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The Processing of Frequency of Occurrence Information by Adults[1]

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Three groups of adults (mean ages 22, 43, and 68 years) listened to a list containing 30 words that were repeated from zero to seven times each. The subjects were then tested for their sensitivity to differences in frequency of occurrence. All groups were found to be equally sensitive to frequency information. Prior knowledge about the exact nature of the forthcoming test did not affect performance. These results are interpreted in light of a theory that suggests that performance is determined by at least two factors: the cognitive capacity that an individual has available, and the capacity demands imposed by the task.

IT has generally been assumed that memory deteriorates with age. In fact, older individuals do complain more than younger ones about memory difficulties (e.g., Kahn et al., 1975), and they perform at levels below those of younger subjects on many laboratory tasks (e.g., Craik, 1977). These differences often persist even when such performance factors as pacing (Canestrari, 1963) and the inherent interest of the task (Hulicka, 1967) are manipulated to favor the older subject. One explanation for these differences has traditionally been that old subjects have less cognitive capacity on which to draw (Welford, 1958), and Kahneman (1973) has recently suggested that this capacity may fluctuate with conditions of arousal. There is some reason to believe that it may vary with mood and disease states as well.

Old subjects do not always perform at levels below those of younger subjects, however. This may be due to the fact that memory processes differ in their capacity demands. *Automatic* processes require minimal capacity and can be run off without the intention or awareness of the information processor (e.g., Posner & Snyder, 1975). These processes are thought to encode basic aspects of both internal and external events such as spatial, temporal, and frequency information (Hasher & Zacks, 1979). They are thought to function from early in life at high efficiency and are minimally responsive to differences in age, effort, practice, or feedback.

In contrast, *effortful* processes require the expenditure of both attention and effort (e.g., Hasher & Zacks, 1979). They drain capacity from the system and so limit the ability of the information processor to engage simultaneously in other effortful activities. Effortful processes are thought to function to maximize the efficiency with which new information is acquired and include mnemonic techniques such as the use of imagery, rehearsal, and organization. They are known to become more efficient with practice and show marked developmental trends at both ends of the lifespan (e.g., Brown, 1975; Craik, 1977).

Based on these considerations, old subjects should do worse than younger subjects on tasks requiring effortful processing and as well as younger subjects on tasks requiring automatic processing. There is ample evidence of differential performance in the case of effortful processing (e.g., Craik, 1977), but there is little evidence concerning the performance of elderly subjects on automatic tasks. Old subjects have been found to be able to discriminate among several levels of presented frequency (Hasher & Zacks, 1979, Exp. 2), but the estimates of frequency assigned by these subjects were significantly lower than those assigned by the younger adults in the study. These differences could reflect differences in sensitivity to frequency information, but they are more likely to reflect differences in response bias. This is the case because subjects were free to assign any values they chose as their frequency estimates and older subjects are commonly

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reported to respond conservatively on such tasks. In addition, in the Hasher and Zacks study, subjects were tested in small groups and were asked to make judgments about visually presented stimuli. It is possible that the older subjects were distracted by this procedure and that younger and older subjects were not equally able to perceive all of the stimuli. These arguments seem to favor an explanation of performance differences based upon differences in criteria rather than one based upon reduced sensitivity to occurrence rate information.

In the present experiment, sensitivity to differences in frequency of occurrence was investigated across the adult lifespan. Individual subjects were presented with adjustable auditory stimuli and were later tested on a two alternative forced choice procedure. These changes were adopted to ensure that all of the subjects were equally likely to perceive the stimulus materials, and, more importantly, to eliminate any criterion based differences in response style. If age differences continue to be found, they may safely be attributed to differences in sensitivity to occurrence rate information.

METHOD

Subjects. — Thirty-two subjects at each of three age levels participated in this study. The students ($M = 22$, range = 18 to 30) were enrolled at Temple University. They participated on a voluntary basis. Both the middle aged ($M = 43$, range = 35 to 51) and the elderly persons ($M = 68$, range = 60 to 77) were community residents who were paid $3.00 for their participation in the study. The groups were selected to be roughly equivalent in terms of educational level, 15.4, 15.0, and 14.6 years, in increasing order of age. The college and elderly persons were a mixture of city and suburban residents, although the majority were from the city. The middle aged persons were suburban residents.

Materials. — Thirty different critical words were used to construct four versions of a 90-slot presentation list. Within each version of the list, critical words occurred from zero to seven times each. Assignment of a critical word to a particular frequency level was made on a random basis with the constraint that no word could appear more than once at a frequency level across the four versions of the list. The subject was tested on a list of 15 pairs of words drawn from the presentation list. Thus, there were four unique test lists. All four were based on the same format. Each test pair was produced by the unique combination of two alternatives generated from a matrix combining three levels of absolute frequency difference between pair members (1, 2, and 3) with five levels of occurrence of the less frequent pair member, termed base frequency (0, 1, 2, 3, and 4). The most frequent pair member occupied the first position within a pair about one-half of the time. To obtain these test frequency pairings, the presentation lists were constructed of four critical words which occurred once, five which occurred twice, six three times, six four times, three five times, two six times, and one seven times. There were also three words which appeared only on the test lists.

The critical words were high frequency (A and AA from Thorndike & Lorge, 1944), concrete nouns equated across lists and presentation frequency levels for concreteness and meaningfulness (Paivio et al., 1968). Repeated words were placed randomly in segments of the list whose size was determined by the number of repetitions (i.e., twice presented words occurred once in the first one-half and once in the second one-half of the list, and so on). A repeated word thus never succeeded itself. This list structure is similar to the one used by Underwood and Freund (1970).

Procedure. — A study-test procedure was used. The study words were presented on a Sony stereo tape recorder at a two second rate. Prior to the study list, tape recorded instructions informed the subject that he or she should, at that time, adjust the volume to a comfortable level. Each test list was presented in written form at an unpaced rate. Each subject was tested individually.

As in the Hasher and Zacks (Exp. 2, 1979) experiment, one-half of the subjects at each age level were either fully or else only generally informed about the exact nature of the task prior to the presentation of the study list. All subjects were then specifically informed about the frequency task just before the test list was presented. After hearing the study list, each subject received a mimeographed sheet containing the 15 pairs of test words. The subject was instructed to circle the word in each pair that represented the word heard more frequently on the study list. Subjects were told that some of the words might not have appeared on the study list (zero presented items), in which case they should circle the other member of that pair. They were also told that there would always be a difference in presented frequency between the two pair members. Finally, they were told to circle one member of each pair even if doing so required a guess.

RESULTS

Here, as in every experiment in which intention to process frequency information has been manipulated (e.g., Hasher & Zacks, 1979), the instructional manipulation had no impact on performance, $F(1,90) = 1.72, p > .05$. That is, the performance of subjects who knew during the presentation of the list that their knowledge of occurrence rate information would be tested after the list was good; but it was not better than the performance of subjects who did not know the exact nature of the forthcoming test. For clarity of presentation of the remaining issues, this variable was then collapsed, leaving a three factor design combining age, base frequency, and absolute difference in frequency. This simplification resulted in identical results with the exception of the elimination of an uninterpretable four way interaction among age, instruction, base frequency, and absolute frequency difference.

The major question of interest here was whether performance on this task is influenced by age. The mean number of errors (out of 15) were 3.06, 2.94, and 3.80 for the three groups in increasing order of age. Analysis of variance confirmed that age did not influence performance, $F(2,93) = 2.84, p > .05$. Because there was a suggestion of a trend in the direction of sensitivity differences between the extreme age groups, another analysis was performed using only the youngest and the oldest groups of subjects. Again, age had no influence on performance, $F(1,62) = 3.43, p > .05$. These findings suggest that the age effects found by Hasher and Zacks (1979) were attributable to age-related differences in the criteria used to assign a value to a subjective magnitude. The present results suggest that sensitivity to frequency information shows little variation over the age range represented here.

This experiment also enabled us to examine whether frequency judgments conform to the Weber function reported by other investigators (e.g., Underwood & Freund, 1970). The relationship is present in our data: errors increase as base frequency increases, $F(4,372) = 10.5, p < .001$, and decrease as the absolute difference in frequency increases, $F(2,186) = 35.11, p < .001$. The nature of this relationship did not vary with age, $F < 1$. Thus, the greater extra-experimental exposure to these words that 65-year-olds have compared to 45-year-olds, and that 45-year-olds have compared to 20-year-olds, did not influence the ability of these variously aged subjects to discriminate relatively small differences in experimental frequency.

DISCUSSION

When procedural changes were made to minimize the operation of criterion differences and to ensure the reception of the stimulus materials by all of the subjects, it was demonstrated that sensitivity to frequency of occurrence information is present at similar levels in adults

Table 1. Proportion of Errors on Forced Choice Discrimination Task.

	Young				Middle				Elderly			
	Absolute Difference in Frequency											
Base Frequency	1	2	3	M	1	2	3	M	1	2	3	M
0	.16	.0	.06	.07	.16	.06	.06	.09	.41	.09	.16	.22
1	.37	.06	.19	.21	.31	.16	.19	.22	.34	.06	.34	.25
2	.37	.25	.12	.25	.28	.22	0	.17	.47	.28	.19	.31
3	.28	.25	.03	.19	.34	.09	.16	.20	.22	.09	.09	.14
4	.53	.25	.12	.30	.44	.22	.25	.30	.50	.22	.34	.35
M	.34	.16	.11		.31	.15	.13		.39	.15	.22	

of different ages. The remarkable nature of this equivalence is best appreciated against the background of the broad range of cognitive tasks in which age differences have been reported. These findings lend support to recent suggestions that there may be a number of cognitive processes that are only minimally affected by aging (Hasher & Zacks, 1979). In addition, frequency sensitivity, unlike most other memory processes, was not influenced by intention. College students, prepared for a test of frequency information, were no more sensitive than were elderly persons who were not so prepared. Rather, it appears that frequency is an aspect or attribute of events which receives automatic or obligatory encoding (Hasher & Zacks, 1979; Hintzman & Stern, 1978). Together with the findings of Hasher and Zacks, these data contribute to the argument that there are at least some memory processes which remain relatively invulnerable to age-related changes and which are unaffected by the intention to deploy them.

The age differences in performance typically found on laboratory memory tasks may be due to the demands of the tasks that are used. Older subjects may be able to perform tasks that involve large automatic components as well as younger subjects; these tasks make relatively light demands on cognitive capacity. However, older subjects appear not to perform as well as younger subjects on tasks that involve large effortful components (e.g., item recall, the use of organizational strategies); these tasks make heavy demands on cognitive capacity — a quantity that may be relatively limited among the elderly.

SUMMARY

Three groups of adults (mean ages 22, 43, and 68 years) heard 30 words which were repeated from zero to seven times each to form a 90-slot presentation list. They were then tested on a two-alternative, forced-choice recognition task to determine their sensitivity to frequency of occurrence information. That is, they were asked to select the more frequent member of a pair of words which had been presented varying numbers of times on a previous trial. One half of the subjects were explicitly informed about the nature of the test task prior to the presentation of the study list. The remaining subjects were informed about the test task only after the study list had been presented.

Subjects at all ages showed similar sensitivity to frequency information, and there were no instructional effects. Thus, sensitivity to frequency of occurrence information appears to be an automatic process; a process that is unaffected by age, intention, or differences in cognitive capacity. It was suggested that the commonly reported age related differences in performance might be due to an interaction between available cognitive capacity and the demands of the task.

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