AGE AND TACHISTOSCOPIC PERCEPTION

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Salthouse, T. A. Age and Tachistoscopic Perception. **Experimental Aging Research, 1976, 2 (2), 91-103.** A perception experiment involving tachistoscopic exposures of 10 alphabetic characters was conducted in order to answer the following questions. Do young and old adult subjects exhibit performance differences in tachistoscopic perception which involves the earliest stages of information processing; and, if so, what is the nature of these differences? The answer to the first part of the question was a clear and definite yes. Old adult subjects were found to perform at a significantly lower level than younger adult subjects in nearly all measures of perceptual performance. With respect to the second part of the question, both strategy and capacity differences were found to be responsible for the poorer performance of the older subjects. The older subjects used a suboptimal performance strategy more frequently, and were apparently slower at processing visual information than younger subjects.

Although previous research investigations have been quite successful in the identification of gross differences in the behavior of young and old people, at present very little is known about the specific deficits responsible for those differences. One perspective that may prove successful in this regard is to view the experimental subject as an information-processing organism. This view entails the conceptualization of perceptual, motor, and cognitive activity as the end result of a succession of stages during which the input (stimulus information) is received, transformed, and otherwise acted upon, and an appropriate response is selected, prepared, and executed.

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The typical procedure in an information-processing approach is to devise experimental manipulations that result in systematic changes in performance and allow one to infer the existence of separate stages in the processing of information. This is not to say that the ultimate goal of information-processing theorists is to postulate as many processing stages as possible (although this sometimes seems to be the case as the number and complexity of information flow diagrams proliferate and the cult of 'boxology' becomes increasingly more popular), but rather it is to understand the nature and sequencing of the information transformations and processing that occur between initial input and final output. As applied to the field of aging the information-processing approach should enable the astute investigator to make fairly precise localizations (in terms of information processing stages) of the basis for performance decrements of older adults.

To many researchers concerned with determining the causes of the performance decrements associated with increased age, the most interesting and important stages are those involving information input and interpretation. If performance differences are evident in these first stages of information processing, then presumably many of the differences evident is subsequent stages could be either explained or more easily understood. At any rate, the strategy of examining the most primitive (at least in the sense of the temporal sequence, if not also in terms of processing complexity) stages of information processing before attributing deficits to subsequent stages would appear to be a most useful one.

The purpose of the current investigation is to investigate age differences in the tachistoscopic perception of complex multi-element displays, a task which can reasonably be argued to involve the earliest stages in the processing of information within the organism. The paradigm employed in this study is a modification of one originally introduced by Sperling (1960). The important features of this paradigm are that a display of 9 to 12 elements is presented very briefly to a subject who is instructed either to report the identities of all of the elements (*i. e.*, the whole report condition), or to report the identities of only some of the elements that have been cued to be relevant (*i. e.*, the partial report condition). Although Sperling was primarily interested in the decline in partial report accuracy as the interval between the stimulus exposure and the presentation of the partial report cue was increased, the comparison of accuracy in the partial report and whole report conditions can also be used, and will be so done here, as a measure of attention flexibility and strategy. Three exposure-cue intervals were employed in the present study (*i. e.*, 0, 50, and 200 msec); but, perhaps because they were examined as a between-subjects factor with relatively unpracticed subjects, they did not prove to be a significant source of variability and will not receive much discussion in this paper.

Another modification of the original Sperling paradigm is the examination of report accuracy as a function of each position in the stimulus array. The consideration of report accuracy separately for each position rather than for an entire row or the complete array allows much greater precision in the specification of deficits attributable to the factors of age and report condition, and provides a stronger base from which one can speculate as to the causes of those deficits.

Method

Subjects

Thirty males and females between the ages of 18 and 30, and 30 males and females between the ages of 60 and 75 served as research participants. All reported themselves to be healthy and were noninstitutionalized residents of a metropolitan area. All of the older subjects and approximately 80% of the younger subjects were paid for their participation, the remainder were volunteers.

Three functional criteria used to screen subjects resulted in the rejection of 15 additional participants. One criterion was ability to follow instructions in the task and to proceed at a pace that would allow completion of the experimental session within two hours, more than twice the average time. Four subjects, all old, were rejected on this basis. A second criterion was an arbi-

trary minimum performance level, *viz.*, the subject had to average at least one correct item per trial. The data from seven subjects, five old and two young, were rejected for failing to satisfy this criterion. The final criterion, which resulted in the rejection of the data from three old subjects and one young subject, was that the subjects had to have less than 10% instances of reporting the incorrect row in the partial report trials.

Materials

A Gerbrands two-field tachistoscope with Sylvania F4T5/CWX 4-watt lamps was used to present the stimuli. The pre- and post-exposure field of the tachistoscope was always dark with the exception of four light points outlining the region of the stimulus array. The dark pre- and post-exposure fields were used to maximize the persistence of the stimulus image and the light points were used to provide a fixation field for localizing the region of stimulus presentation. Normal room illumination was maintained throughout the experiment.

The stimuli were arrays of 10 letters sampled without replacement from the set of 20 consonants. The letters were Visi-Graphics Franklin Gothic 24 pt. transfer letters arranged in two rows of five letters each on either a gray background (approximately 1.6 ftL) or a white background (approximately 3.2 ftL). Initial analysis revealed no differences as a function of the type of background and hence the scores were combined in all subsequent analyses. Forty-eight arrays with different combinations of letters were employed. The starting point in the sequence of 48 stimuli was varied across subjects such that no two subjects in any group received the same array on a given trial. At a viewing distance of 56 cm the letters were approximately 0.60° by 0.72° with an inter-letter space of 1.40°. The entire array subtended an angle of approximately 2.60° vertically by 8.75° horizontally.

The partial report cues were tones of 500 Hz and 750 Hz presented for 500 msec through headphones by a Hewlett-Packard Model 200AB Audio-Oscillator. The intensity of the tones was set by the experimenter to be loud but not uncomfortable. All temporal durations and intervals were controlled by Hunter timers, and monitored by Standard Electric and Hewlett-Packard clocks.

Procedure

The instructions to the subjects informed them that the experiment was concerned with reading from visual images and that they should not attempt to guess which row in the partial report trials was to be cued, but to wait for the tone to read out the correct row. The responses were written in a response matrix consisting of two rows of five lines each. Subjects were required to produce the maximum number of responses on each trial (*i. e.*, 10 in the whole report trials, 5 in the partial report trials) even if some were mere guesses. Instructions stipulated that the letters were to be scored as correct only if they were in the correct positions and hence the subjects were to pay attention to the locations of the letters in addition to the letters themselves.

The experimental session began with a demonstration of the partial report cues and an explanation of their meaning (*i. e.*, high tone — report top row, low tone — report bottom row), followed by 10 practice trials in the partial report condition. The stimulus exposure duration in the practice trials started at 1000 msec and decreased to 500, 200, and finally, to 100 msec. All subsequent experimental trials employed a stimulus exposure duration of 100 msec. The experimental trials consisted of 8 whole report trials, 32 partial report trials, and 8 more whole report trials followed by a 5 to 10 minute break after which the complete 48-trial cycle was repeated in reverse order. The partial report trials contained a heterogeneous mixture of one-half high and one-half low tones.

The interstimulus interval between the offset of the stimulus exposure and the onset of the partial report tone cue was investigated as a between-subjects comparison. Thus, a given subject received only one interstimulus interval in all of his partial report trials. Within each age group ten subjects were assigned to a 0 msec interval condition, ten subjects to a 50 msec interval condition, and ten subjects to a 200 msec interval condition.

Results

The basic datum in the experiment was the number of letters accurately reported in the correct position. For the first analysis, however, the number of letters correctly reported was divided by the maximum possible (*e. g.*, 5 in partial report trials, 10 in whole report trials), to obtain the percentage accuracy.

The means of the percent accuracy measures in the partial report and whole report conditions for the 30 subjects in each age range were 39.8 and 31.9% for the young subjects and 30.1 and 27.0% for the old subjects. Also computed for each subject were absolute (Partial Report — Whole Report) and relative (Partial Report/Whole Report) measures of the partial report advantage. Two-factor (Age and Interval) analyses of variance on each of the four measures yielded the same results; significant ($p < 0.01$) effects of Age, but no effect of Interval ($p > 0.05$), or of the Age by Interval interaction ($p > 0.05$).

The finding that the older subjects were worse than the younger subjects in both measures of partial report advantage suggests that the young and old subjects might have differed in the strategy used to perform the task. In order to test this possibility, all the subjects used in the current experiment were categorized as using one of the three strategies discussed by Von Wright (1972). The strategies, and the operational criteria used for identifying them, were: (a) equal attention, no row greater than 20% more accurate than the other row in partial report trials, in conjunction with small partial report variance[1]; (b) preference, one row greater than 20% more accurate than the other row in partial report trials; and (c) guessing, no row greater than 20% more accurate than the other row in partial report trials, in conjunction with large partial report variance.

The number of subjects identified as using each strategy in each age group were: equal attention, young = 15, old = 3; preference, young = 11, old = 21; and guessing, young = 4, old = 6. The observation that 50% of the young subjects and only 10% of the old subjects ($z = 3.38$, $p < 0.01$) used an equal attention strategy confirms the suspicion that strategy differences could be responsible for some of the observed age differences in performance.

Although the differential use of strategies can apparently account for some of the age differences in performance, it cannot explain all of the performance differences associated with increased age. In order to determine at which positions in the stimulus array the young and old subjects differed, the percentage of correct letters was computed separately for each of the 10 positions in the stimulus array. An analysis of variance was then conducted on these data with Age, Report Type, Array Position, and Interval as factors. Statistically significant (all $p < 0.01$) effects of Age; Report Type; Array Position; Age X Report Type; Report Type X Array Position; and Age X Report Type X Array Position were obtained. As a means of clarifying this pattern of results, Figure 1 displays mean percentage accuracy with each report type at all array positions for the young and old groups of subjects. Separate two-factor (Age and Report Type) analyses of variance were also carried out on the data from each array position. These tests revealed that the following effects were significant ($p < 0.01$): an age difference in positions 3, and 8; a report type difference in positions 6, 7, 8, and 9; and an interaction of age and report type in positions 6, 7, and 8.

These apparently complicated results can be summarized with a few surprising simple statements. First, although young subjects are somewhat more accurate than older subjects at all array positions, individual analyses revealed that they are significantly more accurate only at the third position in each row. Second, the superiority of partial report over whole report is due to a greater accuracy only in the first four positions in the bottom row. And third, the partial report advantage is greater in the young subjects than in the old subjects because the former exhibit a greater partial report - whole report discrepancy in the first three positions in the bottom row of the array.

The result that the young and old subjects differ significantly only in the third position in each row merits further consideration.

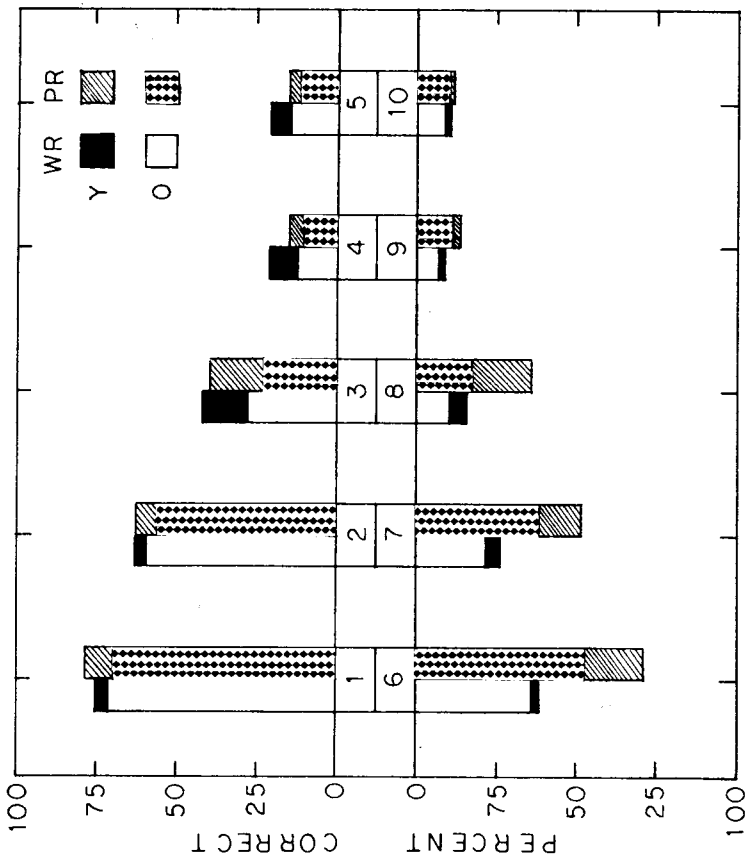

Figure 1. Accuracy of letter identification as a function of age Y = young, O = old), report type (WR = whole report, PR = partial report), and array position (1 through 10). Whole report required the subject to attempt to report all items in the array, and partial report required the subject to report only the items in one designated row. Array positions 1 through 5 represent the 5 letters on the top row of the array, and positions 6 through 10 represent the 5 letters on the bottom row of the array.

Two possibilities that could account for this result are: (a) that old subjects might have a smaller effective visual field than young subjects; or (b) that old subjects might take longer to process or encode visual information than young subjects. Data that allow for a distinction between these alternatives are available in a comparison of two maximum spans. One is the maximum span achieved by the subject from the first correct letter to the last correct letter in a row. This span will be termed the maximum span of unprocessed information since only the first and the last correct item in the row determine the span; it was not necessary for any of the intervening items to be correct. The other span is the maximum consecutive sequence of correct letters achieved by the subject. This span is the largest number of items reported correctly in sequence, and thus will be termed the maximum span of processed information.

The maximum span of unprocessed information did not differ between the young and old age groups, as all subjects achieved the highest possible score of 5. This finding indicates that all subjects had a potential functional visual field of 5 items. In contrast to these results, the young and old subjects did differ in the maximum span of processed information, means of 4.4 and 3.9 for young and old groups (t (58) = 2.41, $>.02$ $p > .01$). Therefore when the requirement is that all of the intervening items must be processed, marked age differences are apparent. This result in conjunction with the observation that young and old subjects had equivalent functional visual fields, strongly supports the hypothesis that the older subjects are limited in the amount of visual information they can process in a brief period of time.

Discussion

The results of the present experiment clearly indicate that there are substantial differences in tachistoscopic perceptual performance between young and old adults. Actually, the current experiment underestimates the extent of these differences between young and old subjects as it will be remembered that the data from 12 additional old subjects and from only 3 additional young subjects had to be discarded for various performance-related reasons.

In attempting to investigate the reasons for the poorer tachistoscopic performance of the older subjects it was discovered that the subjects did not all use the same strategy in the task. This differential use of strategies is important because the greater number of old subjects using a suboptimal strategy appears to account for some of the performance differences between young and old subjects. As revealed earlier, the most common strategy used by the older subjects was the preference strategy in which they apparently concentrated primarily on one row; probably the top row on the basis of the pattern exhibited in Figure 1. Because the advantage of partial report over whole report was caused by a greater accuracy only in the bottom row of the stimulus array, it is not surprising that the older subjects exhibited less of a partial report advantage than the younger subjects since in all likelihood many of the older subjects were not even attending to the bottom row in the partial report trials.

Performance was also analyzed as a function of the item position in the stimulus array. These analyses are particularly interesting because they allow a determination of the locations in the stimulus array at which the factors of age, report type, and the interaction of age and report type have their effects. Moreover, by considering each position independently it is possible to analyze them as if they were separate conditions and, thus, to specify the conditions (*e. g.*, position 1) in which performance is equivalent across all experimental factors, and to specify the conditions (*e. g.*, position 6) in which performance is not equivalent. This feature of these analyses is a distinct advantage in attempting to speculate about the reasons for the results since it allows one to contrast the performance differences obtained in certain conditions with the lack of performance differences obtained in other conditions. In this manner one is assured that the performance differences are not all the result of some simple artifact such as reduced visual acuity or failure to understand instructions.

One of the results from the position analyses was that although younger subjects were generally more accurate than older subjects, they were significantly more accurate only in the third position in each row. Since the pattern of results in Figure 1 suggests that all subjects processed the items in a left-to-right order, one can infer that the young subjects could complete the encoding of three items on each row significantly more often than old subjects. Also consistent with this interpretation is the finding that while the span between correctly reported items did not differ between young and old subjects, the span of correctly reported consecutive items did differentiate the two age groups. This suggests that it is a slower speed of encoding visual information and not merely a restricted visual field that is responsible for the poorer performance of the old subjects. Moreover, the only available evidence (*e. g.*, Wolf, 1967) indicates that age differences in visual field sensitivity are evident only at visual angles greater than 40°; these values are much beyond the 5° to 9° operational regions of the present study.

The conclusion that one of the causes for age differences in information processing is a slower speed of encoding visual information has also been reached by other investigators. For example, in two early studies, Rajalakshmi and Jeeves (1963) and Wallace (1956) reported that older subjects generally performed more poorly than young subjects in perceptual tasks of brief duration; and more recently, in studies with more precise control over the temporal parameters of stimulus presentation, a number of investigators using either a duration threshold paradigm (*i. e.*, Eriksen & Steffy, 1964; Eriksen, Hamlin & Breitmeyer, 1970) or a time-to-escape-masking paradigm (*i. e.*, Kline & Szafran, 1975; Walsh, 1976; Welsandt, Zupnick & Meyer, 1973) have concluded that older individuals require more time to identify a single-element stimulus at the same level of accuracy than younger individuals.

The position analyses in the current study also revealed that the effect of report type was localized to the first four positions in the bottom row of the array. Partial report was significantly more accurate than whole report in each of these positions, but in none of the other positions. This result is consistent with the findings of other investigators (*e. g.*, Dick, 1971; Goryo & Kawai, 1972) and suggests that the partial report superiority is caused by a redirection of attention from the preferred top row to the less preferred, but cued to be relevant, bottom row. That the age and

report type factors interacted in the first three positions of the bottom row indicates that older subjects redirected their attention less effectively than younger subjects. Whether this lower effectiveness was caused by limitations in ability or capacity, or is merely reflection of the difference in strategy discussed earlier, cannot be unambiguously determined from the present data.

The general conclusions from this study are that there are pronounced differences in tachistoscopic perceptual performance between adults of different ages, and that the differences are attributable to both capacity (*i. e.*, encoding speed), and strategy differences. The finding that there are such perceptual differences between different age groups makes it incumbent upon researchers concerned with explaining age-associated performance decrements to consider whether the decrements could be attributed to the differences that are now known to exist in what may be considered to be the initial stages of information processing.

Footnotes

[1]The measure of variance employed for this purpose was the ratio of the standard deviation of a subject's partial report scores to the mean of that subject's partial report scores. Variability was expressed as the percentage of the mean score in this fashion to allow the range of these values to be unrestricted by the magnitude of the mean. For the present purposes, small variance was defined as a standard deviation to mean ratio below the mean ratio of all subjects, and large variance was defined as a standard deviation to mean ratio above the mean ratio of all subjects.

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