Automatic Processing of Fundamental Information

The Case of Frequency of Occurrence

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ABSTRACT: One view of memory supposes that several fundamental aspects of experience are stored in memory by an implicit or automatic encoding process. In this article we review the evidence that suggests that information about frequency of occurrence is encoded in such a manner. This evidence shows that frequency information is stored for a wide variety of naturally occurring events. Laboratory research shows that usually powerful task variables (for example, instructions, practice) and subject variables (for example, age, ability) do not influence the encoding process. Evidence is also reviewed that either directly or indirectly implicates the use of frequency information across issues in psychology ranging from the acquisition and representation of knowledge domains to decision making to sex role development.

How many movies have you seen this year? If the answer is more than one, which did you see most recently? Where did you sit the last time you were at your favorite restaurant? Do more people in the United States die of botulism or of emphysema? Are there more tailors or more lawyers? Which word occurs more frequently in English—*bacon* or *pastrami?* These questions are directed at how often events occur, in what temporal order, and in what spatial contexts. People are surprisingly accurate at answering such questions without being aware of how they acquired the relevant information in the first place. This observation meshes with recent research in human memory to suggest the possibility that the ability to answer such questions stems from a basic operating characteristic of the information processing system. That is, the system seems to support the inevitable encoding into memory of certain fundamental aspects of experience. We have speculated that frequency of occurrence, spatial location, and temporal location are among those aspects of experience that are continually registered in memory, whatever the age, the ability, the education, or the motivation of an individual (Hasher & Zacks, 1979).

We have termed this information acquisition process *automatic encoding,* and we have three aims in this article: (a) to review the research that demonstrates the remarkable characteristics of automatic encoding, (b) to show the importance of automatically encoded information for a wide variety of cognitive and social behaviors, and (c) to begin to redress the imbalance of attention paid by psychologists to deliberate as compared to nondeliberate forms of information acquisition (see also Jacoby & Witherspoon, 1982; Marcel, 1983). We focus here on the encoding of frequency of occurrence information to allow a careful presentation of the data as well as a detailed explication of its applications.

The organization of the article takes the following form. We begin with the set of criteria for assessing automaticity of encoding.[1] We then consider the evidence regarding the degree to which the encoding of frequency information satisfies these criteria. This is followed by a consideration of how repetitions are represented in memory. In the final section of the article we present evidence and speculation about the range of uses for automatically encoded frequency information.

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[1] The term *automaticity* is in widespread use in current empirical and theoretical work in cognition. There is, however, no standard definition of the term (e.g., Hirst, 1982b, Shiffrin, Dumais, & Schneider, 1981). Our definition (Hasher & Zacks, 1979) is used here.

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Criteria for Automaticity

Our central interest is in the encoding of information into memory. Two fundamental ideas underlie our framework. The first is our concept of encoding, which derives from the view that memory for an event consists of a collection of attributes (e.g., space, time, meaning, mood, etc.) regarding that event (e.g., Underwood, 1969, 1983). The second is our concept of automaticity, which derives from the view that the individual's momentary capacity for cognitive activity is limited (e.g., Kahneman, 1973). Three further assumptions are basic to our development of the definition of automaticity: (a) People differ in systematic and predictable ways in the capacity they have available (e.g., older adults have less capacity than younger adults); (b) mental processes vary in the amount of capacity they require, with automatic processes requiring less and effortful processes requiring more; and (c) automatic processes function at optimal levels, continuously and independently of intention for all intact humans, and these processes require only that an event be attended to (see also Hintzman & Stern, 1978). These considerations have led to the development of six criteria, all of which must be jointly satisfied, for us to conclude that an aspect or attribute of experience is automatically encoded: (a) People are sensitive to this information without necessarily intending to be; (b) the information encoded in this way is no different than it is when intention is activated; (c) training at processing such information does not improve encoding and neither does explicit feedback; (d) people differ very little in their ability to encode this information—neither education, nor social class, nor culture of origin will substantially influence the ability to encode such information; (e) encoding of this information will be invariant across a wide range of ages;[2] and (f) disruptions due to arousal, stress, and/or additional simultaneous processing demands will have no impact on the processing of such information.

Before we consider the degree to which the processing of frequency of occurrence information conforms to these criteria, an important point should be made. The encoding of frequency of occurrence information is expected to show quite different trends from those elsewhere in the human memory literature. In that research, memory for materials ranging from syllables to words to complex prose passages is reliably influenced by variables such as training, individual ability, motivation, and intention (e.g., Glass, Holyoak, & Santa, 1979; Kausler, 1982). This contrasting pattern of results occurs because voluntary, effortful strategies are extremely important for the tasks that have been most commonly studied in laboratories. For example, performance on recall tasks is greatly influenced by the use of such strategies as organization, elaborative rehearsal, and imagery. Employment of such strategies depends on conscious decisions of the learner. The efficacy of such strategies increases with training. Most importantly, these strategies all require considerable capacity. Thus, it is not surprising that individual and situational differences are found whenever such strategies are influential.

Evidence on the Automaticity of Encoding of Event Frequency

We begin our review of the literature with a brief description of the research paradigms that have been used. We then consider the evidence bearing on each of the six criteria for determining automaticity.

Research Paradigms

In some experiments, elements that naturally vary in background frequency (e.g., letters, surnames, sources of mortality) are studied. In others, situational frequency is experimentally varied using events such as words, pictures, or sentences. For either class of materials, three methods of measuring people's knowledge of frequency are available. In the frequency judgment method, subjects give direct estimates of the number of occurrences of each of the test items. In the forced-choice or frequency discrimination method, subjects choose the more or less frequent item in each of a series of pairs. In the ranking method, subjects order the items in a stimulus set in terms of their frequency of occurrence. Experiments using all three methods reliably and unequivocably demonstrate remarkable knowledge of the frequency of occurrence of all events so far tested. We now consider the criteria in detail.

Sensitivity Without Intention

People are known to be sensitive to experienced differences in the natural occurrence rates of single letters, pairs of letters, syllables, words, surnames, professions, and sources of mortality and morbidity (Attneave, 1953; Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978; Rubin, 1974; Shapiro, 1969; Tryk, 1968; Underwood, 1971; Zechmeister, King, Gude, & Opera-Nadi, 1975). These are not the sorts of events whose frequency one might be expected to learn deliberately. A striking example of sensitivity without intention comes from the work of Coren and Porac (1977) who surveyed a large sample of drawings, paintings, and sculptures in order to locate depictions of figures engaged in

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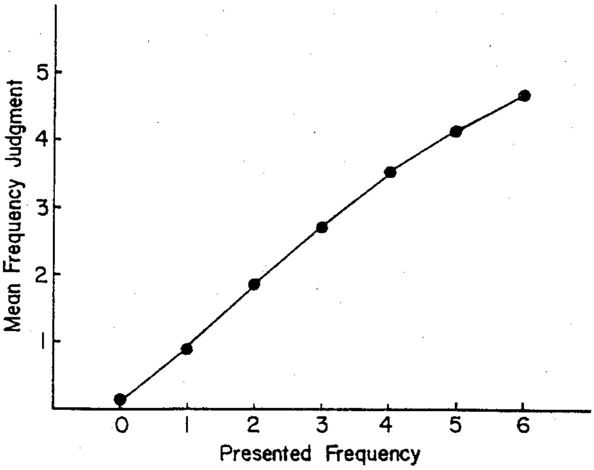
[2] Most automatic encoding processes (e.g., the activation of word meaning) become so through long periods of extensive practice (e.g., Shiffrin & Schneider, 1977). For such processes, developmental invariance is expected only after the attainment of automaticity.

activities that are typically one-handed. Across time periods ranging from prehistoric times to the present, the number of left- versus right-handed people is accurately portrayed. We presume that artists, like the rest of us, are not in the habit of deliberately counting exemplars. Thus, despite the fact that people do not seem to count events, there is good evidence that they store information about frequency. Indeed, experiments regularly report high correlations between the judged and true frequencies of natural events. Attneave (1953) found that the judgments of frequencies of individual letters correlated .79 with the true frequency.

Evidence of sensitivity to frequency is also seen in experimental settings in which the frequency of events is systematically varied (e.g., Flexser & Bower, 1975; Hintzman, 1969; Underwood, Zimmerman, & Freund, 1971). Typical findings from a judgment experiment are shown in Figure 1. The subjects in this experiment were forewarned about a memory test whose nature was not specified. A number of studies using the forced-choice procedure also show good sensitivity to frequency in subjects not expecting such a test (e.g., Zacks, Hasher & Sanft, 1982, Experiment 3). Even when subjects have no reason to expect any sort of memory test at all, they show good sensitivity to frequency (Zacks & Hasher, 1984).

Despite empirical evidence regarding the quality of stored frequency information, most people have no awareness of having this information and so have little confidence in their potential accuracy in tasks based on frequency knowledge. Indeed, when we ask people to estimate the extent of their knowledge of the frequencies of such things as individual syllables or occupations, they generally express surprise at the question itself; they think they lack the information necessary to answer. Similarly, subjects in our experiments express initial doubts about their ability to perform when they are first faced with an unexpected test of frequency knowledge. It is only when subjects begin to respond to specific test items that they realize they actually do have considerable knowledge about the number of occurrences of specific events. Such initial doubts would be expected if the information permitting frequency judgments were encoded without awareness and intention (cf. Ericsson & Simon, 1980; Kellogg, 1982).

Figure 1
Mean Frequency Judgment as a Function of Presentation Frequency: Uninstructed Subjects



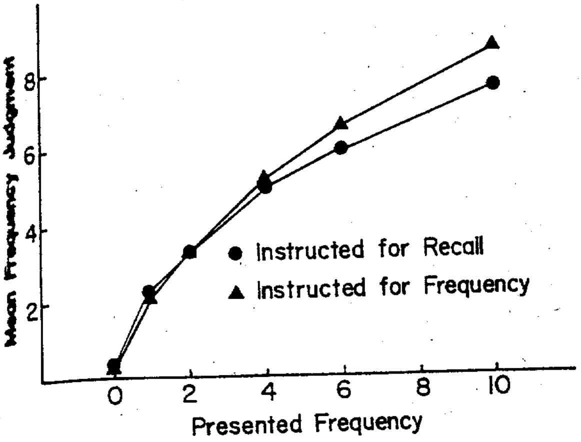
Note. The figure is based on data reported by Underwood, Zimmerman, and Freund (1971). Copyright 1971 by the American Psychological Association. Adapted by permission of the publisher and authors.

The Addition of Intention

A subject's intention to encode frequency can be manipulated with instructions given prior to event exposure. Across experiments, some instructions fully inform subjects about the specific memory task, whereas others misinform subjects, tell only of some unspecified memory task, or even make no mention of a forthcoming memory task (e.g., Flexser & Bower, 1975; Harris, Begg, & Mitterer, 1980; Hasher & Chromiak, 1977; Howell, 1973; Zacks et al., 1982, Experiment 3). To our knowledge, none of these studies has ever found that instructions influenced performance on a test of memory for frequency of occurrence. Figure 2 presents a typical set of data.

It might be argued that subjects fail to benefit from accurate expectations of a frequency memory test because, typically, the presentation procedure makes it difficult to use obvious conscious strategies such as counting. Usually, the items occur in a random order with a variable number of other items intervening between repetitions of any particular item. However, at least one study (Alba, Chromiak, Hasher, & Attig, 1980) included a comparison condition in which it should have been relatively easy for subjects to count frequencies during presentation. In this study, the number of exemplars of different semantic categories was varied, and the subjects' task was to judge category size. In the condition in which a counting strategy should have been easy, the instances of each of several categories were shown contiguously (i.e., a "blocked" presentation sequence was used). Subjects in that condition showed good knowledge of the differences in category size, but their performance was no better than that of subjects in another condition in which it would have been extremely difficult to use a counting (or any obvious) strategy (i.e., the instances were randomly located throughout the list). In sum then, there is considerable evidence that the intention to

Figure 2
Mean Frequency Judgment as a Function of Presentation Frequency: Comparison of Two Instructional Conditions



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encode frequency information does not improve the quality of stored knowledge of frequency.

The Effect of Training and/or Feedback

Two experiments directly address these issues. In the first, subjects received two successive lists after each of which frequency judgments were made. Performance on the second list was identical to performance on the first even for a group of subjects that was given feedback about the accuracy of their first set of judgments (Hasher & Chromiak, 1977, Experiment 2). In the second experiment (Zacks et al., 1982, Experiment 1), subjects were given as many as four successive lists on which to practice. There was little evidence of the development of an effective strategy for processing frequency—or of any improvement with practice. Indeed, performance of some subjects on a fourth frequency discrimination test, although good, was no better than performance of other subjects on a first frequency test given after three recall tests. Subjects with and without laboratory experience at processing frequency were equally proficient (see Figure 3, top).

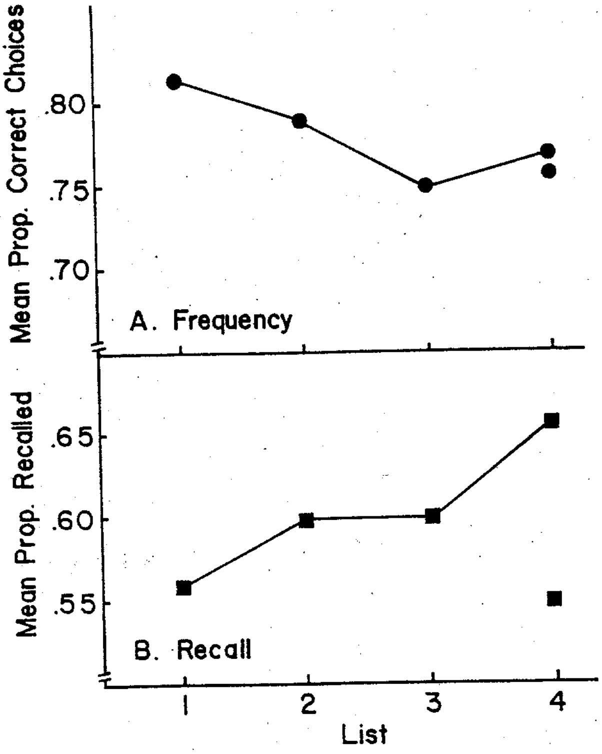
From Figure 3, bottom, it is clear that the performance of subjects making frequency discriminations (Figure 3, top) stands in marked contrast to the performance of subjects who for four trials were trying to recall the very same items. For these subjects, significant benefits of practice were found. Results of the recall test, but not of the frequency test, agree with a substantial literature showing that subjects improve at most tasks, basically by devising task-appropriate, optional strategies (e.g., Postman, 1969).

Thus, the storage of frequency data occurs without intention. It does not benefit from intention, and neither does it benefit from practice or from feedback.

Limited Individual Differences

Differences among people, such as in motivation, in intelligence, in prior relevant knowledge, and in educational attainment, typically play substantial roles in determining performance on memory tasks. For example, consider a study that compared students from two universities on a traditional free-recall task (Zacks et al., 1982, Experiment 3). One group of students was enrolled in University A, a small private school with a selective admissions policy (the median verbal SAT score for entering freshmen during the year of this experiment was 610). The other group was enrolled in University B, a large public school with a less selective admissions policy (the median

Figure 3
Performance on a Frequency-Discrimination and on a Free-Recall Task as a Function of Practice

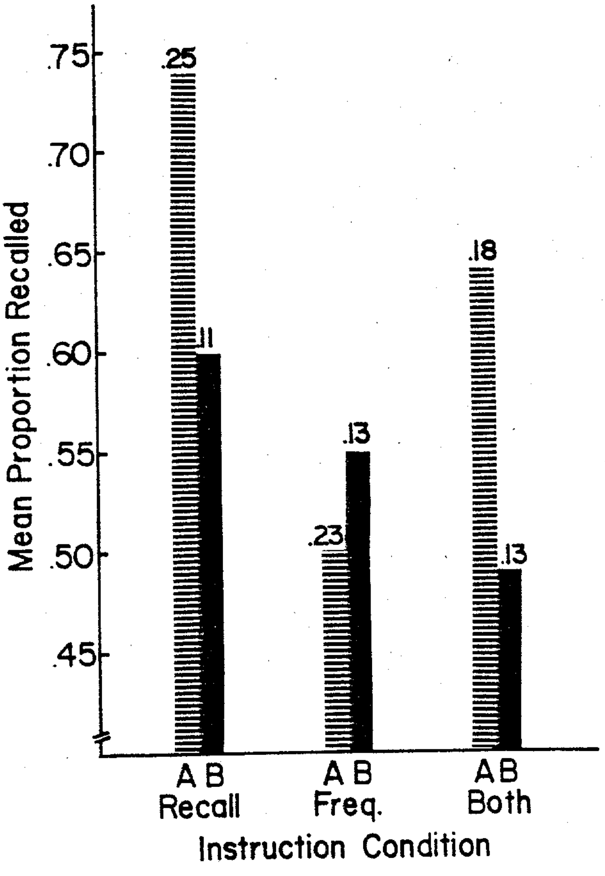


Note. For both tasks, the unconnected points for List 4 represent the performance of subjects who practiced for three lists on the other task. The figure is based on data reported by Zacks, Hasher, and Sanft (1982). Copyright 1982 by the American Psychological Association. Adapted by permission of the publisher.

verbal SAT score was 471). Insofar as SAT scores are correlated with differences in educational background, motivation, socioeconomic status, and possibly intelligence, the students at University A might be expected to have a substantial advantage over those at University B.

This advantage can easily be seen in Figure 4, which depicts the free-recall performance of three groups of subjects from the two universities. Three sets of findings should be noted. First, when instructed that they would be given a free-recall test, the recall of University A students was reliably higher than that of University B students. Second, telling subjects to simultaneously prepare for two different types of memory tests (recall and frequency) reduced the performance of both groups of subjects, but the performance of the less able students (B) was reduced to a greater extent than that of the more able students (A). Third, misinstructing subjects about the exact nature of the upcoming memory test (the subjects expected a frequency test) eliminated the differences in recall seen elsewhere between the two groups of students. Thus, the advantage held by University A students was not inevitably seen; rather, it was one called up by task-appropriate instructions.

Figure 4
Mean Proportion Recalled as a Function of Instructional Condition and Subject Group



Note. The bars labeled A and B represent the data for University A and University B subjects, respectively. The number above each bar is the standard deviation for that group. The figure is reprinted from Zacks, Hasher, and Sanft (1982, p. 114). Copyright 1982 by the American Psychological Association. Reprinted by permission of the publisher.

As expected, levels of recall are influenced by differences in motivation, knowledge, and intelligence. The other half of this experiment showed that these variables did not influence sensitivity to frequency of occurrence. Three other groups of students at the two universities were given identical sets of instructions and were tested for their frequency knowledge using a forced-choice procedure. On this test (see Figure 5), school and correlated ability differences had no effect, and neither did the type of set subjects had about the forthcoming test.

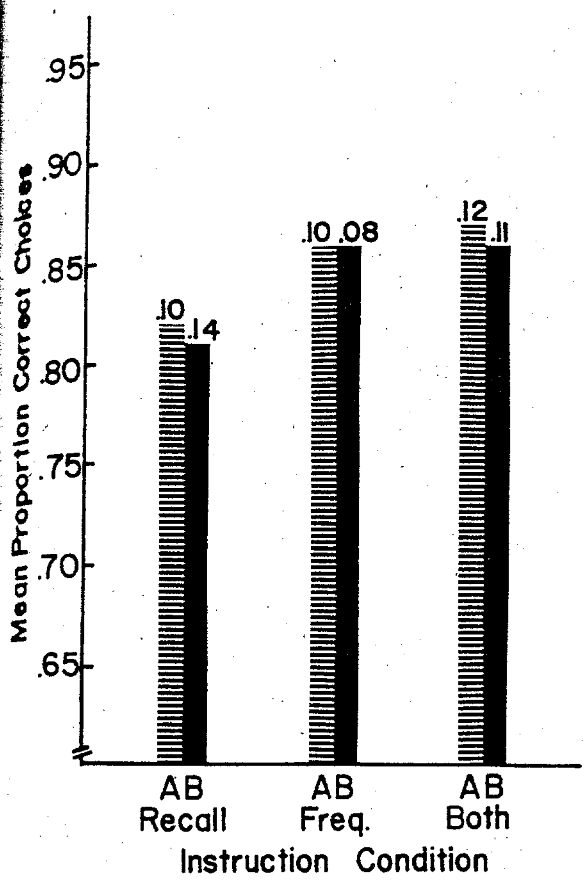
It is also possible to look at differences among individuals by comparing individual performance levels across successive assessments on the same task. Relative to the performance of others, subjects should remain fairly stable on tasks (such as recalling information from memory) in which ability and motivational differences play substantial roles. A person who is good at recalling information on one occasion should also be relatively good on other occasions. Table 1 shows correlations in recall performance across four successive lists. These between-list correlations are significant and sizable.

Between-list correlations for subjects given successive tests on a frequency discrimination task are also shown in Table 1. None of these is significant; performance on one test trial does not predict performance on another. This is exactly what would be expected if subject-related variables do not control performance on a frequency task.

A final study on individual differences compared the frequency processing of children who were proficient classroom learners with those who were not, that is, learning-disabled children (Goldstein, Hasher, & Stein, 1983; see also Lund, Hall, Wilson, & Humphreys, 1983). The children did not differ in sensitivity to frequency although there was evidence reported in that study and elsewhere that learning-disabled children ordinarily show poorer memory performance than nondisabled children.

Individual characteristics that are usually important for cognitive performance (e.g., available capacity, knowledge of effective strategies, and motivation to use them) are irrelevant to the storage of information about occurrences of events. In our view, this occurs because encoding frequency requires minimal capacity and is independent of the use of conscious, effortful strategies. Frequency information

Figure 5
Mean Proportion Correct Choices on the Frequency Task as a Function of Instructional Condition and Subject Group



Note. The bars labeled A and B represent the data for University A and University B subjects, respectively. The number above each bar is the standard deviation for that group. The figure is reprinted from Zacks, Hasher, and Sanft (1982, p. 115). Copyright 1982 by the American Psychological Association. Reprinted by permission of the publisher.

for an event is inevitably stored, given attention to that event.

Invariance with Age

The standard finding in the literature concerning the development of memory is that practically every skill shows improvement through at least the grade-school years (e.g., Flavell, 1977; Kail, 1979). Rehearsal skills, systematic retrieval plans, and the use of elaborative devices all show profound developmental trends. A person's knowledge about the functioning of memory in general and about his or her own memory in particular also develops. Beyond the age of four or five, sensitivity to frequency may not change.

Table 1
Between-List Pearson Product-Moment Correlations for Subjects Given Successive Recall Tests Versus Frequency Discrimination Tests

	Test type	
Lists	Recall tests	Frequency tests
1 and 2	.495*	.146
1 and 3	.351*	−.029
2 and 3	.554*	.234
3 and 4	.531*	.283

Note. Data taken from Zacks, Hasher, and Sanft (1982). Copyright 1982 by the American Psychological Association. Used by permission of the publisher.
* $p < .01$.

In one study (Hasher & Chromiak, 1977, Experiment 1), the frequency judgments of children from grades 2, 4, and 6 were compared to those of college students. All groups of children were able to discriminate differences in frequency, and all groups of subjects did so equally well (see also Johnson, Raye, Hasher, & Chromiak, 1979). In another study (see Figure 6), even younger children were tested: Kindergartners and first, second, and third graders showed equally good memory for frequency information (Hasher & Zacks, 1979, Experiment 1; see also Goldstein, Hasher, & Stein, 1983, for similar results). Taken together, these several experiments demonstrate that at least across the age range of 5 to the early 20s the ability to encode number of occurrences does not change.[3] Furthermore, the

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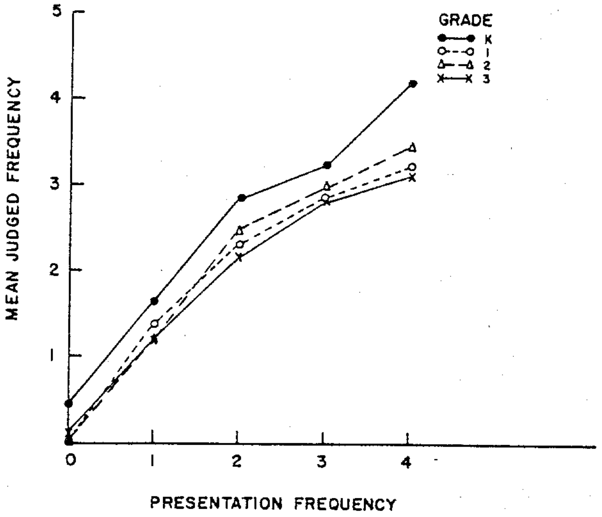
[3] Some conflicting data on the issue of age invariance do exist. Two studies suggest that the invariance may begin around grade 3 (Ghatala & Levin, 1973; Lund et al., 1983, Experiment 1) and that kindergartners are not as good at remembering frequency as are slightly older children. All of these studies do show that kindergarten children discriminate differences in frequency. Whether they do so as well as older children is the central issue. Using the judgment measure, Ghatala and Levin (1973) found no age differences for one set of materials (a word list), but they did find the described age differences for another set (a picture list). Using the discrimination measure, (Lund et al., 1983) found the described age differences for a picture list. Materials differences are not likely to be the source of the age differences found here but not elsewhere (Johnson et al., 1979; Goldstein et al., 1983; Hasher & Chromiak, 1977; Hasher & Zacks, 1979) because both words and pictures were used in these latter studies. In our view, neither the Ghatala and Levin nor the Lund et al. studies can answer the developmental question because of methodological difficulties. Neither used complete counterbalancing of items across frequencies. This is a serious problem because others have shown pronounced subject × item interactions in the judgment of frequency (Underwood & Freund, 1970). The Lund et al. study poses an additional interpretational problem that stems from the fact that their lists used a large number of colored objects that appeared in only one of six different colors. It is clear from their data that subjects had information about both color and frequency and item frequency. What is worrisome

Figure 6
Estimated Frequency of Occurrence as a Function of Actual Frequency of Occurrence for Subjects of Varying Ages



Note. The figure is reprinted from Hasher and Zacks (1979, p. 370). Copyright 1979 by the American Psychological Association. Reprinted by permission of the publisher.

ability of newborns (Antell & Keating, 1983) and infants (Starkey & Cooper, 1980) to discriminate numerosities may indicate that some capacity for encoding frequency is present from birth.

The contrast between these data showing developmental invariance and virtually the entire cognitive development literature led us to a consideration of frequency processing by the elderly. Once again, the vast majority of research on the elderly shows that, on average, memory ability is reduced when compared to that of young adults (e.g., Craik, 1977; Kausler, 1982). Sensitivity to frequency, however, appears to be invariant across the adult years (Attig & Hasher, 1980; Hasher & Zacks, 1979, Experiment 2; Kausler & Puckett, 1980).

The age invariance in frequency processing supports the notion that the encoding of frequency is a fundamental cognitive process for which we are attuned early in life. This operation may belong to the category identified by Flavell (1977) as "basic" memory processes. Such processes are thought to make up the hardwiring of the memory system. For these, developmental trends are completed at an early age and are largely the product of maturation.

Limited Disruptions from Reductions in Capacity

Although cognitive processes that require considerable capacity should be disrupted by reduced capacity, automatic ones should not be. Capacity reductions may result from a variety of sources, for example, from stress, high levels of arousal, disease, depression, or an excess of simultaneous cognitive demands. Insofar as several of these are more common among the elderly, we have already noted some evidence that frequency processing is invulnerable to capacity reductions. Further evidence comes from a comparison of moderately depressed with nondepressed young adults. Depressed adults of all ages show deficits in problem-solving ability and in the use of imagery as a learning strategy, as well as a temporary suppression of IQ, among other deficits (see Weingartner, Cohen, Murphy, Martello, & Gerdt, 1981). Frequency performance is unaffected by depression (Hasher & Zacks, 1979, Experiment 3) even when the level of depression is extremely high (Weingartner, 1984). Finally, there is evidence that although diabetics show deficiencies in paired-associate learning, a task amenable to the use of strategies, they do not show deficiencies in the processing of frequency information (Lichty, 1982).

Another way to examine the impact of capacity reductions is to impose simultaneous task demands. This reduces the capacity available for each task compared to a situation in which there is a single task. For example, our attempts at conversation may be reduced when driving, particularly during an attempt to enter a busy freeway. Consider again the data from the study that compared students from University A, with its selective admissions policy, to students from University B (Figures 4 and 5). Notice that some groups from each school were instructed to prepare for a single test, either recall or frequency, whereas others were instructed to prepare for both types of tests. Recall performance (see Figure 4) was poorer under dual task demands than under single task demands. Subjects instructed to prepare for both a frequency and a recall test try to do so. Not realizing that strategies such as counting are actually ineffective, subjects try to use them and, as a result, have less capacity available to prepare for recall than do subjects preparing only for a recall test. Now consider the frequency data (Figure 5). Here performance was the same whether subjects believed they were preparing only for a frequency test or for both frequency and recall tests. Reductions in capacity over the ranges so far explored do not affect performance on frequency tests.

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here is the possibility of an age-related susceptibility to confusion stemming from having frequency information for both the item and the color. Our own data consistently show no age differences and, given the bias against publishing null results, we believe it reasonable to accept the developmental invariance conclusion beginning at least at age 4 to 5 years, acknowledging, of course, that subsequent studies may identify the onset of invariance at around 8 years. Even this would be remarkable.

Summary and Evaluation

The processing of frequency of occurrence information is remarkable. Information about frequency is recorded in memory without a person's intention to do so. The information stored in this way is apparently no less fine-grained than is the information stored when intention is operating. Training and feedback do not improve the ability to encode frequency information. Unlike virtually every other cognitive skill examined in the history of the field, memory for frequency shows a developmental invariance from early childhood through young adulthood to middle and old age. Similarly, there are no effects of differences among people in motivation, intelligence, and educational background. The processing of frequency information is unaffected by reductions in cognitive capacity stemming from depression, old age, or multiple task demands.

Possible Qualifications

Except for the first criterion (sensitivity without intention), all predict null effects, and the results of a large number of experiments conform to these predictions. This pattern of results is important because our definition of automaticity of encoding hinges on the joint satisfaction of six criteria. Thus, our conclusions are based on a pattern of findings and not on any individual null result. This serves to reduce the possibility that a spurious finding would lead to the classification of an encoding process as automatic. Further, with the exception of intention, the variables that fail to influence frequency sensitivity (e.g., practice and individual differences) are ones known to have powerful effects on other memory tasks. Therefore, the absence of these effects here is informative—assuming, of course, that the experimental measures are not insensitive. We address this issue next.

The most obvious sources of insensitivity of measures are ceiling and floor effects. In the large number of experiments on frequency processing, we find no evidence of any such problems. Furthermore, in both the judgment and discrimination procedures there is evidence of extremely fine-grained sensitivity to frequency. Consider first the evidence from experiments using the judgment measure. A number of these studies show the rather remarkable ability of subjects to discriminate frequency differences between sets of highly similar stimuli including verbatim versus gist repetitions of sentences (Burnett & Stevenson, 1979; Gude & Zechmeister, 1975), auditory versus visual presentations of words (Hintzman, Block, & Summers, 1973), and actual events versus induced imaginations of those events (Johnson, Taylor, & Raye, 1977). Finally, even for nominally identical events, people can recall how often specific items occurred in contexts that are only slightly different (e.g., the first half versus the second half of a list; Hintzman & Block, 1971, Experiment 3; Reichardt, Shaughnessy, & Zimmerman, 1973). Such fine-grained knowledge of frequency of occurrence could not be demonstrated with an insensitive measure.

Consider next experiments using the frequency discrimination measure. Here, too, there are findings that indicate that null effects cannot be attributed to insensitive measures. Ability to discriminate frequency differences between pair members conforms to a Weber function: Errors decline with increasing absolute difference in frequency between pair members, and errors increase the greater the number of occurrences of the less frequent item in a pair (e.g., Attig & Hasher, 1980; Underwood & Freund, 1970; Zacks et al., 1982). The orderliness of these results indicates the sensitivity of measures of frequency knowledge.

There is clear evidence that insensitivity is not the source of the null effects found in attempts to demonstrate that frequency is processed automatically. Rather, the null effects exist because of what may well be the structure of the memory operating system.[4] We turn briefly to a consideration of this issue before returning to our second major aim: the explication of ways in which frequency information is used in behavior.

The Representation of Frequency Information

There is now good evidence that people store a continual and fine-grained record of the frequency of occurrence of events. Along with other data (see e.g., Zechmeister & Nyberg, 1982, Chapter 8), these findings have led a number of investigators (Hintzman, 1976; Hintzman, Nozawa, & Irmscher, 1982; Hintzman & Stern, 1978; James, 1892, p. 150; Johnson, 1977) to propose that frequency information has a special or privileged representational status. After considering a number of possibilities for representational models (including trace strength), Hintzman (1976) attributed this status to a memory system that establishes a separate trace for each attended occurrence of an item. A multiple trace theory of memory does account for the inevitable storage of frequency of occurrence information.

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[4] One variable that reliably influences memory for occurrence rates is the orienting task given to a subject during encoding (e.g., Fisk & Schneider, 1984; Rose & Rowe, 1976, Experiment 2; Rowe, 1974). These findings also help to argue against the idea that the measures used in the present research are insensitive. On the surface, of course, these findings seem contrary to the idea that frequency is encoded automatically. This matter will be addressed subsequently.

Two amplifications of the multiple trace theory are dictated by other findings in the empirical literature. Together with multiple trace theory, these amplifications enable explanations of a few findings (see footnote 4) that are in apparent contradiction to the automaticity assumption. The first amplification stems from the research of Johnson and Raye (see Johnson & Raye, 1981, for an overview) showing that memory traces are created for both actual occurrences of events (e.g., words on an experimental list) and subjective occurrences of events (e.g., covert rehearsals or images of words on the list). Although frequency of overt and covert events can be distinguished (Johnson et al., 1977), subjects are not perfect at this task; covert occurrences will increase the perceived frequency of overt events. This phenomenon accounts for the fact that encoding tasks that alter the number of covert rehearsals items receive will produce differences in frequency judgments. Tasks that increase rehearsals with respect to other tasks will also yield larger frequency estimates than tasks that promote fewer rehearsals (see e.g., Rose & Rowe, 1976).[5]

The second amplification of multiple trace theory stems from the fact that not all memory traces are equally accessible at any given moment. Research in human memory demonstrates that a variety of stimulus, subject, and environmental variables influence trace accessibility. Differences in the accessibility of individual traces would be expected to influence judgments of frequency; the more traces accessed, the higher the judgment. This phenomenon is likely to underlie the incorrect perception that there are more 5-letter words that begin with the letter *k* than there are 5-letter words that have *k* as their middle letter (Tversky & Kahneman, 1973).[6]

Of course, multiple trace theory is not the only theory put forward to account for the body of empirical findings on knowledge of frequency (see Hintzman, 1976). Other theorists (e.g., Underwood, 1983) seem to favor the existence of a counting mechanism at input. Regardless of the final resolution of the issue of the representation of frequency, it is clearly the case that the empirical findings on memory for frequency of occurrence are atypical: It is exceptional to find invariance in performance across individuals differing in age, ability, experience, motivation, and mood. It is also exceptional to find no effects of intentionality, practice, feedback, or competing demands.

These findings are not just of consequence to memory researchers. Evidence implicating a central role for frequency information in numerous cognitive and social behaviors suggests otherwise. The remainder of this article describes some of these uses and in doing so demonstrates broad implications for the research on encoding of frequency of occurrence.

Uses for Automatically Encoded Frequency Information

Some uses for frequency information have been directly demonstrated in empirical research; others can be reasonably inferred from the existing data. We have grouped these two sources of information together and have organized our discussion of the utility of frequency information into four broad categories. The first of these addresses the role of frequency in mediating memory for events. The second addresses the role of frequency as a device for organizing existing knowledge and for acquiring new knowledge. The third addresses the role of frequency in decision making. A final section provides examples of the role of frequency information in both cognitive and social development.

Event Memory

A good deal of research on forgetting shows the critical role retrieval cues play in accessing stored information (e.g., Tulving & Pearlstone, 1966; Tulving & Thomson, 1973). Frequency information can serve as a potent retrieval cue. For example, one can cue oneself with the knowledge that a momentarily forgotten name is a common or uncommon one. Or, one can use frequency information to remember the number of items on a recall list (e.g., that the marketing list had eight items on it or that there were three people in attendance at a particular meeting). Direct studies with children as subjects show that the provision of cues about the size of a category will increase the number of list items recalled (e.g., Posnansky, 1978).

In addition, at least one major theory of recognition memory (Underwood, 1971) proposed that frequency information is the major source of people's ability to distinguish between events they have ex-

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[5] One procedure that has been shown to increase covert rehearsals (see Postman & Kruesi, 1977, Experiment 1) is a rating task in which subjects judge individual list items on a multipoint scale (e.g., for connotative strength). In doing this task, subjects apparently try to maintain consistency in the ratings they assign by remembering the ratings they gave to previous items, thus producing covert rehearsals, or traces, of the actually presented items. If subjects are then asked to judge the frequency of actually presented items, the traces representing covert occurrences of items will be confused with traces representing actual occurrences of items (Johnson & Raye, 1981). This will tend to inflate estimates of the frequency with which items actually occurred. Indeed, there is good evidence of higher frequency judgments being made by subjects given just such rating cover tasks (see Rose & Rowe, 1976; Rowe, 1974) as compared to subjects given cover tasks that focus attention on each item alone (e.g., such tasks as counting syllables or consonants), tasks that probably minimize the number of covert rehearsals given to individual items (Postman & Kruesi, 1977).

[6] The availability heuristic is discussed at some length subsequently.

perienced and ones they have not; the latter have no "frequency tags." Other theories (e.g., Mandler, 1980) also proposed a role for frequency in recognition but provided for the operation of other processes as well. There is considerable evidence for at least the more conservative notion that frequency information partially determines recognition (see, e.g., Harris et al., 1980; Underwood, 1983).

Another indication of the importance of automatic encoding for normal episodic memory comes from recent work on amnesia; this work implicates the failure of automatic encoding as a factor in amnesia (Grafman, Boutelle, Kaye, & Martin, 1983; Hirst, 1982a; Huppert & Piercy, 1978; Weingartner, 1984). For example, Weingartner et al. (1983) have found that amnesics show a deficit in memory for frequency of occurrence (see also Huppert & Piercy, 1978). Hirst (1982a) offered one suggestion of how deficits in automatic encoding might affect memory. If a person devotes effort to encoding information that is usually automatically encoded, then less capacity is available for normally effortful mnemonic activities (e.g., organizing input or imagining it). If, on the other hand, no attempt is made to encode information that in normal individuals is encoded without effort, then the crucial contribution of this information to memory (e.g., in retrieving stored information and discriminating old events from new ones) is lost (Hasher & Zacks, 1983). In either case, a breakdown of automatic encoding will have serious negative consequences for memory performance.

Knowledge and Skill

Concepts. A major subset of human knowledge consists of information about concepts. Concepts enable us to manage the enormous diversity of our experiences by allowing us to categorize objects and events that are discriminably different into classes whose members can be treated as equivalent entities (Bruner, Goodnow, & Austin, 1956). The "classical" view of the representation of concepts assumed that people had a set of criteria that comprised the conditions that were necessary and sufficient to determine the category membership of any particular exemplar (Smith & Medin, 1981). This view was brought into question in large measure because of the work of Rosch and her colleagues (e.g., Mervis & Rosch, 1981; Rosch, 1978). Recent work demonstrates that conceptual knowledge depends directly on frequency information (Chumbley, Sala, & Bourne, 1978; Kellogg, 1981; Kellogg, Bourne, & Ekstrand, 1978; Livingston & Krueger, 1982; Neumann, 1974, 1977).

Before turning to this work, it is important to consider the shortcomings of the classical view of people's knowledge of concepts. For present purposes, they center on the inability of this theory to account for two facts: (a) that category instances are unequal in the degree to which they are seen as representative or typical of the category as a whole (compare robins and ostriches as exemplars of "birds" and (b) that there are often no clear-cut boundaries between categories (e.g., McCloskey & Glucksberg, 1978; see Smith & Medin, 1981, for a review). Current research suggests that any category is most often thought of in terms of its best examples or "prototypical" members and that categories are organized as "fuzzy sets" with the extent of category membership of an exemplar varying in degree.

Several contemporary views of category representation emphasize the importance of frequency information. Included here are feature-frequency and item-frequency (or exemplar-frequency) theories (Livingston & Krueger, 1982). Feature-frequency theories propose that concepts are represented in terms of their most frequent features. For example, the features "can sing," "can fly," and "small size" are frequent features of the category "bird." Birds that have all these features (e.g., robin, sparrow) are more prototypical birds than birds that do not (e.g., ostrich, chicken). Thus, differential frequency information (in this instance, of the frequency with which different features occur in category members) seems central to how we represent natural categories.[7]

A variety of findings from research with experimenter-generated rather than with naturally occurring categories also support the feature-frequency view. For example, Kellogg et al. (1978) found that subjects who had learned categories of schematic faces judged stimuli with features that had appeared frequently in the exposure set to be more typical than those with infrequent features. Subjects gave higher recognition confidence ratings to items containing frequent features than to ones containing infrequent ones (e.g., Neumann, 1974). Also relevant

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[7] In a number of places, Rosch (Mervis, Catlin, & Rosch, 1976; Rosch, Simpson, & Miller, 1976) argued that frequency information is unimportant to conceptual representation. However, most of the negative evidence presented concerns frequency of exemplars. Feature frequency is quite another matter. Consider, for example, the hypothesis (e.g., Rosch & Mervis, 1975) that a category member's typicality is a function of the extent to which its features overlap those of other category members (i.e., of the extent to which it bears a "family resemblance" to other category instances). In most demonstrations supportive of this hypothesis, the family resemblance structure of a category depends on differential feature frequency (see Rosch et al., 1976, p. 501). Even the item-frequency view is not completely without support: The findings of Livingston and Krueger (1982) indicate that item-frequency differentials can, under some conditions, determine instance typicality independently of the effects of other variables (e.g., distance from the "prototype"). Our point here is not to argue that feature or item frequency is the sole determinant of category representation, but that one or both of these play an important role in category representation, and that this role will have to be accommodated by theories of conceptualization.

is the fact that subjects can accurately recall the frequencies of individual features (e.g., Kellogg, 1981). Finally, in a study that pitted a feature-frequency model against a distance-from-prototype model, Chumbley et al. (1978) obtained data favoring the feature-frequency model.

The importance of feature frequency for category representation is consistent with what is known about adults' knowledge of a wide variety of natural category classes, including categories of common objects (e.g., furniture, birds; Rosch, 1978), of personality traits and types (e.g., dominance, gregariousness, extraversion; Buss & Craik, 1981; Cantor & Mischel, 1979), and of social situations (e.g., parties, religious ceremonies; Bower, Black, & Turner, 1979; Cantor, Mischel, & Schwartz, 1982). Similarly, feature frequency has been shown to be important in the organization of the knowledge of experts. This includes the knowledge that medical professionals have of disease categories (Bordage & Zacks, 1983) and that psychiatrists have of psychiatric diagnoses (Cantor, Smith, French, & Mezzich, 1980). In sum, frequency information plays an important role in category representation.

Sensitivity to frequency may also play a role in the acquisition of new categories. Kellogg and Dowdy (1982) have suggested that people gain knowledge of the relative frequency of features in a set of instances through a passive, automatic process. The knowledge thus acquired, they argued, is both necessary and sufficient for concept acquisition. How, then, can we account for the classical evidence that subjects often seem to use hypotheses (e.g., Bruner et al., 1956) that lead them to sample and test stimulus features to determine the defining attributes of the category? For one thing, the fact that hypotheses are generated does not necessarily imply that they have a functional role in the acquisition of concepts (Kellogg, 1980). Indeed, Kellogg's work (1980, 1982) showed that hypothesis testing appears to be an optional rather than an obligatory process.[8] The automatic encoding of frequency information, on the other hand, seems critical for both the acquisition of new categories and the representation of existing conceptual information.

Schemata. Although the terms *concept* and *schema* refer to related ideas, most models of knowledge include both. Schemata are more comprehensive knowledge structures than are concepts, and they represent an organization of a variety of different types of information including concepts. Schemata of classes of events (e.g., going to a restaurant), locations (e.g., a library), and people (e.g., introverts) are presumed to play a central role in information processing. This is so for at least two reasons: (a) as with concepts, schemata allow us to organize large amounts of information; and (b) they allow us to make predictions about forthcoming events, predictions that enable us to reliably and easily process incoming information. With respect to the organization of schematic knowledge structures, arguments made in the previous section about the importance of frequency information for the acquisition and representation of concepts are relevant here as well. We turn now to the issue of prediction.

It is widely held that the existence of schemata permit much information processing to be "conceptually driven" (e.g., Lindsay & Norman, 1977). That is, processing is frequently under the control of schematically derived expectations about which a person is often not even aware. Expectations serve to speed the rate at which the environment can be sampled because less information needs to be sampled to confirm a (correct) expectation than is required to decode an unexpected event.

Expectancy-guided or schema-driven processing has been incorporated into models of story comprehension (e.g., Mandler & Johnson, 1977), reading (e.g., Goodman, 1967), pattern recognition (e.g., Lindsay & Norman, 1977), artificial intelligence (e.g., Lindsay & Norman, 1977), and memory (see Alba & Hasher, 1983, for a review). Consider first the artificial intelligence concept of "default values." These are instances that are part of the schematic representation of a particular knowledge domain. People are thought to interpolate these instances in their representation of a particular event whenever the incoming event is ambiguous or is missing information. Default values turn out to be the most frequent instances in a given context. Consider this: A nurse is mentioned in discourse. What sex do you suppose that person to be?

More generally, what is the source of the expectancies proposed by schema models? This issue is not directly addressed in most theoretical statements, and so there is little in the way of direct evidence. However, information about frequency of occurrence is the logical and fundamental source of schema-dependent expectancies.

Word-decoding skills. Skilled reading is an extremely complex ability composed of many subskills, among the most important of which is the ability to read, or decode, individual words rapidly and effortlessly (e.g., Mason, 1975; Massaro, Venezky, & Taylor, 1979). To do this, skilled readers rely heavily on knowledge of the ways in which word spelling is constrained or structured. Various types of structure may be important, including sequential constraints (e.g., *q* is always followed by *u*) and orthographic rules (e.g., no letter can be tripled and

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[8] In fact, the hypotheses offered by subjects in these studies are sometimes generated on the basis of frequency information.

there are 10 letters including *q*, *u*, and *y* that are almost never doubled). Also important for word decoding is "single-letter positional frequency" (Mason, 1975). This refers to the fact that at each location in a word particular letters occur more frequently than others. For example, *p* is more frequent than *r* in the first position of 6-letter words, whereas the reverse is true for the last position. The existence of such frequency differentials has been shown to facilitate word decoding for both children and adults (Mason, 1975, 1978; Massaro et al., 1979; McClelland & Johnston, 1977). To the extent that structures other than single-letter positional information are also cued by frequency differentials, automatic encoding of frequency can set the stage for their use by children who are learning to read as well as by more skilled readers.

Decision Making

People often must make decisions in the face of incomplete, equivocal, or probabilistic data. To do this, people rely on preferences, beliefs, and subjective probabilities, all of which depend to some extent on the encoding of frequency information.

Preferences and beliefs. Consider the decision about where to buy a house. In many cities, a choice of the "best" place includes assessments of the safety of the neighborhood and the quality of the local public schools. Neither author has yet met anyone who reported making a decision about where to buy a house without taking into consideration such factors, and neither has yet met a person who has actually obtained definitive, objective data on these issues. In situations such as these, frequency information can influence decisions in at least two ways. The first involves affective responses, including preferences. These are known to be affected by event frequency. For example, research on the "mere exposure effect" (e.g., Zajonc, 1968) has shown that alternatives to which a person has been frequently exposed are preferred over those to which the person has been infrequently exposed.

The second way in which frequency information may influence decision making has to do with a person's belief in the validity or truth of whatever information is available. For example, in deciding where to buy a house, a person's major source of information will often be reports of other individuals about the neighborhoods in question. It may well be that the more often someone hears good (versus bad) things about a neighborhood, the more likely that person is to believe in the validity or truth of the good things. Several experiments confirm that frequency of occurrence is at least one component in the judgments people make about the validity of facts (e.g., rice is grown in Florida) whose truth value is unknown or difficult to access (Bacon, 1979; Hasher, Goldstein, & Toppino, 1977).

Subjective probabilities. Information about event frequency also plays a crucial role in decisions made in probabilistic environments, such as predictions of election outcomes or of gambling events. Decisions in such situations are often said to be determined by an individual's "subjective probabilities." Although there is an extensive literature on subjective probabilities, recent work leads to the conclusion that probabilities are not stored directly but are derived from the more basic knowledge of frequency (Estes, 1976a, 1976b). One of the experimental manipulations that led Estes to this conclusion involved pitting relative frequency and relative probability directly against each other (these are usually completely confounded). For example, in a simulated opinion poll, on each of a series of trials, subjects observed the outcome of a minipoll contrasting two alternatives (e.g., two political candidates). The exposure sequence was designed so that in some cases one event had a higher probability of "winning" than another but a lower overall frequency of winning. When two such events were paired directly, subjects typically picked as the likely "winner" the candidate whose absolute frequency of winning elections was higher. Estes' research clearly demonstrated the crucial role of frequency information in making probabilistic choices.

Similarly, it has been shown that subjects perceive a change in the incidence of a probabilistic phenomenon (e.g., teenage pregnancy, illness among friends), when simple frequency changes even though the rate (i.e., probability) has remained constant (Silka, 1981). Insofar as people base decisions about the rates of events on frequency rather than on probability, this creates a potentially serious problem for decision makers.[9]

Thus, important economic, political, and affective behaviors are influenced in part by information stored in memory about frequency of occurrence. Frequency data almost certainly play a role in the decisions and preferences of animals other than humans. For evidence of the sensitivity of animals to numerosity information see Davis and Memmott (1982). For example, in situations in which alternative behaviors have differing probabilities of pro-

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[9] What we have said might be seen as conflicting with demonstrations of the importance of the availability heuristic (e.g., Tversky & Kahneman, 1973) in making decisions about frequency. In this view, subjects are biased toward judging frequency on the basis of the availability of events in memory (e.g., the belief that there are more 5-letter words that begin with the letter *k* than there are that have *k* as their middle letter). As Zechmeister and Nyberg (1982) noted, however, the conflict between our view and that of Tversky and Kahneman is more apparent than real. First of all, in most instances frequency and availability (like

ducing positive outcomes (reinforcers), animals distribute their behaviors among the alternatives in accordance with the probabilty of reinforcement. Included here are studies of reinforcement "optimization" in operant learning paradigms (e.g., Rachlin, Green, Kagel, & Battalio, 1976) and of "optimal foraging" by predators in natural habitats (e.g, Sih, 1980). Preference for responses more frequently associated with reinforcement or for locations in which prey are more frequently found might well depend upon sensitivity to occurrence rate information.

We have now considered the role of frequency information in a variety of contexts; these include recall and recognition processes in memory for events, for the acquisition and representation of schematic and categorical knowledge, for reading, and for decision making. With the exception of reading skills, our speculations have centered on the behavior of adults. However, young children are known to encode frequency information in much the same manner as adults. Young children confront some especially interesting knowledge-acquisition problems, and so we turn now to a consideration of the uses of frequency information in development.

Developmental Implications

The encoding of frequency information is a memory skill that attains adult efficiency levels at a very early age. It is not surprising that frequency information may play a central role in a number of the cognitive and social accomplishments of childhood, including the acquisition of knowledge about categories, the development of ability to make accurate probability judgments, and even sex roles.

Category knowledge. One of the major accomplishments of early childhood (see Bruner et al., 1956) is the acquisition of the basic categories of events in the environment. Feature frequency is considered important in both category acquisition and representation. So, the early onset of sensitivity to frequency can facilitate a child's acquisition of knowledge about categories. There is some direct evidence in the developmental literature to support the idea that knowledge of frequency is important in category acquisition. Children learn the category membership of more prototypical members (those that embody more frequent features) before they learn the category membership of less prototypical members. Children learn that robins and sparrows are birds before they learn that chickens and ostriches are birds (see Mervis & Rosch, 1981, for a review of this literature). Recent work shows that infants as young as 3 to 4 months in one case (Bomba & Siqueland, 1983), and 10 months in another (Strauss, 1979), use prototypicality as the basis of category representation.

Probability judgments. Children are also able to respond appropriately to differences in probabilities, although this ability increases with age (e.g., Brainerd, 1981). This increase is not, however, due to age differences in the encoding of frequency information. In agreement with other research, Brainerd (1981) found that even the youngest children tested (4-year-olds) had excellent knowledge of relevant frequencies. There were, however, developmental differences in the likelihood of retrieving stored frequency information to make the requested probabilistic predictions. When retrieval of the relevant frequencies was maximized, appropriate predictions occurred at high levels for all ages. Brainerd's research thus showed that the early onset of the ability to encode frequency provides the basis for the early development of probability judgment skills.

Sex roles. For social development, one of the most important acquisitions of childhood is that of sex-appropriate attitudes, motives, and behaviors. Theories of sex role development generally assume that a major mechanism of sex role acquisition is the tendency of children to imitate same-sex models more than opposite-sex models (cf. Perry & Bussey, 1979). However, children will not imitate just any same-sex model; they require information about how representative a particular model is of his or her sex. This information can be provided in situations in which the behaviors of groups of potential role models can be observed (Perry & Bussey, 1979). Only when specific behaviors show a large frequency differential between the sexes are children likely to show a same-sex imitation tendency. So, for example, pronounced same-sex imitation was seen among 8- and 9-year-old children when all the female models behaved in one way and all the male models behaved in another. When the within-sex consensus among the models was reduced to 75%, the children's tendency to imitate same-sex models was similarly reduced. A single model did not produce a same-sex imitation tendency unless the children had pre-

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frequency and probability) are highly correlated: More frequent events are, other things being equal, more recallable or "available" than less frequent events. In such situations, any biasing effects of the availability heuristic will not be seen. Use of availability will bias frequency estimates most clearly when the retrieval cue (i.e., the event to be judged) is a weak one (as in the example of words having a particular letter in a middle position). It is worth noting, in addition, that in other illustrations of the availability heuristic, the actual frequency differentials are small (e.g., 19 versus 20) and the countervailing effects of other variables (e.g., stimulus familiarity) are very strong. Such is the case in Tversky and Kahneman's (1973) experiment in which subjects misjudged as being more frequent 19 famous names scattered in a list that also included 20 nonfamous names. Although laboratory studies demonstrate that memory for numbers of occurrences is good, it is certainly not perfect: indeed, this is the sort of discrimination that might be at chance.

viously observed the model performing behavior consistent with the model's sex (i.e., unless the child already had evidence that the model was a "valid" representative of his or her sex). Again, sensitivity to frequency information has a crucial role in development.

Summary. We have discussed three areas in which the child's early sensitivity to frequency information seems to provide a basis for critical developmental acquisitions. Our examples are certainly not exhaustive; other possible childhood acquisitions in which frequency information may play an important role include the development of syntax (Robinson, 1982) and of number concepts and of the implicit rules of social discourse and interaction.

Conclusion

People of all ages and abilities are extremely sensitive to frequency of occurrence information. We have speculated that such information may well be critical in the development of both social and cognitive knowledge systems. We have also speculated that such information provides people with the bases for establishing preferences, making decisions, and interacting with others as well as with the environment throughout the lifespan. To return to the domain of cognitive psychology, however, we note that the major conclusion of this area of research stands on a firm empirical base: The encoding of frequency information is uninfluenced by most task and individual difference variables. As a result, memory for frequency shows a level of invariance that is highly unusual in memory research. This is probably so not because frequency is unique but because memory researchers have paid little attention to implicit, or automatic, information acquisition processes. Here we demonstrated the existence of one such process. We also showed its implications for the acquisition and utilization of some important aspects of knowledge.

We end with some speculations on the boundary conditions to the phenomenon of automatic encoding of frequency information. First, are there people who cannot process frequency? In our own research we have found unreliable frequency judgments given by approximately five subjects out of the thousand or so we have tested. Others have suggested that in some neurologically impaired populations, frequency encoding will fail. In particular, Weingartner, Grafman, Boutelle, Kaye, and Martin (1983) have evidence that frequency is not processed by Alzheimer's patients. Smith and Milner (1983) reported that people with frontal lobe lesions have some limitation on their ability to process frequency. And Stein, Laskowski, and Troncone (1982) reported that profoundly retarded people cannot process frequency except to make gross discriminations.

Second, are there circumstances under which stored frequency information will not be used? The answer is probably yes. People seem largely unaware of the quality of their stored frequency knowledge and of the range of information for which this knowledge exists. To the extent that a situation depends on conscious reasoning, frequency knowledge may not be used. Not long ago, such a statement would have been interpreted to mean that the underlying information had a trivial impact on behavior because the main focus of cognitive psychology was on conscious processes. However, a number of findings have refocused the attention of cognitive psychologists on the role of unconscious processes in tasks ranging from perception to speech production (e.g., Bock, 1983; Jacoby & Witherspoon, 1982; Marcel, 1983). Indeed, it now seems possible that a good deal of mental life functions independently of access to consciousness.

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