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Processing of occurrence-rate and item information by children of different ages and abilities

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Two experiments compare the performance of children who vary in both age and learning ability. In the first experiment, learning disabled and nondisabled children from three age groups were tested for their incidental memory for frequency of occurrence information. In the second experiment, learning disabled and nondisabled children from two age groups were tested for their intentional memory of item information on a free recall test. In agreement with the notion that frequency is automatically encoded, all groups extracted frequency information and neither age nor learning ability influenced performance. However, both age and ability influenced performance on the recall test.

Hasher and Zacks (1979) have proposed that the frequency with which events occur may be one of a small number of attributes that are encoded into memory automatically. In their framework, automatic encoding operations are ones that use little capacity, do not interfere with other ongoing activities, and function continuously and well without the intention of the individual. Automatic processes are "basic" (see Flavell, 1977) in that they are expected to show minimal developmental trends across the entire lifespan with maximal levels of proficiency already present early in life. Of particular interest to this paper is the suggestion that automatic processes should be widely shared among people: differences in education, in socioeconomic status, in culture, and/or in intelligence should all have little impact on the ability to encode an automatically processed attribute.

Thus, the processing of frequency information stands in marked contrast to more familiar effortful encoding operations, including imagery, rehearsal, and the development of retrieval plans. Such strategies are thought to require the intention of the person and to use considerable cognitive capacity. They typically show pronounced interference effects with other effortful tasks. In addition, their reliable use varies as a function of age, motivation, education level, and intelligence (see Hasher & Zacks, Note 1).

The literature evaluating the assumptions about the basic nature of frequency processing is not large. There is, though, fairly good evidence that frequency encoding is invariant across the lifespan: kindergarteners are as sensitive to frequency differences as are third graders; second graders are as sensitive as college students; college students, middle-aged adults, and elderly adults are all equally sensitive (see Attig, Note 2; Attig & Hasher, 1980; Hasher & Chromiak, 1977; Johnson, Raye, Hasher, & Chromiak, 1979; Kausler & Puckett, 1980).

There is less research available on the extent to which individual differences influence the encoding of occurrence-rate information. Two experiments do suggest that differences among and within individuals have minimal impact on frequency encoding: (a) students who differ markedly in scholastic aptitude and its correlated motivational and socioeconomic status variables do not differ in their sensitivity to frequency information (Zacks, Hasher, & Sanft, 1982, Exp. 3), and (b) how a student performs relative to other students on one test of frequency discrimination does not reliably predict how that student will perform on another test of frequency discrimination (Zacks et al., 1982, Exp. 1). In the case of both of these studies, reliable individual differences were found for performance on free recall, a task thought to be mediated by effortful processes.

While the lack of individual differences in frequency processing was fairly clear in the Zacks et al. studies, the findings are nonetheless surprising because ability and motivation are widely thought of as potent variables (e.g., Hunt, 1978). Consequently, we thought it important to evaluate the extent of individual differences in frequency processing from yet another perspective. The present experiment does that by comparing the frequency sensitivity of normally proficient learners with that of less proficient learners.

The groups of children selected to represent learners of low proficiency came from a population of learning disabled children enrolled in a special school and treatment center. Learning disabled (LD) children are those who, despite normal intelligence, have selective cognitive difficulties which result in significant school failure (as assessed by below-grade level performance) in one or more areas, such as in reading and in mathematics (see Kinsbourne & Caplan, 1979; Lavigne

& Burns, 1981; Lerner, 1981). Our more proficient learners were children selected from standard classrooms.

A survey of the research literature on LD children reveals that they have a number of cognitive problems prominent among which are attentional deficits (e.g., Copeland & Wisniewski, 1981; Ross, 1976). There is also evidence that LD children are less proficient than their nondisabled (NLD) age-mates on a variety of memory tasks and processes, including verbal rehearsal (Bauer, 1977; Torgesen & Goldman, 1977), organization (Parker, Freston, & Drew, 1975), elaboration (Bauer, 1979), and short-term recall (Cohen & Netley, 1978; Torgesen & Houck, 1980). This latter set of findings is of special interest here because it suggests that LD children have difficulty with memory tasks thought to require considerable effort for optimal performance (e.g., Hasher & Zacks, 1979). Thus, learner proficiency may have a reliable impact on effortful tasks. Does it also on automatic tasks?

Two studies are reported in the present paper. The first enables us to examine three questions: (a) whether LD children encode frequency of occurrence information in an incidental memory task, (b) whether LD children are as sensitive to frequency differences as are NLD children, and (c) whether there is a developmental progression in the processing of frequency information across the years from 6 to 9. We expected to find that less proficient learners would be sensitive to frequency information even in the present case, one in which they did not know that this attribute was to be remembered. We also expected to find no evidence of differences between proficient and nonproficient learners in sensitivity to occurrence-rate information. In addition, we expected to find no age-related differences in frequency processing. The second study assessed the ability of LD and NLD children to recall items under intentional memory instructions. Since recall is a task mediated by a number of effortful strategies, we expected to find proficient learners at an advantage compared to less proficient learners.

EXPERIMENT 1

METHOD

Subjects

Forty-two children, 21 of whom were LD and 21 of whom were NLD, served as subjects in this experiment. Each LD child was matched for age with one NLD child. The age range was from 6.0 years to 9.0 years with a mean of 7.5 years. While one half of the NLD children were boys, two-thirds of the LD children were boys. Since previous research on children's frequency processing failed to uncover a sex difference (Hasher & Chromiak, 1977), the lack of equal numbers of boys and girls (which is typical of LD children) was not perceived as a problem for the present research. Each of the two samples was further subdivided into three age groups of seven children each: younger (mean = 6 yr., 5 mo.), middle (mean = 7 yr., 5 mo.), and older (mean = 8 yr., 7 mo.). The LD children were enrolled in the Therapeutic Educational Program (TEP) of the Irving Schwartz Institute for Children and Youth, a private, not-for-profit child guidance clinic located in Philadelphia. Children selected for the TEP program must demonstrate the potential for at least average intellectual functioning and be underachieving in their current school placement or be deemed "at risk" to develop a learning problem. Only children who were at least one year below age and IQ expectancy in *both* reading and mathematics achievement and who were not taking medication for hyperactivity qualified for inclusion in the present study. In addition, only children with WISC-R Full Scale IQ scores greater than 85 were selected (mean = 95.6, SD = 12.3).

The NLD children attended a Philadelphia parochial school and came from the same working-class background as the LD children. Individual IQ scores were not available, but all were within the normal range (85–115) and all of the children were functioning at or above grade level in both reading and arithmetic.

Design

Younger, middle, and older LD and NLD children were shown a series of slides and were informed that after seeing the slides they would be asked some questions about them. Embedded in a long series of slides were critical slides which occurred 1, 2, 3, and 4 times. In addition, the test list included some slides which had never been presented. The design was then a 2 (Group—LD vs. NLD children) × 3 (Ages) × 5 (Levels of Frequency of Occurrence) factorial with the last factor tested within subjects.

Materials

The materials consisted of a set of colored slides of drawings of 50 objects familiar to young children, such as a newspaper, balloons, cookies, and a bus. These items were used to form a presentation list that was 70 slots in length. Ten items were selected to serve as buffers in the first and last five slots of the list. Another 20 items served as filler items and were presented in the middle 60 slots of the list. Each filler was presented only once, and there were five such items in each quarter of the list. The remaining 20 items served as the critical items in the experiment. Four critical items appeared at each of the four levels of frequency (1, 2, 3, and 4) with one item representing each frequency category occurring in each quarter of the list. The last 4 of the 20 critical items served in the zero-presented condition; these were not shown to the subject until the test list. Items were assigned randomly within the four middle segments of the list with the exception that no repeated item ever followed itself. Five forms of this list were created by rotating each of the sets of critical items into each of the five critical frequency levels. This was done because frequency estimates are influenced by unknown characteristics of individual items (Underwood & Freund, 1970). The test list contained all 50 items. These were randomly ordered.

Procedure

Each child was tested individually in a quiet classroom. Each child was told that he or she would see a series of pictures on a small screen and was asked to name each object depicted. The child was asked to pay close attention to each object, because after all the slides were seen, some questions would be asked about them. No information was given about the multiple presentations of some slides, nor about the true nature of the test task. The list was then presented with each slide shown for 3 sec plus .8 sec for the slide change. All children assigned the appropriate name to every picture and the same name to each occurrence of a picture.

The test instructions were given immediately after the last slide was presented. Each child was told that all the pictures would be presented again, together with some that had not been seen before. The children were also told that pictures had been seen 1, 2, 3, 4 or more times before.[1] If the child had never seen an item before, he or she was to tell us so; otherwise he or she was to tell us how many times the item appeared on the list. Naming the number series for the children was a change from previous work with children (e.g., Hasher & Chromiak, 1977). It was adopted here because pilot work showed that this increased the willingness of the youngest children to respond during the testing procedure. The test items were then shown for 6 sec with .8 sec for slide change. Most children gave estimates for all items, only rarely was one omitted.

RESULTS

The dependent variable was the mean of the estimates given by a subject for the four items at each frequency level. The average of these may be seen, for each age and subject type, in Figure 1. A 2 × 3 × 5 mixed analysis of variance confirmed that age was not a significant factor in this experiment, either as a main effect or in interaction with subject type or frequency of presentation. This agrees with the findings of other studies (e.g., Hasher & Chromiak, 1977; Johnson et al., 1979); the processing of occurrence-rate information appears to be invariant with age.

Estimated frequency increased significantly with actual frequency, $F(4, 144) = 138.96, p < .01$. The LD children assigned significantly higher numerical estimates than did the NLD children, $F(1, 36) = 16.43, p < .01$. The tendency for LD children to produce higher estimates occurred systematically at all frequencies with the exception of the never-presented items, accounting for the significant Group × Frequency interaction, $F(4, 144) = 7.49, p < .01$.

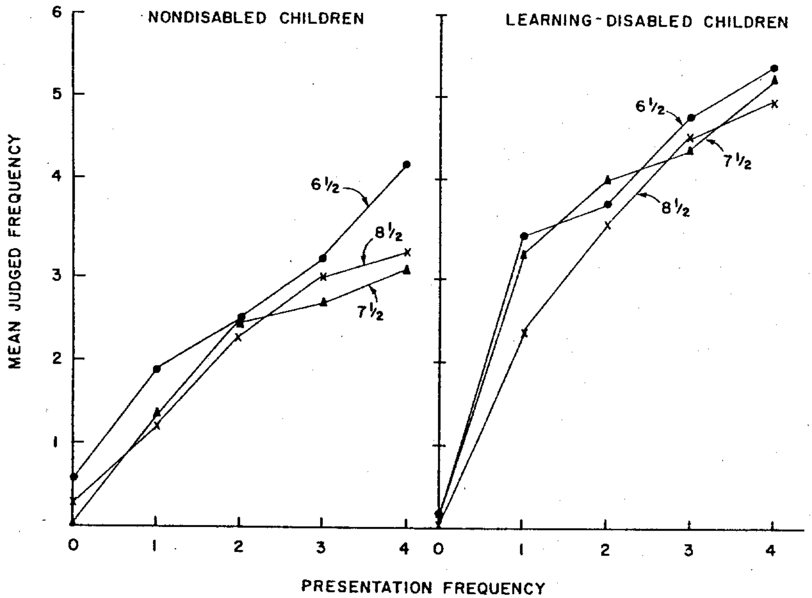

Figure 1. Mean of the mean judged frequencies as a function of actual frequency and age for nondisabled and learning-disabled children

A central concern here is whether both groups of children were sensitive to differences in frequency. To answer this question, Newman-Keuls analyses were done on the judgments of the LD and NLD children separately. Significant differences ($p < .01$) were found between each pairwise comparison for both groups of children. Thus, for every increase in actual frequency, both LD and NLD children reliably increased their estimates of frequency.

The actual estimates given by the LD children were substantially larger than those given by the NLD children. In fact, estimates larger than four, the highest actual frequency, were quite rare in NLD children (7% of all estimates) and quite common in LD children (36%). Thus, a derived measure of the degree to which the two groups of children were sensitive to frequency differences was obtained. We chose a measure originally proposed by Flexser and Bower (1975) as a way to test for the existence of differences in the sensitivity to frequency between fully informed and uninformed adult subjects. This measure is the correlation coefficient calculated for each subject on all of his or her estimates for each of the 20 items judged. Because this measure is uninfluenced by any differences among individuals or groups of individuals in the criterion used to assign a particular numerical value to a subjective magnitude, it was of particular value in the present case.

An inspection of the individual correlations revealed that for all but one subject (a child in the oldest NLD group), the coefficients were significant at or beyond the .05 level. Thus all but one child gave estimates indicating reliable sensitivity to frequency. The average correlation for the NLD children was .78; for the LD children the correlation was .73. These correlations are not significantly different from each other (t tested at .05).

Since the LD children showed a strong relationship between judged and true frequency and since they discriminated each increase in true frequency, to what should we attribute their marked tendency to overestimate actual frequency? Criterion differences operating at the time numerical values are applied to subjective magnitudes seem the most likely source of estimation differences. Given the poor school performance of the LD children, one possible source of the criterion differences might be their delayed acquisition of knowledge of the number system. This system develops first for smaller numbers and subsequently for large numbers (Gelman, 1972). Since the youngest LD children tended to give the largest estimates (see Figure 1), it seemed reasonable to consider the possibility that LD children retested later in the school year would give estimates more like those of NLD children.

We were able to retest 18 of the LD children 9 months after the initial session, at the end of their school year. Materials and procedures were those used in the first session. No child was retested on the same list used initially. An analysis of variance which included the three LD groups and two sets of scores at each of five frequency levels revealed a significant effect only for frequency of occurrence, $F(4, 60) = 114.52$, $p < .001$. Thus, while these LD children continued to reliably discriminate frequency after a 9-month interval, there was no reliable change in the size (or accuracy) of their estimates.

Since number system knowledge was known to have improved at least somewhat during the school year (as assessed by a standard mathematics achievement test), the failure to find a significant change in the accuracy of the frequency estimates suggests that number system knowledge may not be an important factor in the differences seen between LD and NLD children. The source of the presumed criterion difference remains obscure. There is some suggestion that a general bias towards the overestimation of events is present in these children; for example, they are known to greatly overestimate brief temporal durations (see Gearheart, 1977, chap. 5).

DISCUSSION

The present results show that both NLD and LD children encode frequency of occurrence information and do so under incidental memory conditions. For both groups, subjective judgments of frequency increased with each increase in actual frequency. Also, a measure of sensitivity failed to detect differences between the two groups. Thus, despite apparent criterion-based differences in the size of the estimates made by LD and NLD children, the two groups appear to be equally sensitive to differences in occurrence rates, at least under the present experimental conditions.

Thus, two groups of children who differ widely in their academic ability fail to show differences in their ability to incidentally extract frequency of occurrence information from events. The present findings then lend support to the contention that only limited individual differences are to be expected in the encoding of automatically processed information. This conclusion would be more powerful, however, if we were able to show that LD and NLD children reliably differed on more effortful tasks, in which individual differences in, for example, motivation and strategy use, can easily play a role. Some evidence to support this contention does already exist in the literature (e.g., Bauer, 1977, 1979; Torgesen, 1977; Torgesen, Murphy, & Ivey, 1979). But this is not a large body of research and, in addition, given the variability in the literature in the definition of learning disability, we thought it important to assess the existence of differences between the present groups on a more effortful task.

EXPERIMENT 2

We chose to use free recall as the memory task because it is one known to be influenced by a variety of effortful strategies (see Zacks et al., 1982). In addition, free recall is a task on which pronounced developmental trends are typically seen. These trends are most often attributed to the development of memory strategies (see Kail, 1979, for an overview). Since strategies require motivation as well as effort, proficient learners should be at a pronounced advantage compared to less proficient learners.

METHOD

Design and subjects

LD and NLD children of two different ages studied and recalled from a single series of pictures. Forty-eight children were chosen, 24 from each of the same two populations as in the first experiment, a school for LD children and a parochial school in a geographical area from which the LD school draws its children. There were 12 children in each of two age groups, 7.5 and 9.5 years. The mean ages of the two groups of LD children were 7 yr., 5 mo. and 9 yr., 7 mo. The mean ages for the two groups of NLD children were 7 yr., 5 mo. and 9 yr., 9 mo. In each group of 12 children, there were 8 boys and 4 girls.

Materials and procedure

Each child was tested individually on a list that comprised 25 of the 50 objects used in Experiment 1. These were shown, one at a time for 5 sec each, on a small screen in front of the child. Children were fully informed about the test task, and recall began immediately after the last slide went off the screen. The recall test was intentional to allow motivation and ability differences to play a role. A 2-min. period was allowed for oral recall.

RESULTS

The mean number of objects recalled by each group (and standard deviations) are shown in Table 1. It is obvious from this table that the pattern of results here is quite different from that obtained in Experiment 1. First, older children recalled more picture names than did younger children, $F(1, 44) = 4.41, p < .05$. Most importantly, NLD children showed a reliable two-item recall advantage compared to LD children, $F(1, 44) = 11.29, p < .01$. Age and learning ability did not interact.

Superior recall is thus associated with older as compared with younger children and with NLD as compared with LD children.

Table 1. Mean number recalled and standard deviations for younger and older LD and NLD children

	Age		
Group	7½	9½	Mean
LD			
Mean	6.92	8.42	7.67
SD	1.68	2.27	
NLD			
Mean	9.17	10.17	9.67
SD	2.59	1.53	
Mean recall	8.04	9.30	

GENERAL DISCUSSION

A straightforward conclusion about individual differences in learning ability can be drawn from these two studies: while such differences may influence recall, a task susceptible to strategies, they appear not to influence the processing of occurrence rate information. These two studies thus strengthen the findings of Zacks et al. (1982), in which able college students, informed about a forthcoming recall test, outperformed less able students. In this instance, ability differences were deduced from the existence of substantial differences in Scholastic Aptitude Test scores between students at the two schools. Scholastic ability did not influence performance on a frequency task, whether or not the students were properly forewarned about a forthcoming test. The present findings show that even at the very beginning of the grade school years, students who differ in ability show reliable differences in recalling items—but not in sensitivity to frequency.

The present findings also support another of the Hasher and Zacks (1979, Note 1) criteria for automaticity—that of minimal age-related effects. In agreement with their framework and with other studies, we find no age effects for frequency monitoring; we do find age effects, as have many others (e.g., Kail, 1979), for recall.

One last issue should be noted. The present data do appear, on the surface, to show that NLD children give more accurate frequency estimations than do LD children. That is, the judgments of the NLD children were not only smaller than those of LD children, but (as can be seen from Figure 1), they were closer to the true frequencies. While it is puzzling that the LD children persistently overestimate true frequency, we think that the central fact here is that they discriminate the differences that are present and do so as well as the NLD children. Such differences in judgment biases have been found before; older adults give reliably smaller (and less accurate) estimates than do young adults (Hasher & Zacks, 1979), but they are as sensitive to differences (Attig & Hasher, 1980).

We think it significant that children who differ in scholastic ability and achievement are able to discriminate frequency under incidental conditions. Our view is based on the speculation that knowledge about the occurrence rates of events may provide information essential to two of the most basic cognitive tasks that confront young children: (a) the development of concepts or categories that are congruent with naturally occurring ones (Rosch, 1978), and (b) the development of linguistic skills, particularly of reading and comprehension since these are thought to rely heavily upon redundancy (Gibson & Levin, 1975, chap. 7; Haber, 1978). Indeed, frequency information is the basis for the expectancies that are central to all conceptually driven models of behavior (see Lindsay & Norman, 1977). Frequency may also provide information essential for social learning as well. For example, there is some evidence that frequency information is involved in sex role-appropriate imitation behavior (Perry & Bussey, 1979), as well as in the determination of the truth of statements about people, facts, and events (Hasher, Goldstein, & Toppino, 1977).

Notes

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1. In the literature on scaling and discrimination, specifying the range of appropriate values is one of a number of factors known to influence the absolute value subjects assign to subjective magnitudes. Some of these factors have also been shown to influence the size of frequency judgments. In this study, our foremost concern is not with the magnitude of estimates but with the question of whether or not children of these ages and abilities can actually discriminate differences in frequency of occurrence.

2. Because of the constraints introduced by the availability of subjects, we were unable to obtain children of the precise ages used in Experiment 1.

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