Journal of Gerontology
1984, Vol. 39, No. 1, 72–78

Data-Driven and Memory-Driven Selective Attention in Visual Search[1]

David J. Madden, PhD[2]

The present experiment investigated Rabbitt's (1979) hypothesis that age differences in selective attention occur when memory-driven processing must be employed. Young and older adults performed a visual search task, which, on some trials, provided advance information (a cue) regarding the particular target letter most likely to appear in the display. The nature of the selectivity required by the cue was either data-driven (Condition 1) or memory-driven (Condition 2). Analyses of the benefit in search performance associated with the cued trials and of the cost in performance resulting from the presentation of misleading advance information yielded limited support for Rabbitt's hypothesis. The older adults, but not the young, did exhibit a smaller cuing benefit in Condition 2 than in Condition 1. Both age groups, however, demonstrated substantial benefits and costs within each condition. Age differences in selective attention are thus not determined completely by the requirement to use memory-driven processing.

Key Words: Aging, Human performance, Reaction time, Cuing

THE successful performance of a variety of cognitive tasks, in everyday life as well as in the laboratory, depends on the effective use of attention. Posner and Boies (1971) distinguished three types of attentional functions: the selection of task-relevant stimulus information, the allocation of limited processing capacity, and maintaining vigilance or alertness. Several authors have raised the possibility that aging is accompanied by a decrement in the selective aspect of attention (Layton, 1975; Rabbitt, 1965a; Schonfield, 1974). For example, studies of card sorting (Farkas & Hoyer, 1980; Rabbitt, 1965b) and problem solving (Hoyer et al., 1979) have reported that older adults are more vulnerable than young adults to distraction by irrelevant information. Age differences in selective attention have not been obtained invariably, however. If relevant and irrelevant stimuli are partitioned by color or display position, then there appears to be no age-related decline in the ability to attend selectively to the relevant items (Madden, 1983; Nebes & Madden, in press; Wright & Elias, 1979).

Rabbitt (1979) has proposed that the appearance of age differences in selective attention is determined by the nature of the selectivity that is required by a particular task. Using a distinction introduced by Norman and Bobrow (1975), Rabbitt claims that when the selection of relevant information is accomplished by means of the repetition of encoding and response processes, *data-driven* selective attention is being employed; *memory-driven* processing, in contrast, occurs when the selectivity depends on the retrieval of additional information stored in memory (see also Broadbent, 1970). According to Rabbitt, memory-driven selective attention undergoes significant decline in later adulthood, whereas the efficiency of data-driven selectivity is maintained. The primary evidence for this interpretation of age-related changes in selective attention is the data reported by Rabbitt and Vyas (1980). These authors employed a two-choice reaction time (RT) task in which a single digit was presented visually on each trial. Three types of transitions between adjacent trials were possible in this paradigm: identical stimuli, response-equivalent (but nonidentical) stimuli, and response-different stimuli. Rabbitt and Vyas found that both young and older adults exhibited faster RT when the preceding trial contained an identical stimulus than when it contained a response-different stimulus. For the young adults, however, RT for the response-equivalent transitions decreased, over practice, to the level of the identical stimuli, whereas the older individuals' RT for the response-equivalent transitions remained at the level of the response-different trials. Rabbitt and Vyas viewed the identical-stimulus transitions as essentially involving the repetition of the encoding and response processes that were carried out on the most recent

[1]This research was supported by research grant R01 AG02163 from the National Institute on Aging. I am grateful to Janice Blinder and Audrey Norman for invaluable technical assistance. David Mitchell and John Cerella gave helpful comments on previous versions of the manuscript.

[2]Center for the Study of Aging and Human Development, Box 2980, Duke University Medical Center, Durham, NC 27710.

trial. The RT facilitation associated with these transitions would thus represent data-driven selective attention. Any RT facilitation exhibited on the response-equivalent trials, in contrast, must rely on the stimulus-response mapping rules learned for this particular task, and thus reflects the use of memory-driven selectivity. The fact that the gradual improvement on the response-equivalent trials was restricted to the young participants implies an age difference in memory-driven selective attention. In a second experiment, Rabbitt and Vyas (1980) found that young adults used a larger sample of trials than older adults for anticipating the probabilities of individual stimuli appearing in the trial sequence. Rabbitt (1979) cited several unpublished RT studies that lead him to conclude that "Old people show no apparent decrement in data driven changes in sensitivity, but show marked decrement in memory driven sensitivity (p. 91)."

The distinction between data-driven and memory-driven selective attention is a valuable heuristic in the analysis of perceptual tasks. There are other experiments, however, in which age differences in selectivity clearly are not determined by the requirement to use memory-driven processing. Thomas et al. (1978), for example, found that both young and older adults performed a memory-search task more rapidly when the target stimuli were organized in a highly familiar sequence (a, b, c, d, e, f) than when the sequence was less familiar (p, g, k, t, r, i). Young and older adults also appear to be qualitatively similar in their ability to take advantage of a categorical distinction between target and nontarget items (letter vs. digit) as a means of improving their performance in search tasks (Madden, 1982). Finally, in a two-choice RT paradigm that elicited faster RTs for stimulus alternation across adjacent trials (as compared with stimulus repetition), older participants, like the young, adjusted their response speed according to the proportion of stimulus alternations appearing in the trial sequence (Fozard et al., 1976). This sensitivity of older adults to the structure of the trial sequence and to the organization of the stimuli is not consistent with the presence of an age-related deficit in memory-driven selective attention.

The present experiment provided a direct comparison of age differences in data-driven and memory-driven selective attention within the context of a visual search task. Participants held two target items (letters) in memory during each trial block and, on each trial, decided whether or not one of the targets was present in a four-item visual display. On two-thirds of the trials, the display was preceded by the appearance of a cue — one of the current target letters. The cue indicated which of the two targets was most likely to be present in the upcoming display. The performance "benefit" associated with the cue was defined by the decrease in search RT (and error rate) that occurred on the cued trials, as compared with noncued trials. In Condition 1, the relationship between the cue and display was a version of stimulus repetition; the cue benefit in this condition was thus assumed to reflect primarily data-driven selectivity. Condition 2 was designed to elicit memory-driven selective attention; the effective use of the cue required the retrieval of additional information regarding the current target letters. If Rabbitt's (1979) analysis of age differences in selective attention is correct, then older participants should show a smaller cue benefit than the young in the memory-driven condition but not in the data-driven condition.

The improvement in performance associated with using selective attention is, in theory, independent of the task's demands on processing capacity. For example, it is possible to obtain performance benefits even when participants are not consciously intending to use the information provided by the cue (Posner & Snyder, 1975). In order to obtain evidence regarding the capacity demands of the cue in the present experiment, there were several trials within each condition on which the cue provided misleading information. Such trials typically lead to "cost," an increase in RT relative to the noncued trials. The presence of RT cost has been interpreted previously as one measure of the degree to which attention, in the sense of processing capacity, is allocated to the advance information provided by a cue (e.g., Taylor, 1977).

METHOD

Participants. — Twenty-eight young and 28 older adults participated in the experiment; there were 14 men and 14 women in each age group. The young adults were Duke University students ranging from 18 to 24 years of age (M = 20.2). The older adults were relatively healthy, community-dwelling individuals ranging from 62 to 73 years of age (M = 68.7). The average number of years of education was 14.8 for the young and 14.7 for the older participants. The two age groups did not differ significantly in their performance on the vocabulary subtest of the Wechsler Adult Intelligence Scale; the mean raw scores were 62.4 and 60.9 for the young and older adults, respectively. The young adults' mean raw score on the digit symbol substitution subtest (73.8) was significantly higher than that of the older adults (46.8), $t(54) = 11.3, p < .001$.

All participants reported that they possessed normal or corrected-to-normal vision; none encountered any difficulty in seeing the present stimuli.

Stimuli and design. — On each trial, the participants were required to decide whether or not one of two target letters was present in a visual display. The visual display presented on each trial contained four letters, whose midpoints were located at the corners of an imaginary square whose sides each subtended 1.75°. The letters were black, uppercase Chartpak 72 pt Zentak Grotesk mounted on white tachistoscope cards. Each letter subtended approximately .75° wide by 1° high. The five letters J, C, K, H, and Y were used as target items. Two of these letters were assigned as a memory set at the beginning of each trial block. Target letters that were not members of the memory set for a particular trial block did not appear in the stimulus displays of that block. The nontarget items in the displays were drawn from the letters N, F, T, D, P, G, M, S, L, R, B, V, Z, Q, and A. On the *yes* trials, exactly one of the two memory set letters, plus three different nontarget letters, were present in the display. On the *no* trials, four different nontargets were present. Individual letters were counterbalanced as closely as possible in their assignment as memory-set items and in their appearance at the four display positions.

The complete trial sequence contained one block of practice trials, followed by seven blocks of test trials, with each block containing 36 trials (18 yes, 18 no). Seven different orders of the test-trial blocks, forming a complete Latin square, were used; two individuals within each age group and experimental condition received each order. Each trial block contained a randomized sequence of 24 cued (12 yes, 12 no) and 12 noncued (six yes, six no) trials. On each of the cued trials, the display was preceded by a signal that indicated the particular memory-set letter that was most likely to be present. This signal (i.e., the cue) was the appearance of one of the current memory-set letters in the center of the viewing screen for 1 sec prior to the onset of the display. The letters used as cues were 48 pt uppercase Chartpak Zentak Grotesk, each subtending approximately .5° wide by .75° high. Each memory-set letter was used as a cue on six yes and six no trials per block. On the 12 noncued trials within each block, a black dot (.5° in diameter) was presented in the center of the screen for 1 sec prior to the display. This dot indicated that the two memory-set items were equally likely to appear in the upcoming display.

The participants were instructed that the cue would inform them as to the memory-set item most likely to appear in the display but that they should always be prepared to respond yes at the appearance of either of the current memory-set items. On a total of 14 of the cued-yes trials, the cue was in fact incorrect and the nonindicated memory-set letter was present in the display. The number of these miscued trials ranged from one to three per trial block. Thus, on 70 of the cued-yes trials (83%) the cue was an accurate indicator of the particular memory-set item that appeared in the upcoming display, whereas on 14 of these trials (17%) the cue provided incorrect information.

Fourteen individuals (7 men, 7 women) within each age group were assigned to each of two experimental conditions. The same sequence of four-item displays and the same relative proportion of cued, noncued, and miscued trials were used in each condition. The two conditions differed, however, with regard to the manner in which the memory-set letters were assigned as cues on the yes trials. In Condition 1 the participants were informed that the particular memory-set letter appearing as a cue would be the one most likely to appear in the upcoming display. Because the presentation of the cue merely prepared the participants for the reoccurrence of this stimulus in the display, the cuing effects in Condition 1 were assumed to be determined primarily by data-driven selective attention. In Condition 2, in contrast, the presence of one memory-set letter as a cue meant that the *other* current memory-set letter was the one most likely to appear in the upcoming display. Because the particular two items comprising the memory set changed across trial blocks, and the memory-set letter appearing as the cue varied from trial to trial, Condition 2 required participants to use a memory-driven form of selective attention in using the cue to improve their performance.

Apparatus. — The stimuli were presented via a Scientific Prototype three-channel tachistoscope in which the luminance level was approximately 61.7 cd/m^2. The participants viewed the stimuli binocularly and, on each trial, responded yes (target present) or no by moving a paddle switch mounted on a board in front of the tachistoscope. Each participant held the paddle switch in his or her preferred hand during the experimental session. Half of the individuals within each combination of age group and experimental condition moved the switch toward themselves for a yes decision and away for no; half had the reverse arrangement. The movement of the switch from a central resting position stopped a millisecond clock that had begun running at the onset of the four-item display.

Procedure. — The participants were tested individually in a single session lasting approximately 1 hour. Written instructions were given that described the task and the specific nature of the cue, according to the experimental condition assigned. Speed and accuracy were stressed equally. At the beginning of each trial block, the participants were shown a new two-letter memory set in the tachistoscope and were permitted to view it as long as they wished. The motors of the tachistoscope card changers served as an audible signal of the initiation of a trial. Approximately 2 sec after the stimulus cards were advanced, a blank resting field was replaced by either the black dot or a cue (one of the memory-set letters) for 1 sec. The offset of this signal was immediately followed by the onset of the four-item stimulus display. The movement of the response switch replaced the stimulus display with the resting field.

RESULTS

The participants' RT on each trial was the dependent measure of primary interest. In order to reduce variability in the RT distributions, individual RTs that exceeded each individual's original mean (for each cell of the design) by ±3 standard deviations were excluded from analysis. All reported means are based on the remaining data. Approximately 1% of the trials for each age group were discarded by this procedure. The RTs of incorrect responses were also excluded from the RT analysis; error rates were analyzed separately. For all analyses, all effects that were significant at the .05 alpha level or beyond are reported. Utility index (*UI*) values (Gaebelein & Soderquist, 1978) are provided for those effects that were significant by analysis of variance. The mean RT and error rate in each experimental condition are presented in Figure 1. Because cue benefits could be obtained on both yes and no trials, whereas costs could be obtained only on yes trials, costs and benefits were examined separately. Data from the miscued-yes trials were not included in the analyses of cue benefits; costs were examined in a separate analysis of the miscued-yes and noncued-yes trials.

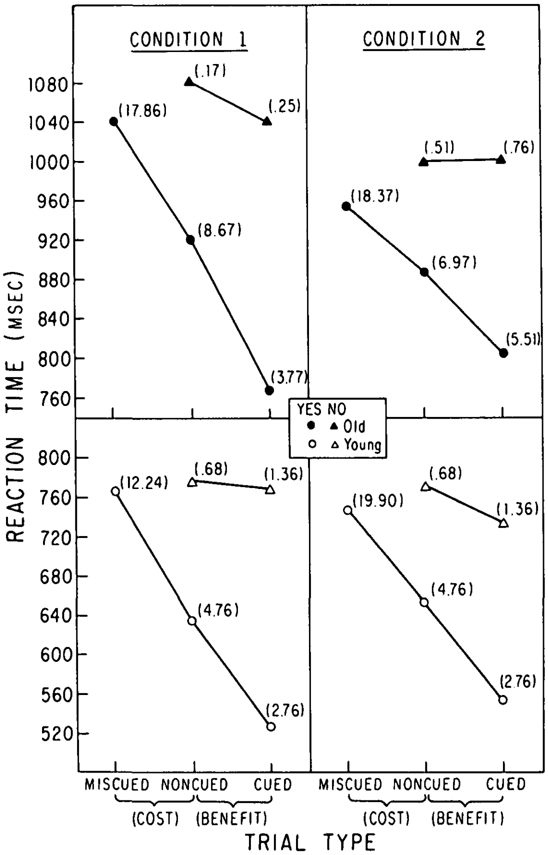

Figure 1. Mean reaction time in each experimental condition as a function of trial type. The task involved data-driven selectivity in Condition 1 and memory-driven selectivity in Condition 2. The two age groups (old, young) and response types (yes, no) are plotted separately. The mean percentage error associated with each data point is presented in parentheses.

Analysis of cue benefits. — A split-plot analysis of variance was performed on mean RT in which age group (young, old) and condition (1[data-driven], 2[memory-driven]) were between-groups factors; response type (yes, no) and trial type (noncued, cued) were within-groups factors. Significant main effects were obtained for age, F (1, 52) = 54.87, *UI* = .358, and response type, F (1, 52) = 170.45, *UI* = .262. These effects represent relatively longer mean RTs for the older adults and for the no trials. The trial-type main effect, F (1, 52) = 90.24, *UI* = .036, represents a significant cuing benefit: RT on the noncued trials was 65 msec higher than on the cued trials. The interactions of response type × trial type, F (1, 52) = 66.63, *UI* = .017, and age × condition x trial type, F (1, 52) = 4.82, *UI* = .002, were also significant. The two-way interaction occurred because the benefit associated with the cue was larger in magnitude on the yes trials (110 msec), when a target was actually present in the display, than on the no trials (20 msec), when the display did not contain a target. Simple effect tests revealed that the cuing benefit was significant on the no trials, $F\ (1, 52) = 8.44$, $UI = .005$, as well as on the yes trials, $F\ (1, 52) = 116.86$, $UI = .141$.

The age × condition × trial type interaction may, to some extent, be due to between-groups variability across Conditions 1 and 2. This interaction is theoretically important, however, because it suggests that the cuing benefits for the two age groups were affected differentially by the type of processing required by the cue. The age × condition × trial type effect was thus investigated by obtaining, for each participant, a cue-benefit value that represented the RT difference between the noncued and the cued trials. The mean benefit values in Condition 1 (data-driven) were 95 msec for the older adults and 62 msec for the young adults; the benefits in Condition 2 (memory-driven) were 39 msec for the older adults and 66 msec for the young. Although these values are consistent with Rabbitt's hypothesis, in that the young adults exhibited a larger cue benefit than the older adults in Condition 2, simple effect tests indicated that the age difference in cue benefit was not significant within either experimental condition. The two age groups did differ with regard to the change in the size of the cue benefit across conditions: The older adults' decrease in benefit from 95 msec in Condition 1 to 39 msec in Condition 2 was significant, $F\ (1, 26) = 5.28$. $UI = .067$, whereas the young adults' benefit did not change significantly across conditions. The mean RT benefit was significantly greater than zero for each combination of age group and experimental condition, with $t\ (13) > 2.38$ in each case.

A split-plot analysis of variance performed on the error percentages revealed significant main effects of age, $F\ (1, 52) = 5.94$, $UI = .014$, response type, $F\ (1, 52) = 136.71$, $UI = .348$, and trial type, $F\ (1, 52) = 10.79$, $UI = .021$. The age and trial-type effects are consistent with the RT data in that the mean error rate was higher for the older adults (3.33%) than for the young adults (2.39%) and higher for the noncued trials (3.40%) than for the cued trials (2.32%). The response type effect, however, appeared because the error rate on yes trials (4.99%) was substantially higher than on no trials (.72%) although the yes responses were faster.

Two interactions were significant in the error data: age × response type, $F\ (1, 52) = 17.63$, $UI = .043$, and response type × trial type, $F\ (1, 52) = 17.69$, $UI = .042$. The former interaction occurred because the older adults' error rate on the yes trials (6.23%) was higher than that of the young adults (3.76%), whereas the young adults exhibited a slightly higher rate (1.02%) than the older individuals (.42%) on the no trials. The response type × trial type interaction is consistent with the RT analyses, in that the magnitude of the cue benefit was greater on the yes trials (2.59%) than on the no trials (−.42%).

Analysis of cue costs. — The attentional demands of the cue can be inferred from the magnitude of the cost (in speed and accuracy) associated with the miscued-yes trials, as compared with the noncued-yes trials. Separate analyses of variance were performed on mean RT and error rate for these trials, in which age and condition were between-groups factors and trial type (noncued, miscued) was a within-groups factor. These analyses demonstrated that the participants were devoting substantial processing capacity to the cue, although there was no evidence suggesting changes in this form of attention as a function of either age or experimental condition. Significant effects were obtained in the RT analysis for age, $F\ (1, 52) = 44.79$, $UI = .381$, and trial type, $F\ (1, 52) = 49.26$, $UI = .110$, with mean RT on the miscued-yes trials being 103 msec slower than on the noncued-yes trials. The error data on the miscued trials were in accord with the RT findings. The only significant effect in the analysis of the error data was the main effect of trial type, $F\ (1, 52) = 32.28$, $UI = .219$, with the error rate of the miscued trials (17.09%) exceeding that of the noncued trials (6.29%).

Regression analysis. — The present experiment was concerned with the possibility that age differences in visual-search RT would be determined by qualitative differences in the type of processing required by the cue. Other authors (e.g., Cerella et al., 1980; Salthouse & Somberg, 1982), however, have suggested that a concern with qualitative age differences in the speed of performance is premature in view of the fact that, across a variety of tasks, RT for older adults is simply a monotonically increasing function of the young adults' RT. In other words, the absolute value of age differences in RT tends to increase as the complexity of the task, as defined by the young adults' RT, increases. In

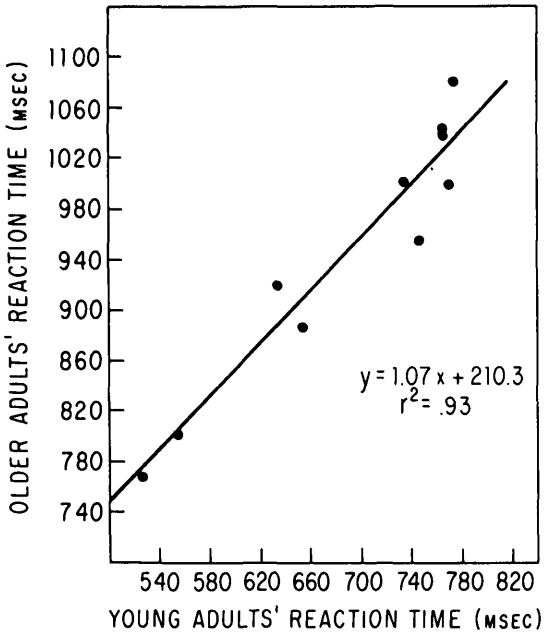

Figure 2. Mean reaction time of the older adults as a function of the young adults' reaction time in each of the present experimental conditions. The amount of variance accounted for by linear regression (r^2) and the least-squares estimate of the line of best fit are also presented.

Figure 2 the older adults' mean RT in each of the present experimental conditions is plotted as a function of the young adults' corresponding mean RT. These data are consistent with the Cerella et al. (1980) and Salthouse and Somberg (1982) complexity hypothesis in that a linear equation accounts for 93% of the variance. Task complexity does not appear to be a major determinant of age differences in the present experiment, however. Cerella et al. (1980) reported that older adults' RT is on the average slower than that of young adults by a factor of 1.36. The slope value of the linear equation presented in Figure 2 indicates age-related slowing by a factor of only 1.07. The absolute value of the age differences in RT is thus relatively constant across the range of difficulty elicited by the present version of visual search. This relationship suggests that the age differences are due to the demands of one or more processing stages rather than to the complexity of the task as a whole.

Discussion

In the present experiment, the appearance of an informative cue led to significant benefits in both RT and error rate, relative to noncued trials, regardless of whether the particular letter appearing as a cue could be expected to reoccur in the display. The cue was thus effective in leading participants to attend selectively to one of the target letters in performing the visual search task. The magnitude of the benefit associated with the cue, however, was larger on the yes trials than on the no trials. This pattern of results suggests that when the expectation elicited by the cue is not confirmed immediately by the display, participants recheck the display and/or their decision before responding. The fact that the no responses were in general slower but more accurate than the yes responses is also consistent with a strategy that involves rechecking (Krueger, 1978).

The significant age × condition × trial type interaction obtained in the RT analysis indicated that the relationship between age and cuing benefit changed across the experimental conditions, and this change actually occurred in the direction predicted by Rabbitt (1979). The older adults showed significantly smaller RT benefit when using the cue that depended on a memory-driven version of selective attention (Condition 2) than when only data-driven selectivity was required (Condition 1). The complete pattern of results, however, provides relatively limited support for Rabbitt's (1979) hypothesis of an age-related decline in memory-driven processing. The age differences in RT benefit within each of the present experimental conditions were not significant, and the magnitude of benefit for each combination of age group and condition was significantly greater than zero. The analysis of RT cost, in addition, suggested that there were no age differences, within either condition, in the allocation of processing capacity required by the cue. The present results, as well as those of previous studies (Fozard et al., 1976; Madden, 1982; Thomas et al., 1978), indicate that the distinction between data-driven and memory-driven processing is not sufficient to account for age differences in the use of selective attention and that older adults' ability to use memory-driven processing is relatively preserved in some visual classification tasks.

It is possible that the age differences obtained by Rabbitt and Vyas (1980, Experiment 1) occurred as a result of the particular demands imposed by their task, rather than as a result of the nature of the selective attention required. Rabbitt and Vyas employed a choice-RT paradigm in which each target item appeared 50 msec after the response to the previous target. This procedure allowed 2,000 trials to be presented within each of two 30-min testing sessions. Because the requirement to respond under time pressure has been found to increase the magnitude of age differences (Arenberg, 1965; Riegel, 1965), the extremely brief intertrial interval employed by Rabbitt and Vyas may have contributed to the RT differences they obtained.

At the present time there is no adequate theory of age differences in attention. Such a theory will eventually need to include not only a distinction between data-driven and memory-driven processing, but also a description of the role of attentional capacity in these two forms of selectivity, and an account of how the relationship between selection and capacity may change across various categories of tasks. In addition, the stimulus-onset asynchrony between the cue and the display was held constant at 1 sec in the present experiment; it is possible that age differences exist in the amount of time required to use the cue effectively. Finally, the age differences in RT associated with the present visual-search task appear to be an exception to the complexity hypothesis of Cerella et al. (1980) and Salthouse and Somberg (1982). The contribution of selective attention to this discrepancy needs to be clarified.

References

Arenberg, D. Anticipation interval and age differences in verbal learning. *Journal of Abnormal Psychology*, 1965, *70*, 419–425.

Broadbent, D. E. Stimulus set and response set: Two kinds of selective attention. In D. I. Mostofsky (Ed.), *Attention: Contemporary theory and analysis*. Appleton-Century-Crofts, New York, 1970.

Cerella, J., Poon, L. W., & Williams, D. M. Age and the complexity hypothesis. In L. W. Poon (Ed.), *Aging in the 1980s: Psychological issues*. American Psychological Association, Washington, DC, 1980.

Farkas, M. S., & Hoyer, W. J. Processing consequences of perceptual grouping in selective attention. *Journal of Gerontology*, 1980, *35*, 207–216.

Fozard, J. L., Thomas, J. C., & Waugh, N. C. Effects of age and frequency of stimulus repetitions on two-choice reaction time. *Journal of Gerontology*, 1976, *31*, 556–563.

Gaebelein, J. W., & Soderquist, D. R. The utility of within-subjects variables: Estimates of strength. *Educational and Psychological Measurement*, 1978, *38*, 351–360.

Hoyer, W. J., Rebok, G. W., & Sved, S. M. Effects of varying irrelevant information on adult age differences in problem solving. *Journal of Gerontology*, 1979, *34*, 553–560.

Krueger, L. E. A theory of perceptual matching. *Psychological Review*, 1978, *85*, 278–304.

Layton, B. Perceptual noise and aging. *Psychological Bulletin*, 1975, *82*, 875–883.

Madden, D. J. Age differences and similarities in the improvement of controlled search. *Experimental Aging Research*, 1982, *8*, 91–98.

Madden, D. J. Aging and distraction by highly familiar stimuli during visual search. *Developmental Psychology*, 1983, *19*, 499–507.

Nebes, R. D., & Madden, D. J. The use of focused attention in visual search by young and old adults. *Experimental Aging Research*. (in press)

Norman, D. A., & Bobrow, D. G. On data-limited and resource-limited processes. *Cognitive Psychology*, 1975, *7*, 44–64.

Posner, M. I., & Boies, S. J. Components of attention. *Psychological Review*, 1971, *78*, 391–408.

Posner, M. I., & Snyder, C. R. R. Attention and cognitive control. In R. L. Solso (Ed.), *Information processing and cognition: The Loyola Symposium*. Erlbaum, Hillsdale, NJ, 1975.

Rabbitt, P. Age and discrimination between complex stimuli. In A. T. Welford & J. E. Birren (Eds.), *Behavior, aging, and the nervous system*. Charles C Thomas, Springfield, IL, 1965. (a)

Rabbitt, P. An age-decrement in the ability to ignore irrelevant information. *Journal of Gerontology*, 1965, *20*, 233–238. (b)

Rabbitt, P. Some experiments and a model for changes in attentional selectivity with old age. In F. Hoffmeister & C. Müller (Eds.), *Brain function in old age: Evaluation of changes and disorders*. Springer-Verlag, New York, 1979.

Rabbitt, P., & Vyas, S. M. Selective anticipation for events in old age. *Journal of Gerontology*, 1980, *35*, 913–919.

Riegel, K. F. Speed of verbal performance as a function of age and set: A review of issues and data. In A. T. Welford & J. E. Birren (Eds.), *Behavior, aging, and the nervous system*. Charles C Thomas, Springfield, IL, 1965.

Salthouse, T. A., & Somberg, B. L. Isolating the age deficit in speeded performance. *Journal of Gerontology*, 1982, *37*, 59–63.

Schonfield, D. Translations in gerontology — from lab to life: Utilizing information. *American Psychologist*, 1974, *29*, 796–801.

Taylor, D. A. Time course of context effects. *Journal of Experimental Psychology: General*, 1977, *106*, 404–426.

Thomas, J. C., Waugh, N. C., & Fozard, J. L. Age and familiarity in memory scanning. *Journal of Gerontology*, 1978, *33*, 528–533.

Wright, L. L., & Elias, J. W. Age differences in the effects of perceptual noise. *Journal of Gerontology*, 1979, *34*, 704–708.