The Learning of Categories: Parallel Brain Systems for Item Memory and Category Knowledge
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A fundamental question about cognition concerns how knowledge about a category is acquired through encounters with examples of the category. Amnesic patients and control subjects performed similarly in classifying novel patterns according to whether they belonged to the same category. As a set of training patterns. In contrast, the amnesic patients were impaired in recognizing which dot patterns had been presented for training. Category learning appears to be independent of declarative (explicit) memory for training instances and independent of the brain structures essential for declarative memory that are damaged in amnesia. Knowledge about categories can be acquired implicitly by cumulative information from multiple examples.

Memory is not a single mental faculty but is composed of multiple separate abilities that are mediated by distinct brain systems (4). The major distinction is between declarative or explicit memory, which depends on limbic and diencephalic structures (2) and provides the basis for conscious recollection of facts and events, and various nondeclarative or implicit memory abilities, which support skill and habit learning, simple conditioning, and the phenomenon of priming (3, 4).

Declarative memory typically refers to memory for recent single encounters and is usually assessed by tests of recall or recognition for specific items. However, when encountering a series of items, a subject not only learns about each item in the series but also acquires information about what all the items have in common. In this way, a subject learns about the category that is defined by the items that are presented. The question of interest is What kind of memory supports the acquisition of category-level knowledge (5)? One view holds that category-level knowledge is acquired in the form of information about prototypes (average instances) or ill-structured about the statistical properties of the training items, and this knowledge is represented separately from knowledge about the training items themselves (6). Another view is that category-level knowledge has no special status but emerges natuurally from item memory (7). Thus, a novel item would be made up of the sum of the number of the training items and the exemplars of that category that had been presented (8).

Studies of amnesic patients could illuminate these issues, because these patients have impaired declarative (explicit) memory (5, 6) and recently, amnesic patients exhibited normal classification learning (9) when category membership was defined by adherence to the rules of an artificial grammar (10). In the present study, we examined the ability of amnesic patients to learn to classify items on the basis of natural categories, that is, categories such as tools or furniture for which membership is based on family resemblance rather than on adherence to items of fixed rules.

Examples of such items and test items are shown in Fig. 1 (11). For the 12 control subjects and 10 amnesic patients (12) were presented with 40 training patterns (13). The subjects were instructed that these patterns all belonged to a single category of patterns in the sense that the semantic category had been presented, every item would belong to the semantic "class" in accordance to a particular category. Each subject had training pattern with 84 new patterns and were asked to judge in each case whether the pattern did or did not belong to the same category as the training patterns (14). The two subject groups made category judgments with similar accuracy (11). ANOVA indicated a significant effect of item type on classification (F(4, 5) = 5.6, P < 0.01) but no differences between groups and no interaction of group and item type (F(4, 0.2) = 0.15). According to overall performance on the classification task (percent correct: F(1, 2) = 14.5, P < 0.05) together with the results for a second study, the test session, scheduled an average of 1 to 2 months later, in which all subjects attempted to recognize patterns that had appeared earlier (15). The subjects differed in their ability to recognize the particular items that had been presented (F(1, 2) = 3.3, P < 0.05). There was also a significant interaction between the performance of the two groups on the classification and recognition tests (F(1, 20) = 5.5, P < 0.05).
We next considered the possibility that amnestic patients performed so well on the classification task, in contrast to the recognition task, because of the greater separation of the information to be remembered in the classification task or because of the smaller amount to be remembered, rather than because different memory systems were used in the two tasks. In the classification task, a single prototype was to be retained for each of 48 related patterns, whereas in the recognition task five different items were to be recognized after presentation of 40 related patterns, which are more difficult to retain and each was presented eight times. To address this issue, subjects were tested for their classification ability after studying only four training examples and were tested for their recognition ability after studying six training examples presented four times (16). In this case also, there was an effect of item type on classification performance (Fig. 5B). For example, item type (P < 0.01), no difference between groups, and no interaction between group and item type (P > 0.1). Figure 7D shows the overall results for the classification task (450 test trials), t(19) = 1.42, P > 0.1) and shows that the control subjects performed better than the amnestic patients at recognizing the training patterns (t(19) = 2.1, P < 0.05).

There was a trend for an interaction between subject group and trial (classification or recognition) F(4, 19) = 1.2, P = 0.20. In a trend test, experience with the task had not been presented any training patterns performed at chance on the classification test (53%) and 1.2% correct (t(19)). Thus, classification performance does depend on having experience with the training stimuli. Performance on the classification task was actually a little better numerically after subjects were shown four training patterns than after they were shown 40 training patterns (n = 0.25 score for both groups, 66.4% versus 59.5% correct). However, when there was a 4-week delay between study and test (18), normal subjects performed better after being presented 45 training patterns than after being shown four training patterns (66.0% versus 34.4%, t(19) = 2.2, P < 0.05). Moreover, after the 4-week delay, subjects who were shown four training patterns performed at chance levels (P > 0.1). Thus, training with more items does result in more robust, longer lasting category knowledge.

The results suggest that category-level knowledge can develop independently of and in the absence of normal declarative memory for the items presented during training. Thus, experience with a classification task appears to lead to a second parallel consequence. First, information can be retained about subclassification items which depend on the intrinsic dimensional structure that are encoded in amnesia and that are essential to category knowledge. Second, repeated experience leads to category-level knowledge in the form of information about the category to which the training items belong. Category-level knowledge may be acquired by abstracting information across examples with some examples. Alternatively, classification learning could depend on specific item information stated in the distalized fashion, as common in theoretical models (5, 7). However, in the latter case, the information supporting classification learning must be distinct from declarative information about the separate items. A stimulus model in which classification judgments derive from, or in any way depend on, long-term declarative memory does not account for the finding that the amnestic patients performed well on the classification task.

The possibility must be considered that classification learning is dependent on declarative knowledge, such that even a little declarative memory for the training patterns could support substantial classification ability. Although the difference in classification performance between amnestic patients and control subjects in the tests never approached statistical significance, the amnestic patients did perform numerically worse than the control subjects (Fig. 2). It is possible that residual declarative knowledge available to the amnestic patients translates into partial normal classification performance. Although this possibility is difficult to address definitively, it is worth noting that amnestic patients have scored numerically better than normal subjects on a classification task for artificial grammar (9).

If classification does not depend on the limits of declarative memory in amnesia, which brain systems could be involved? The discussion comes from the parallel between classification learning and the learning of skills and habits, namely...