, 1972), assumes that each exemplar presented is encoded literally, without abstraction of summary information, and that perception of a probe will be guided by one encoded instance, the one objectively the most similar to the probe. This is an extreme form of item-level explanation, suggesting that the representation of experience consists of exact respecification of the instance encountered. Experiment 3 was designed to test the single-access assumption of this model.

Method

The procedure was identical to that in Experiment 2, except that Experiment 3 used the \( II_0 \) items (e.g., \( \text{FEKIG} \)) in training and the stimulus set \( I_0 - II_0 - III \) (e.g., \( \text{FUKIG, FEKIG, PEKIG} \)) in transfer. These items differ by one, two, or three features from the mode (\( \text{PURIG} \)) and by one, zero, and one features from the nearest training item. Mean cue validity of the definitional categories was 0.8, again maximal for the space.

Results and Discussion

The obtained mean gain scores were \( I_0 = 0.95; II_0 = 1.13; III, 0.75 \) (within-subjects ANOVA, \( F[2, 58] = 9.00, p < .01 \); pairwise, the training items \( II_0 \) were better perceived in transfer than the \( I_0 \) items, \( p < .05 \), and the \( I_0 \) items better than the III items, \( p < .05 \).

These results contradict the hypothesis that the number of features shared with a single encoded instance predicts the relative amount of assistance a probe receives in perception. If this were the case, III probes would have been just as well perceived as \( I_0 \) items, inasmuch as each differs from the nearest training item by exactly one feature. Instead, these results suggest an effect of typicality on the relative ease of perception of the probes because more central novel items are better perceived.

Prototype theories interpret correlations with typicality as due to direct representation of typicality by means of an abstracted prototype. In contrast, average-distance models (Reed, 1972) assume that typicality information is not directly coded and that the correlation is an emergent phenomenon arising because the perception of a probe is guided simultaneously by multiple instances and because typicality indexes the proximity of a probe to the set of instances. The latter interpretation of typicality is also in accord with the data of Experiment 3 because the \( I_0 \) probes share an average of 2.6 elements with training items in general, whereas III probes share only 1.8 (as can be verified in Table 1). Thus, if all encoded instances simultaneously guide perception of the probes, the \( I_0 \) probes would be expected to receive more facilitation than the III probes, as they do.

However, the data of Experiment 3 cannot be completely explained as a typicality effect because the old items (\( II_0 \)) share an average of only 2.2 dimensional values with training items in general (including themselves), but are better perceived than more typical novel probes (\( I_0 \)). Moreover, in Experiment 2 the three types of probes \( (II_0, II_1, \) and \( III) \) were of identical typicality, each sharing an average of 2.2 elements with training items in general, but differed in perceptual accuracy, the pattern being predictable by their proximity to the nearest training item.
Preservation of Particular Experiences

Thus, both typicality (proximity to the center or proximity to all instances) and proximity to particular instances appear to be important. A model able to account for both effects might combine the multiple-access assumption of average-distance models, with the nearest neighbor model’s emphasis on proximity to particular instances. First, to account for the importance of typicality, the model might assume parallel access of all instances, with the influence of any one instance depending on its similarity to the probe. Second, to account for the observation that proximity to a particular instance may outweigh typicality, the model might assume that the effective similarity of a probe and trace is a nonlinear function of their proximity (number of features shared). As a result, proximal instances could be more similar than their proximity suggests, and distal instances less similar, so that close proximity to a single instance may result in higher overall similarity than moderate proximity to many instances. This nonlinearity assumption is in accord with the results of Experiment 1, which indicated that features are not processed independently, so that a count of shared features may be an inappropriate metric of effective similarity.

This reasoning is the basis of a new account of representation and processing, the *episode model*. Like an average-distance model, this model assumes that multiple encoded instances simultaneously guide the processing of a probe, that a probe is assisted by any particular instance to the degree of similarity between them, and that the total assistance a probe receives is the sum of the assistance it receives from each instance separately. Unlike any model discussed so far, however, it does not assume that the similarity of a probe and instance (a psychological scale) is an invariant function, either linear or nonlinear, of the sum of their shared components (an experimenter-defined scale). Instead, it assumes that the relation between similarity and number of shared components depends on how the subject experiences the stimuli, in particular on the degree to which the subject integrates stimulus elements in processing them to satisfy a particular task.

More concretely, the episode model assumes that each episode of encountering an item consists of processing the item for some purpose and results in a memory trace. The purpose of the encounter determines how the components of the item are processed, varying from processing each quite separately, through to processing all of the components as a single unit. The trace reflects the degree to which the components were integrated in encoding, through the degree to which its components can later be accessed independently. This property of the trace determines the relationship between similarity and shared components. If the components of a trace are independently accessible, its similarity to a probe is a linear function of the number of components shared. In contrast, if the trace consists of dependent components, the relation is nonlinear, with similarity declining rapidly compared with number of shared components.

Formally, the episode model assumes that a feature of a trace and a corresponding feature of a probe have some proximity, which is given by the physical degree of match between the two, and (following Medin & Schaffer’s, 1978, context model) the salience of that pair of features. This proximity is scaled from zero to one, zero representing a pair of features with no physical match or no salience. The sum of these proximities is the multidimensional proximity of the trace and probe. The similarity of the trace and probe is assumed to be a function of the multidimensional proximity, where the function is defined by the level of integration of separate dimensions occasioned by the task. The total facilitation received by a probe is the sum of its similarity to all traces. The similarity function takes the form of the general distance formula, converted to proximity. The whole model may be specified as

\[ \text{Total relative facilitation} = \sum_{j=1}^{m} \left( \sum_{i=1}^{n} \frac{p_{ij}}{r} \right)^{1/r}, \]

where \( p_{ij} \) is the degree of match between the \( i \)th element of the target and the \( j \)th element of the \( i \)th trace, and \( r \) is a parameter indexing the average value of the dependency of components within traces. The total facilitation so computed is a relative quantity, meaningful only in the comparison of two probes. Because the range of values assigned to degree of match is arbitrary, the absolute magnitude of the quantity is also arbitrary.

This model is similar to Hintzman and Ludlam’s (1980) Minerva, or Medin and Schaffer’s (1978) context model, in assuming multiple access and salience differences between dimensions. However, whereas these are relational models (Smith & Medin, 1981), implying the retention of configural information (Medin, Altom, Edelson, & Freko, 1982), the episode model assumes that the relationship between similarity and number of shared elements depends on the degree of integration of elements occasioned by the task, and may range from additive, through moderately dependent, to totally configurual.

To explain this in more detail, traces can be thought of as possessing generalization gradients, expressing the degree of facilitation a trace can support (its similarity to a probe) as a function of the number of elements it shares with a probe. The episode model defines the slope of the gradient through the integration parameter, reflecting the degree of dependence among the components of the trace. Where \( r = 1 \) (city-block metric), the generalization gradient is linear: A unit change in the number of matches between a trace and probe causes a unit change in similarity. Thus, this metric defines statistical independence of the elements of the trace item (or separability, in Garner’s, 1974, terms). By contrast, for \( r = 2 \) (Euclidean metric), the elements of a trace do not have independent impact on facilitation: The change in similarity resulting from increasing the match between target and trace depends on the number of components shared before the change. Thus, a change from .2 to .4 overlap of trace and target causes less increase in similarity than does a change from .8 to 1.0 overlap (.4^2 - .2^2 = .12; 1.0^2 - .8^2 = .36). In Garner’s terms, this defines integrality of the elements within each trace. The generalization gradient is curvilinear, with similarity falling off rapidly with respect to number of matches. In the extreme case, where \( r \) approaches infinity (Garner’s dominance metric), the generalization gradient is flat and near zero for most of the range of possible overlap values. Only near-perfect matches between trace and target result in significant facilitation. (Values of \( r \) between zero and one can also be imagined. In this case, the effective unit of processing is smaller than the
experiment-defined component, perhaps at the level of the letter segment, and the facilitation gradient is curvilinear, but bowed out.)

As well as affecting the similarity between one trace and the probe, alteration of the metric affects the relative contributions of traces to total facilitation. Where \( r = 1 \), each trace contributes to overall similarity in proportion to its overlap with the target, as in independent models. However, as the metric increases toward infinity, the trace having largest individual similarity to the target provides a disproportionately large amount of the total facilitation accruing to the target. The dominance metric in effect predicts that the facilitation of a target is determined only by its similarity to its nearest neighbor.

To test the model, it was necessary to estimate the value of \( r \) for the particular encoding task of copying training items. This was accomplished by generating predictions from the model for a range of values of \( r \) and fitting the predictions to the results obtained in Experiments 1–3. For these purposes, the salience of all of the features was assumed equal (which is probably not accurate, but not seriously wrong), and the degree of match between features of training stimuli and probes was rated as zero (nonmatch) or one (match). The model made incorrect ordinal predictions with values of \( r \) less than 2.5 (reversing the perceptibility of the \( I_1 \) and \( I_{20} \) items in Experiment 3), but successfully postdicted the results of all experiments with a value of the integration parameter of about \( r = 3 \). (Total relative facilitation scores generated from the model are shown in Table 2.) This value indicates that stimulus components are perceptually integrated, consistent with the dependence found in Experiment 1.

The episodic model was thus found capable of postdicting results of several studies in which a variety of semantic-episodic and purely semantic predictions had failed. However, because postdiction is at best a weak test, the predictive power of the parallel-access and processing integration assumptions was evaluated in a further series of studies involving a variety of distributions of training items and encoding tasks.

**Experiment 4**

Posner and Keele (1968) discovered that novel items close to the category center may be as much facilitated as are less central old items, a pattern of transfer that has been cited as strong evidence for abstract representation (Homa et al., 1981; Rosch, 1977). This result is in contrast with the evidence reported in Experiments 1–3, in which old items were always better perceived than novel items of equal or greater typicality. Experiment 4 was designed to test whether the episodic model could predict results like those achieved by Posner and Keele. It was hypothesized that these results could be obtained for the same probes used in Experiment 3 if, under the assumed metric of similarity, novel and old probe items were equally similar to training items in general. This condition was achieved by increasing the number of training items from 5 to 15 per category, all two features distant from the category center. With a large set of instances, moderate proximity of a probe to many of the training items may confer as much total similarity to the whole set as does high proximity to fewer items. Under these conditions, novel items close to the category center may be as similar to the whole set as are old items farther away.

**Method**

**Procedure.** The method of Experiment 4 was identical to that of Experiment 3, except in its training stimuli. Unlike previous conditions, it employed three sets of stimuli, \( I_A, I_B \), and \( I_C \), as training items. They were presented once only each, thus achieving the same number of learning trials (30) that had been used in all of the foregoing conditions. As usual, training stimuli formed two categories, in this case with mean cue validity of .3 (maximal for the space). The stimulus sets \( I_A, I_{20} \), and \( I_C \) were employed as probes, as in Experiment 3.

**Predictions.** The episodic model, with \( r = 3 \), was used to predict the rank order of transfer scores, employing all 30 training items as traces. The mean similarity scores computed in this fashion were \( I_A, .92; I_{20}, .87 \); and \( I_C, .58 \), giving a predicted order \( I_A > I_{20} > I_C \), with only a marginal difference predicted between \( I_A \) and \( I_{20} \).

**Results and Discussion**

The obtained mean gain scores were \( I_A, 0.81; I_{20}, 0.78 \); and \( I_C, 0.58 \) (within-subjects ANOVA, \( F[2, 58] = 2.41, p < .09 \)). Planned comparisons indicated that the means of \( I_A \) and \( I_{20} \) are not significantly different, although both of those means are greater than the mean of \( I_C \) (.85, p < .05, in both cases), in accord with the model's predictions. Thus, the episodic model, assuming multiple access to dependently coded traces, was found to be capable of accounting for a pattern of results usually interpreted to support abstraction of typical information. In general, if training items are densely dispersed around the category center, as in this condition, or if their density is correlated with proximity to the category center, as in the domain used by Posner and Keele (1968), then central novel probes may be more similar than old probes (under the appropriate metric) to representations of experiences of particular instances.

The training sets of Experiments 3 and 4 had identical modes and variability, as computed under the assumption of independence. The fact that different transfer patterns were observed in these two cases (\( I_{20} > I_A > I_C \) in Experiment 3 vs. \( I_A, I_{20} > I_C \) in Experiment 4) indicates that a summary of central tendency and variability information is an inadequate model of the effective representation. The episodic model is more successful in accounting for these results because it retains additional information about particular experiences.

This study also provided an opportunity to assess the worth of the model's parallel-access assumption. Nearest neighbor models, which lack this assumption, predict that old items are always best perceived because they are most similar to the training items. In contradicting this prediction, the results of Experiment 4 support the power of parallel access.

**Experiment 5**

Perhaps the most appropriate test of the relative importance of specific and general knowledge would be a pair of experiments, one of which held similarity to the category center constant and varied similarity to instances and the other reversed the relationship. The first of these has already been described: Experiment 2 indicated a strong role for similarity of novel items to particular training items when their similarity to the category center was held constant. However, the other experiment is impossible if one assumes that it is not similarity to the nearest, but similarity to all traces, that is important. Although
variation in the distance of a probe from the category center need not affect the distance to the nearest training item, as seen in Experiment 3, it does of necessity alter the similarity of that item to training items in general. Given this constraint, Experiment 5 was constructed as a reasonable approximation.

Method

Procedure. The procedure of Experiment 5 was identical to that of Experiment 4, except that it used the $I_0$ items in training (with mean cue validity of .8)—as did most of the preceding conditions—and the transfer set $I_{0}$, $I_{1}$, and $I_{3}$.

Predictions. This transfer set pits similarity to particular instances directly against typicality: $I_{1}$ items (e.g., FUKIP) differ by two elements from both the nearest item (PEEK) and also the category mode (FUKIP), whereas $I_{3}$ items (PEEK) differ from the category mode by three elements, but from the nearest training instance by only one. Moreover, each type $I_{3}$ item is more similar to the training set in general than each $I_{1}$ item under the assumption that $r > 2.5$, whereas $I_{1}$ items are more similar when $r < 2.5$. The episode model with $r = 3$ generates total relative facilitation scores of 1.21, 0.58, and 0.70 for $I_{0}$, $I_{1}$, and $I_{3}$, predicting the order $I_{0} > I_{1} > I_{3}$. By contrast, typicality defined as similarity to the mode (simple independent representation) predicts $I_{0} = I_{1} > I_{3}$, inasmuch as each type $I$ item shares three elements with the mode and type $I_{3}$ items share only two. Typicality defined as similarity to all features of the training set in proportion to their presentation frequency (complex independent representation) also predicts that $I_{0} = I_{1} > I_{3}$ because type $I$ items possess more modal elements than do type $I_{3}$ items, and modal elements are more frequent in the training set. Strong-hybrid models, which employ only typicality to predict performance on novel items, predict that $I_{0} > I_{1} > I_{3}$. Weak-hybrid models, which claim a role for both general and specific information in performance on all targets, seem to predict an ordering between those predicted by instances alone or general information alone, perhaps that $I_{0} > I_{1} = I_{3}$. I believe that no model assuming independent processing of features would predict that $I_{3} > I_{1}$, which is the prediction of the episode model in this case.

Results and Discussion

The obtained means were $I_{0}$, 1.22; $I_{1}$, 0.65; and $I_{3}$, 0.86 (within-subjects ANOVA, $F[2, 58] = 16.47, p < .01$). In planned comparisons, type $I_{0}$ items are best perceived ($p < .01$ in the comparison with both $I_{1}$ and $I_{3}$), and type $I_{3}$ items are better perceived than type $I_{1}$ ($p < .05$).

The finding that the old items are better perceived than the equally typical $I_{1}$ items disconfirms once again all predictions based purely on typicality. However, the relative perceptibility of the novel items is more important. This evidence suggests that of all the hypotheses tested, only similarity to multiple instances can account for performance on probes and only if the similarity of a probe and instance is defined on the basis of dependence among the components of the trace.

The finding that less typical novel items are better perceived than more typical novel items limits the generality of the observation often cited as the main evidence for abstract representation, the correlation of responses with typicality. That observation appears to be a product of confounding density of items with item typicality.

Experiment 6

In all of the preceding experiments, the categorical structure of the stimuli was incidental to the training task. The represen-

tations differentially supporting later perception were a byproduc-
t of processing the training stimuli to satisfy the demand of copying. Whereas abstraction of category structure apparently did not occur under these conditions, it might if subjects were made aware of the structure. Experiment 6 was designed to test this possibility. It employed the same training and transfer conditions as Experiment 5, but subjects in Experiment 6 were made fully aware of the categorical nature of stimuli during training. They were not, however, required to learn to classify the stimuli. Thus, the conditions of this experiment fall midway between deliberate and implicit category learning.

Method

Procedure. The procedure was identical to that of Experiment 5, with two exceptions. First, no baseline measure of perceptual fluency was taken. This measure was dropped as being simply unnecessary because stimuli of all kinds were perceived with approximately equal ease in all baseline conditions already discussed. Instead of gain scores, the dependent measure employed for these conditions was the mean percentage of letters correctly identified per probe item.

Second, the entire set of training stimuli (the $I_{0}$ set) was presented to the subject at one time. These stimuli were massed within their categories, so that subjects saw all five items of one category in a vertical list on one side of the monitor and those of the other category on the other side. As well, the prototype stimulus of each category was displayed above the relevant list of items. This display remained unchanged on the monitor throughout the training phase.

In addition, at the beginning of the training phase, subjects were (a) told that there were two categories of items, (b) told that each list formed a category, (c) shown the prototypes, (d) instructed in how the categories were generated from the prototypes, (e) told that as a result the two lists formed categories on the basis of their similarity to the prototype patterns, and (f) shown that the categories were separated by minimal sharing of features between lists. Thus, prior to training, they were aware of a great deal of information about the categorical and typicality structure of the lists.

Following these instructions, subjects were required to copy all of the stimuli of one category three times and then to copy all of the stimuli of the other category. This training was identical to that used in Experiment 5 in terms of the task demanded and the structure of the training stimuli, but differed in that in Experiment 5, (a) experience of stimuli was massed within categories, (b) subjects had been instructed in categorical structure, and (c) all stimuli remained on the screen throughout the training. The transfer phase was identical to that of Experiment 5.

Predictions. Because the structure of training and test stimuli was identical to that of Experiment 5, predictions of all abstractive models are also the same; and because the encoding task was also held constant, predictions for the episode model are also as they were.

Results and Discussion

The obtained mean perceptual accuracy scores for Experiment 6 were $I_{0}$, 75.6; $I_{1}$, 69.86; and $I_{3}$, 72.26 (within-subjects ANOVA, $F[2, 58] = 8.342, p < .001$; all scores significantly different, $p < .05$). Thus, Experiment 6 replicates the results of Experiment 5, despite subjects' awareness of categorical structure and massing of practice within categories. As in Experiment 5, less typical novel items are better perceived than more typical novel items. This suggests that even when subjects are aware of the categorical nature of stimuli, they do not abstract typicality information, or else that abstracted typicality infor-
mation does not determine behavior when the task is not explicitly categorical. Instead, subjects' behavior in the transfer task appears to be controlled by memory for particular events, although the task does not call for episodic report.

Experiments 7 and 8

The results of all of the conditions discussed, except Experiment 4, are incompatible with abstraction of independent features, if single letters are assumed to be the features. It could be argued that, in fact, the effective features are larger, consisting perhaps of pairs or triples of letters. In this case the appearance of dependence in the preceding studies would be an artifact of correlating subsaspects of features that are independently related within features. However, whatever the features, they are assumed by semantic-memory models to be stable, determined by situation-independent encoding routines (Jacob & Brooks, 1984). In contrast, the episode model suggests that the representation of a category is variable and depends on the task demands under which the learner encounters instances. Experiments 7 and 8 were designed to test these alternative assumptions.

Method

Procedure. The procedure of Experiment 7 was identical to that of Experiment 6, including the stimulus set, instructions regarding the category structure, and presentation of items massed within categories beneath their prototype patterns. The only change was that instead of copying each item, subjects were instructed to compare each item to its prototype pattern and to copy matching letters on one page and nonmatching letters on another. This task was intended to encourage relatively letter-by-letter processing of items.

Experiment 8 was like Experiment 3 in that it employed the II items in training and the I, IIo and III items in test, subjects were not informed about category structure, and items were presented on successive trials in random order and with items from the two categories intermixed. To make the results comparable with Experiment 3, the baseline phase was reintroduced, and results are given in gain scores. Unlike Experiment 3, the appropriate prototype pattern was presented above each item. Subjects were required to compare items with the presented prototype, but copied only matching letters in this case. They were not informed that the prototype had any special status. Compared with those of Experiment 6, these are poor conditions in which to expect abstraction of general structure.

Predictions. For Experiments 7 and 8 the similarity metric employed in the episode model was changed from \( r = 3 \), reflecting integral processing, to \( r = 1 \), reflecting the independent processing of letters encouraged by the encoding tasks. For Experiment 7 the episode model, with \( r = 1 \), predicts that each item will be perceived in terms of the proportional frequency of the presentation of its component letters. Each modal component occurs three times, and each deviation element occurs twice in the entire set. Because type III items differ from the others only in that they have one fewer modal and one more deviation element, the episode model generates total facilitation scores of 0.26, 0.26, and 0.24 for IIo, II, and III, respectively, predicting that the three types of items will be perceived approximately equally well, in contrast to the predictions of Experiment 6.

In Experiment 8, subjects were instructed to ignore nonmatching letters. Because the matching letters are modal elements and because independent processing of elements was expected in this condition, the episode model with \( r = 1 \) and salience of ignored elements set at zero acts like a simple independent model. Thus, it predicts \( I < IIo < III \). Because Experiments 3 and 8 are identical in stimulus structure, the simple independent model predicts this pattern (incorrectly) for both. However, because the processing task changed between studies, the episode model reverses its prediction from \( IIo > I \) to \( I > IIo \).

Results and Discussion

The obtained mean perceptual accuracy scores in Experiment 7 were IIo, 72.94; II, 71.26, and III, 71.34. These scores did not differ significantly (within-subjects ANOVA, \( F[2, 58] = 0.6 \)), and relative to Experiment 6, the differences between each pair of probe types decreased significantly (\( p < .05 \), in all cases). Thus, the change in processing demand from copying to matching occasioned a change in performance patterns, which is predictable through a change in the level of the integration parameter of the episode model.

The obtained mean gain scores in Experiment 8 were I, 0.57; IIo, 0.34; and III, 0.11 (within-subjects ANOVA, \( F[2, 58] = 5.59, p < .01 \); all means significantly different, \( p < .01 \)). The predicted reversal of scores for I and IIo items in the contrast of Experiments 3 and 8 is also significant (simple interaction following two-way between—within ANOVA, \( p < .01 \)).

Experiments 3, 6, 7, and 8 illustrate that variations in the task, as well as in the distribution of training and test stimuli, can have a large impact on performance patterns. Episodic accounts explain these results in terms of variable encoding procedures leading to variable representations, coupled with retrieval specific to the particulars of the encoding experience. By contrast, because of their assumption of stability of encoding procedures, abstractive models have difficulty explaining differences in performance due only to changes in the training task.

Brooks (1978, in press) has typified abstractive processing as analytic, consisting of breaking stimuli into stable, predictable units. The training tasks of the last two conditions lead subjects into analytic processing of the training stimuli, either encoding each separate element in terms of its frequency in the set (Experiment 7) or encoding only elements relevant to classification (Experiment 8). However, this style of encoding is not automatic, as demonstrated by the comparison of Experiments 3 and 6, nor is it deliberate in Experiments 7 and 8. Instead, analytic processing is in this case a by-product of satisfying a task demand. It is suggested that analytic processing of real-world stimuli may also be incidental in some cases, so that the observation of analytic encoding need not immediately suggest the operation of a general, abstractive organizing mechanism.

General Discussion

The dual-memory hypothesis (e.g., Cohen & Squire, 1980; Tulving, 1983) suggests independent semantic and episodic representation systems, retaining abstract, decontextualized information arising across experiences, and autobiographical, unique information characteristic of particular events, respectively. This hypothesis has taken its support from demonstrations of independence of effects of prior study on tasks evidently calling for episodic report, such as recognition, and tasks in which nonspecific familiarity may assist performance, such as perceptual identification. This account is made more complicated by findings of variable dissociation between the tasks (e.g.,
Jacoby & Witherspoon, 1982). The analog of the dual-memory hypothesis for the representation of categorically related events is a distinction between class-level stimulus characteristics, such as typicality, and item-level characteristics, such as specific familiarity (e.g., Rosch, 1977). Support for this distinction has been drawn from observations that suggest a dominant influence of class-level information in generalization (Homa et al., 1981; Posner & Keele, 1968). However, demonstrations like those cited that representation systems retaining only event-level information can account for patterns of generalization call the utility of this distinction into question.

Three major conclusions regarding the nature of representation systems may be drawn from the demonstrations in this article:

• Abstraction of general information is not automatic but rather a by-product of the demands of particular tasks.
• When density of instances is unconfounded from their typicality, performance appears to be controlled by memory for specific experiences rather than by general knowledge.
• The unit of information processing varies with the task in which events are experienced and cannot be accounted for by stable, general encoding routines interacting with the objective structure of the category.

**Abstraction Not Automatic**

Whether class-level information was left implicit (Experiments 1–5) or was made explicit (Experiment 6), it had no observable effect on generalization of performance unless the task invoked processing of that information (Experiments 7 and 8). However, several important conditions were not assessed in these experiments. First, while experiencing the training stimuli, subjects did not anticipate having to judge related stimuli. The expectation that current experiences will be useful for future decisions may be sufficient to induce abstraction of class-level information, at least in cases where one anticipates the demand to classify events. Second, the only task used to evaluate conceptual structure was perceptual identification, a task that does not explicitly require a class-level decision. It is possible that subjects developed abstract categorical knowledge, but failed to use it in this task. This would suggest that abstraction is automatic, but not the use of abstract information. However, similar patterns of transfer to those above have been found in classification studies in which typicality and similarity to particular instances are unconfounded (e.g., Medin & Schaffer, 1978; Whittlesea, 1983).

This, of course, does not mean that people are insensitive to class-level information. We can undoubtedly generate descriptions of prototypical members of many classes and may commonly process category-level information in learning to discriminate categories. Deliberate processing of abstract information is an important ability, serving as it does the portability of decision-making principles across domains and the ease of social transmission of information. Further, analytic processing of events, deciding which aspects are relevant and which irrelevant for particular purposes, or differentially weighting the diagnosticity of aspects, provides a check on the robust accuracy of the use of nonanalytic analogy (Brooks, in press). However, the prevalence of deliberate abstraction of category-level information may be limited because massed experience of category members is rare and because encounters with members of the same class frequently emphasize different characteristics, rendering the comparisons necessary for deliberate analysis difficult. Moreover, deliberate abstraction need not result in a unique, stable representation: As was demonstrated by Labov (1973), changes of processing context can affect the inclusion of objects in categories, resulting in variations in the category-level information abstracted.

Even when category-level information has been encoded, its use as a basis for generalization need not be automatic. In spite of being able to describe a prototypical category member, and having available information about what is typically true of the category, people may use close analogy to particular events in making judgments rather than invoking abstract information. Use of close analogy may be a faster or more economical procedure, particularly if the category structure is complex. Moreover, if similar judgments about similar events occur frequently, specialized identification routines may evolve (Brooks, in press). Analytic information may be primarily used when precision is vital or when justification is demanded for decisions.

**Performance Controlled by Memory for Specific Events**

In general, the results of the preceding studies were consistent with control of performance by knowledge about particular items. Perception of particular components was dependent on reinstatement of specific context, and relative performance on probes was predictable only in terms of configurations of components occurring in particular items. However, the predictions of the episode model in Experiments 7 and 8 illustrate that episodic accounts need not propose the encoding of complete and objective information about items or even information specific to particular items. The episodic claim is that information about particular events is encoded as the events are experienced. If a task requires analytic processing of an item, then some nominal aspects of the item may not be processed and not form part of the processing episode or the subsequent representation. However, in the absence of deliberate analytic effort at the time of retrieval, performance in subsequent tasks is expected to be specific to whatever information was processed in the encoding episodes. Thus, the episode model predicted the results of Experiment 3 on the basis of information about all stimulus components, integrated within particular items, whereas its predictions for Experiment 8 were based on a limited set of components and with no information about their co-occurrence. Episodic accounts are thus abstractive in a sense, in that they do not propose literal encoding of instances. However, the abstraction process is thought to be a passive one of not attending to particular properties, rather than an active generation of summary information.

**Variability of Encoding**

Nonanalytic generalization, based on particular episodes, emphasizes the variability of processing routines and the resultant variability of representation. In contrast, analytic generalization is most successful if encoding routines are stereotyped,
resulting in the abstraction of stable processing units (Jacoby & Brooks, 1984). Such stable encoding routines may be expected in tasks requiring deliberate isolation of necessary and sufficient, or relevant and irrelevant, features, such as learning to justify classification judgments. However, even under these conditions, it is possible that the identification of particular events may be accomplished through nonanalytic generalization. That is, although the learner may develop a representation of the core of the concept, and appeal to this information in justifying decisions, the decisions themselves may be accomplished through specialized identification routines based on the similarity of the current event to past processing episodes (Brooks, in press; Miller & Johnson-Laird, 1976; Osherson & Smith, 1981).

The conclusion that variable encoding is responsible for the differences between response patterns based on experience of structurally identical training and transfer stimuli (e.g., Experiments 3 and 8) counts against the generality of accounts suggesting the automatic abstraction of the objective structure of categories. Feature-frequency models (Elio & Anderson, 1981; Hayes-Roth & Hayes-Roth, 1977; Neumann, 1977), unlike prototype accounts, can account for interfeature dependence because they propose that the frequency of all possible n-tuples of the set of stimuli are encoded. However, if this encoding is independent of the processing induced by the task, such models could not account for variations in performance accompanying changes in task. In a similar vein, Elio and Anderson (1984) have demonstrated that later performance is affected by the order of presentation of representative- and low-variability subsets of categories, suggesting that sensitivity to objective structural characteristics is not stable.

Feature-frequency accounts may be modified to incorporate the assumption that the representation of experience is a product of what is processed rather than of the objective structure of the category. In effect, a feature-frequency system operates on an ANOVA model, with 1-tuples picking up linear relationships between similarity and shared features, whereas higher order n-tuples pick up nonlinear relations (interactions). The episode model does the same job in a different way, through adjusting the integration parameter to fit the degree of nonlinear relation between similarity and the feature overlap of a probe and trace. The flexibility of explanation afforded by variable salience of stimulus elements and variable integration of elements can be duplicated in feature-frequency models through differential weighting of the various n-tuples. However, as a result of incorporating this change, feature-frequency models in effect become episodic models, storing information about particular experiences.

Most generally, evidence on variability of encoding counts against extremes of both abstraction and instance accounts. Although stable encoding of category-level information cannot provide a general account, neither can the automatic, literal encoding of the structural properties of particular instances.

**Representativeness of Surface Structure Categories**

The use of pseudoword stimuli, as in the preceding experiments, has a number of implications. Learning pseudowords calls on practiced skills, unlike learning dot patterns, but does not tap into preformed cognitive structures as directly as the use of words or pictures of real objects would. One benefit of using pseudoword stimuli is that, unlike dot patterns, they permit investigation of the effective relation among stimulus components, as illustrated in Experiments 1 and 2. However, learning pseudowords may not be a representative conceptual activity and may tell us little about the formation of "natural concepts." This is likely to be a problem in studying learning of any arbitrary stimuli, including dot patterns and schematic faces. The reverse problem, that makes such studies useful, is that the familiarity of natural categories and objects cannot be controlled or manipulated as precisely as that of artificial stimuli.

One aspect of the representativeness problem of pseudowords is that they call on reading skills, which are highly practiced in most of the subjects tested. It is likely for this reason that the component letters of stimuli were found to be dependently related in perception after three copying trials. With other stimuli for which no special skill has been developed, independence of components might have been observed in all conditions. Although this is a limit on the generality of the present experiments, the idea that skill development may result in different representations supporting conceptual activity is itself important, especially if skill development leads to flexible rather than stereotyped processing.

A second aspect of the problem is that pseudowords have no referents. To the extent that surface structure similarities are responsible for creating psychologically real categories, this is not a problem. However, there is evidence that important categories may emerge on the basis of deep structural commonalities (e.g., Medin, 1983; Murphy & Medin, 1985). Thus, the important features of events may not be perceptually evident, and the basis of a classification decision may not involve surface similarity. This does not mean, however, that investigation of the processing of surface characteristics is an irrelevant pursuit for two reasons. First, the processing of surface properties may be a good model for the processing of deep structural features. Although the generating principle of categories is evidently different in these two cases, it is unclear that the type of representation or means of access differs in any important way. That is, although the important features of an event may be deep structural ones, and the category to which it is assigned may be determined by a theory rather than based on surface similarity, nonetheless the representation of the category may differ from the representation of a surface structure category only in the identity of the features. Similarly, access to the representation may still depend on similarity, the only difference being that different features are compared. If this is the case, then domains of stimuli without deep structure may provide a reasonable testing ground for theories about all types of categories and are particularly valuable because the identity and familiarity of surface properties are more easily manipulated and measured.

A more important reason for continued study of surface feature similarity is that although the category membership of an event may be determined by its deep structure, the routines used to perceive or identify the event may become specialized (Brooks, in press). This argument is similar to the one already stated regarding the generality of analytic processing, appealing to possible dissociation between identification routines and the core of the concept (Miller & Johnston-Laird, 1976; Osherson...
& Smith, 1981). Some evidence on the rapidity with which such specialization can occur with members of natural categories is presented by Brooks, Jacoby, and Whittlesea (1984).

Conclusion

Specificity of performance to the particular contexts and experiences of events, as demonstrated, suggests that the use or development of abstract, semantic representation is not automatic. To the extent that it is not automatic, additional principles must be added to account for the conditions under which it is used. However, these additional principles would seem to involve the task demands under which the learner is operating, as well as the structure of the materials, and thus limit the independence of representation from the context of processing. The apparent effects of variability of encoding on subsequent performance lead to a similar conclusion. Variability of performance on identical stimulus sets under different tasks also counts against the economy of abstract representation, suggesting a proliferation of representations that in number and specificity come to resemble the representations of particular events. All of these factors limit the utility of dual semantic—episodic representation.

An alternative, episodic approach to the problems of task dissociations and phenomena of generalization emphasizes the processing leading to representation and generalization (e.g., Brooks, in press; Jacoby & Brooks, 1984; Jacoby & Witherpoon, 1982; Whittlesea, 1983). Instead of distinguishing between information stores that may have differential impact on performance, this approach emphasizes differences in encoding and retrieval depending on interactions of the learner’s intentions and expectations, the demand of current tasks, the similarity of the current situation to past situations, and the nature of the materials. This approach promises to provide an integrative framework for understanding remembering, attention, perception, and concept learning and application through the common basis of the use of memory for particular processing episodes.

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