AGE DIFFERENCES IN THE EFFECTS OF PERCEPTUAL NOISE

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CHAPTER I

INTRODUCTION

Review of the Literature

There are multitudes of studies illustrating that older subjects in comparison with younger subjects process information in a less efficient fashion (Elias, Elias, & Elias, 1976; Schaie, 1968; Welford & Birren, 1965; Layton, 1975). Several hypotheses have been proposed to deal with this phenomenon. One of the more popular hypotheses is the proposal that older individuals have more difficulty ignoring or "blocking out" irrelevant stimuli (Rabbitt, 1968). Layton (1975) has reviewed a number of studies that illustrate such a decrease in processing efficiency as a result of some kind of interference. This phenomenon has been termed "perceptual noise." The perceptual noise hypothesis states that "in the performance of a purely perceptual task, decrement in performance due to the presence of irrelevant or interfering stimuli (perceptual noise) is an increasing function of age" (Layton, 1975).

The perceptual noise hypothesis postulates an age related perceptual deficit which should be distinguished from receptor decline. There is, of course, receptor decline with age. The crystalline lens of the eye becomes less transparent due to a loss of water and an accumulation

of inert tissue at the center of the lens with age. This increasing opacity interferes with transmission and refraction of light, producing higher absolute thresholds for vision. Opacity of the crystalline lens and vitreous humor also produce a scattering of light that results in lowered visual acuity (Corso, 1971). Another factor in visual acuity is accommodation, the adjustment of the focal length of the lens by means of the ciliary muscle. The pliable cortex of the lens is primarily involved in this adjustment. With age, this cortex becomes reduced in relation to the rest of the lens, resulting in a lowered capacity for accommodation. Deterioration of the ciliary muscle may also be involved in the loss of accommodation (Duane, 1931). Thus, declines in visual thresholds and visual acuity with age must be dealt with in the interpretation of results as supporting the perceptual noise hypothesis. Age differences due to perceptual noise should be of a magnitude greater than could be explained by receptor decline alone.

The perceptual noise concept should also be distinguished from other noise concepts that are more physiologically based (Welford & Birren, 1965). One neurological noise concept (Gregory, 1959) proposed that there is increasing spontaneous neuronal discharge with age. This is proposed to produce an increase in ambient noise level

which is hypothesized to decrease the signal to noise ratio, thereby decreasing the probability of signal detection. A second neurologically based noise concept is that of stimulus persistence (Axelrod, 1963). This hypothesis postulates a decrease in the rate of recovery from the initial effects of stimulation, which masks or blocks the perception of other incoming stimuli. This is very similar to Welford's (1952) concept of "psychological refractory period," which refers to a hypothetical interval during which an organism cannot efficiently respond to incoming stimuli due to involvement with prior stimuli and their responses. Physiologically, this refractory period is conceptualized as blocked or delayed transmission of new impulses through the "single channel." These concepts differ from the perceptual noise concept in that they infer a physiological mechanism from behavioral data. The perceptual noise hypothesis is not reductionistic, i.e., it posits the existence of a specific age related decline without abstracting any physiological causal mechanism.

Neurological noise concepts deal with inferred physiological noise, while the perceptual noise concept deals with environmental noise. As a result, the methods for investigating each concept are different (Layton, 1975). For example, Gregory's (1959) signal to noise ratio concept has been investigated by observing age related

declines in visual and auditory thresholds. Axelrod's (1963) stimulus persistence model has been tested by observing age declines in critical flicker fusion frequency thresholds (Weiss, 1959) and decreases in reported oscillations in the Necker Cube (Heath & Orbach, 1963). In contrast, the perceptual noise concept deals with perceptions that are in some way hampered by the presence of irrelevant stimuli. The response measures are times required to process and respond to stimuli. "Noise" in the perceptual noise hypothesis is defined as stimuli that are irrelevant to the task, i.e., that need not be processed in order to meet the task requirements. The hypothesis that the ability to ignore irrelevant information declines with age can only be tested under conditions where the irrelevant stimuli can actually be ignored.

Some tasks that are described as providing stimuli that are "irrelevant" actually require the processing and active discarding of those stimuli designated as irrelevant. A review of a study by Rabbitt (1965) illustrates this point. Young and elderly subjects were timed on a card sorting task. The number of "relevant" letters (i.e., piles of cards, and therefore, responses) and the number of "irrelevant" letters on each card were varied. Subjects searched the cards for the relevant letter, then sorted each card according to the relevant letter present.

The results indicated that although increasing the number of relevant items resulted in increased sorting times, this effect was not differentially large for the elderly. However, increasing the number of "irrelevant" letters on a display increased "the sorting times of the old subjects more sharply than those of the young subjects" (Rabbitt, 1965). This effect was more pronounced when there were eight as opposed to two relevant letters. As Eriksen and Eriksen (1974) have pointed out:

> The search task by definition requires some processing of noise in order to locate the target. Thus, inferences as to the effects of noise are confounded with assumptions as to how this search of the display is carried out.

The Rabbitt (1965) study therefore cannot be considered a direct test of the perceptual noise hypothesis of age related performance decrement. These results can be interpreted as an age decline in ability to discriminate relevant from irrelevant items, but not in the ability to ignore irrelevant items.

Another approach that at first seems to be related to the perceptual noise hypothesis is the work on Embedded Figures and Gottschaldt Figures tasks. Both tasks involve the identification of a simple figure that is embedded in a larger, more complex one. In the Gottschaldt task, the subject must specify which of four complex figures contains the simple target figure. The simple figure could appear

in one or more of the complex figures. In the Embedded Figures task, the subject must locate the simple figure in a single complex figure. The dependent measure is the latency to locate the simple figure. Both of these tasks require "the ability to maintain and recognize a given closure despite the intrinsic distractions of a more stable larger field and equally good competing gestalten" (Basowitz & Korchin, 1957).

In terms of age related performance, Schwartz and Karp (1967), Karp (1963, 1967), and Markus and Nielsen (1973) have reported age-related declines in Embedded Figures performance. Using a children's version of the Embedded Figures task, Markus (1971) has reported that institutionalized elderly perform more poorly than healthy elderly. Poorer performance on the children's Embedded Figures task have also been found to be associated with mortality among institutionalized elderly (Markus, Blankner, Bloom, & Downs, 1970). Declining performance on the Gottschaldt task with age has been reported by Basowitz and Korchin (1957), and Axelrod and Cohen (1961). These results have been interpreted as an age decline in the ability to extract the relevant information from an embedded context.

Embedded Figures and Gottschaldt Figures tests relate to the perceptual noise hypothesis to the extent that the

background of the target can be considered "noise." Karp (1963) factor analyzed a battery of field dependence tests (body adjustment, rod-and-frame, and Embedded Figures tasks), WAIS subtests, match problems, and insight problems. "Embeddedness" and "distraction" were found to be factorially distinct, although somewhat correlated. Karp defined "embeddedness" as involving gestalts that were in competition for critical elements of the figure. "Distracting" tasks obscured but did not change or compete for critical elements of the target figure. The background figure in Embedded Figures and Gottschaldt Figures tasks provides a context in which the target figure is embedded. This interfering context is not completely irrelevant, however, because it must be processed in order to locate the target figure. Therefore, because of this required processing of the "noise," the embedded figures type tasks cannot be used to test the perceptual noise hypothesis.

A task that does contain truly irrelevent noise and that shows declines in performance with age is the Stroop task. Difficulty with the Stroop task results from inability to ignore one aspect of the stimulus (a printed word) when trying to focus attention on another aspect (the color of the ink of the printed word). Subjects are asked to name the color of the ink of several kinds of stimuli. The time to name a series of color patches is

first recorded. Then subjects are timed as they name the color of the ink of a series of words that name a different color (e.g., the word BLUE written in red ink would require a response of "red"). The difference between color naming times with and without the conflicting color words reflects the interference due to the presence of the word, i.e., the subjects' inability to suppress the irrelevant information. Comali, Wapner, and Werner (1962) suggest that the Stroop effect reflects "the capacity to maintain a course of action in the face of intrusion of other stimuli." With this interpretation, and because processing the printed word is not required by the task, the Stroop test can be considered a test of the perceptual noise hypothesis.

Comali et al. (1962) tested subjects between the ages of seven and eighty and found significant interference effects at all ages on the Stroop test. This effect showed marked age differences. Interference effects were greatest at age seven, dropped to a plateau by 17-19 years, and rose again in the 65-80 year old group. In another study (Comali, 1965) two different populations of older men (ages 65-85 and 80-90 years), all of whom were relatively healthy and living in the community, were compared. Even with this restricted and overlapping age range, the 80-90 year old group showed significantly poorer Stroop performance than the 65-85 year old group.

Comali, Krus, and Wapner (1965) reported greater susceptibility to Stroop effects in an institutionalized elderly sample than in a roughly equivalent noninstitutionalized elderly sample (matched for age, education, and health). Bettner, Jarvik and Blum (1971) also reported greater susceptibility to Stroop effects in an elderly group, and greater susceptibility in elderly persons with organic brain syndrome (OBS) compared with non-OBS elderly. These results indicate that elderly people have more difficulty suppressing irrelevant information than younger adults.

The level of information processing at which the interference occurs in the Stroop task is not clear. Does the presence of an incongruous color name interfere with the encoding of the color of the ink, or does the interference occur at the response level, with the reading of the name producing a response that competes covertly with the naming of the ink color? If the effect is due to response competition, there should be less interference when nonsense syllables instead of color names are used. Klein (1964) and Ray (1974) reported maximal interference when the word named a color that was used in the experiment (i.e., was a potential response) but was different from the color of the ink. A lesser degree of interference was seen with nonsense syllables. These results

suggest that reading the color name does interfere with production of a correct response. Liu (1975) found that reducing the name reading response by having subjects hold the Stroop cards upside down significantly reduced color naming times. Another study compared color naming times under conditions where the words used were (1) the same as the ink color, (2) different from the ink color, and (3) unrelated to color. Times for naming colors when the word was the same as the ink color were significantly faster than with the other conditions. If the interference is primarily at the encoding level, any word, including the color name of the ink, should produce interference. If the interference is at the response level, interference should occur only when the color word and the color of the ink produce different responses. The facilitative effect found in the absence of response competition therefore supports an output rather than an input explanation of the Stroop effect (Hintzman, Carre, Eskridge, Owens, Shaff, & Sparks, 1972).

The studies cited support the hypothesis that Stroop interference occurs at the response level. Evidence that interference in the Stroop task occurs at the encoding level as well has been supplied by Ray (1974). Ray found that color naming times were slower with nonsense syllables than with color patches. If interference acts solely at

the verbal response level, the effect should dissipate when the response required is not verbal. When the usual verbal response to the incongruous pairs was replaced by responses on color coded keys, interference was reduced, but was still significantly more than for a non-interference control (Pritchatt, 1968). Hock and Egeth (1970) defined a target set of colors and instructed subjects to respond yes or no to individual Stroop cards on the basis of their membership in the target set. The presence of incongruous color names still produced interference, suggesting that response production is not the sole locus of Stroop interference. The authors suggested that incongruous color names distract attention from the encoding of the color of the ink (Hock & Egeth, 1970). The elimination of a verbal response does not, however, eliminate the possibility of covert response competition.

In summary, a large portion of the Stroop interference effect has been explained as competition between color naming and color-word reading responses. Another possible location of interference that has some support from the literature is the encoding level. The magnification of the Stroop effect seen in elderly people could result from an exacerbation of the interference effects at either or both of these sites.

Performance of the Stroop task involves ignoring or suppressing certain aspects of the stimulus input. Another paradigm that involves the suppression of perceptual noise is one developed by Eriksen and his associates (Eriksen & Collins, 1969; Eriksen & Hoffman, 1972a, 1972b, 1973; Eriksen & Rohrbaugh, 1970). In this paradigm the presentation of a circular display of letters is preceded by a bar indicator which designates the location of the target letter. Subjects are typically instructed to name the target letter or to flip a two choice switch. The dependent measure is response time. The task does not require any processing of the surrounding noise elements. In fact, optimal reaction times would be expected if the noise items could be completely ignored.

Eriksen and Collins (1969) found that the voicing latency of the target decreased as the indicator preceded the display by increasingly longer intervals. They estimated that it took their young adult subjects about 200 msec to locate and process the indicator information and direct their attention to the target location.

Apparently, eye movements are not a critical factor in this effect. To demonstrate this, Eriksen and Collins (1969) instructed subjects to report the indicated letter and the letter diametrically opposite the indicated letter. They reasoned that if eye movements were placing

the target letter in a more optimal area of retinal resolution, this would necessarily put the opposite letter in a less optimal foveal region. If eye movements are important to the leading indicator effect, one would expect more errors in identification of the opposite letter. Eriksen and Collins (1969) instead found improved accuracy for both letters with increasing delay between the onset of the leading indicator and the display (stimulus onset asynchrony--SOA). Another indication that eye movement is not critical in this selective attention paradigm is that the leading indicator effect has been shown both when total display times were less than and greater than the average latency for a voluntary saccadic movement (Eriksen & Rorhbaugh, 1970; Colegate, Hoffman, & Eriksen, 1973). Colegate et al. (1973) also recorded eye movement data with subjects who were instructed to maintain a central fixation. Despite individual differences in ability to maintain this fixation, a similar leading indicator effect was found in all subjects. This evidence supports the conclusion of Colegate et al. (1973) that changes in foveal fixation are not necessary for selective encoding with this type of visual display.

The number of elements in the display also affects response times in this task. As the number of noise letters in the circular display was increased from eight

to twelve, report accuracy decreased (Eriksen & Rorhbaugh, 1970) and voicing latencies increased (Eriksen & Hoffman, 1972a). One possible explanation for this display size effect is that the increased noise reduces the discriminability of the indicator. If this is the case, the display size effect would be expected to dissipate with increasing stimulus onset asynchronies (SOAs) which allow more time for processing the indicator. However, voicing latencies appear to have reached asymptotic values at about a 250 msec SOA, and the display size effect has also been found when the indicator preceded the display by as much as 350 msec (Colegate et al., 1973). Colegate et al. (1973) concluded that display size does not act by impairing the localization or processing of the indicator, but rather by impairing the processing of the target letter (Colegate, 1973). The selective mechanism that determines which information is processed, or which information is processed first, is apparently less efficient when more irrelevant items are present, even though conceptually the task does not require their processing.

The display size effect, as it has been investigated, confounds the effects of number of elements and the spacing between elements. To separate these effects, Eriksen and Hoffman (1972b) held the number of noise letters constant (at 4) and varied the spacing between the target and

nearest noise letters. At the closest spacing the noise items were in adjacent clock positions in the circular display, two on each side of the target. In the other two spacing conditions, the nearest noise items were either one or two clock positions removed from the target. The two noise items on each side of the target were always adjacent. In addition to the noise letter conditions, the same spacing conditions were also filled with black disks to investigate the differential effects of letters and noncharacter noise on selective encoding. The procedure of this study differed from those previously mentioned in that the target letter was presented simultaneously with the indicator and the noise elements followed at SOAs of 0, 50, 100, 150, 200, or 300 msec.

With noise letters, reaction times to vocalize the target letter name were significantly longer with the closet spacing. The reaction times of the two more distant spacings did not differ from each other. Noise items with 1/2 degree of visual angle of the target resulted in slowed reaction times, while separation of target and noise items beyond the degree of visual angle was immaterial. This spacing effect was apparently only at SOAs of 150 msec or less. With longer SOAs the subjects apparently had time to encode the target before the onset of the noise.

Contour interference is a possible explanation of such interference at the closest spacings. This explanation would not, however, explain why the black discs at the same spacings produced much less interference than the letters. At spacings close enough to produce contour interference (about 1/3 degree) with letters, Eriksen and Rorhbaugh (1970) found comparable interference with discs. Eriksen and Hoffman (1972b) therefore concluded that the observed interference effect was not due to contour interference.

As an alternative explanation, Eriksen and Hoffman (1972b) postulated an attentional field that varies in the level of processing or information extraction. In the periphery of such a field only gross information would be extracted, while in the focus of the field, stimuli are processed in greater detail. From the interference effects observed (Colegate et al., 1973; Eriksen & Hoffman, 1972, 1972b; and Eriksen and Rorbaugh, 1970) the focus of this attentional field appears to be about 1 degree of visual angle. Noise elements falling within 1/2 degree of the target appear to be processed to the point of identification along with the target. Noise elements outside this focus have little effect, presumably because they are processed at a lower level (Eriksen & Hoffman, 1972b). This type of central attentional mechanism need not coincide

with foveal fixation, although attention directed to the periphery would be limited by lessened acuity and perhaps more rapid information decay.

Slowed reaction times to target letters with noise items falling within this area of maximal information extraction could arise from several processes (Eriksen & Hoffman, 1972b). Parallel processing of several inputs could require more "energy" or feature analyzers, resulting in a slowed encoding of the target. Or perhaps the processing of items within this area is serial, and on some trials the noise items are identified before the target. This could result in slowed reaction times due to either delayed target encoding or response competition arising from the initial identification of a noise element that activates a response. Response competition could also arise if the items are processed in parallel: two or more letters could have been simultaneously identified, all of which may lead to incipient response incompatibile with the response to the target (Eriksen & Hoffman, 1972b).

As in the Stroop studies, the noise interference effects in the Eriksen paradigm could be explained in terms of interference at the encoding level or at the response level. Eriksen and Hoffman (1973) utilized the clock display with a leading indicator in a two choice forced response task to investigate these alternative explanations.

Subjects were instructed to move a lever in one direction if the designated target letter was an H or an M, and in the other direction if the letter was an A or a U. The type of noise letters in the display, (1) required the same response as did the target (e.g., H and M as noise letters with H as the target) or, (2) required the opposite response as did the target (e.g., H and M as noise letters with U as the target). The distance between opposite response noise items and the target, and SOA between indicator and display were also varied. If interference occurs at the response level, there should be maximal interference when all the noise letters are of the opposite response category. If interference occurs at the encoding level, noise items in either the same or opposite response sets should lead to longer reaction times than a control display containing only the target item.

The opposite response noise letters produced the longest reaction times at all SOAs (0, 50, 100, 150, 200, 350 msec). This effect was most pronounced when the opposite response noise items were immediately adjacent to the target. When such noise items were four clock positions away from the target, the effect was the same as with same-response noise (Eriksen & Hoffman, 1973). This supports the response competition hypothesis and also the attentional field hypothesis that Eriksen and Hoffman

(1972b) proposed. In a similar study, Eriksen and Eriksen (1974) also found longer reaction times and more errors under opposite-response noise conditions. Response competition with this paradigm has also been demonstrated using digits (Hoffman, 1975).

These results tend to localize a major part of the interference effect of noise in young subjects at the response level. Eriksen and Eriksen (1974) have suggested that an inhibitory process is required to prevent the incipient responses evoked by the noise items from becoming overt. During this inhibition period, fine localization and processing of the target occurs, and is followed by an overt response to the target. The response competition explanation implies that some of the noise elements are being processed along with the target to the point of tending to elicit incipient responses.

Although response competition accounts for much of the interference effect in the Eriksen paradigm, there is some evidence that interference occurs also at the level of perceptual encoding. Reaction times to targets in a background of noise items requiring the same response as the target were longer than reaction times to no noise trials in a block of mixed trials, in which no-noise trials occurred only occasionally (Eriksen & Eriksen, 1974; Eriksen & Hoffman, 1973; Hoffman, 1975). Hoffman

(1975), using digits, found an intermediate level of interference from noise that was response-neutral and noise for which there was no immediately accessible verbal label. Thus, the presence of irrelevant items impedes target identification even when there is no response competition. As mentioned previously, such an encoding impairment could result from delayed target encoding due to competition for feature detectors or processing "energy" or to a lack of precision in determining the order of item processing within the limited focus area of maximal processing (Eriksen & Eriksen, 1974).

The results from studies using the Eriksen paradigm can be summarized as follows: (1) presence of a leading indicator that designates the location of the target decreases time to name the target, (2) processing of the location information takes about 150-200 msec, (3) even with a leading indicator, items within a one degree focus are processed along with the target, resulting in slower identification times than when no noise is present, (4) response competition effects of noise items account for at least part of the slowed reaction times when noise items are present, and (5) impairment of the encoding of the target by the presence of noise items is also a likely source of reaction time slowing.

It may be concluded from studies using the Eriksen and Stroop paradigms that the presence of perceptual noise hampers the performance of young adult subjects. In these young subjects this interference effect has been attributed primarily to interference at the response level. According to this explanation, the "irrelevant" aspect of the stimulus is processed along with the "relevant" aspect. When the two sources of information evoke different responses, covert response competition occurs resulting in longer response times. In addition, both the Stroop and Eriksen paradigms provide evidence for interference at the encoding or input level. This explanation attributes the slowed information processing in the presence of perceptual noise to the delayed or slowed encoding of the relevant aspect of the target stimulus due to competition for feature analyzers or processing "energy."

The Stroop studies provide evidence that perceptual noise has greater effects upon the performance of elderly people than on that of younger people. That is, the difference in response time between conditions where perceptual noise is present and conditions where it is absent is greater for elderly people. The locus of this exaggerated interference effect with increasing age is not known.

Extrapolating from the studies done with young subjects, the magnified response slowing in the presence of

perceptual noise with increasing age could be attributed to (1) slower or more delayed encoding of the target stimulus due to distraction by the noise, i.e., more input interference, or (2) more difficulty suppressing covert responses to the noise, i.e., more response competition. Localization of this age related performance decrement at one or both of these points in information processing would yield a valuable insight into processing deficits with age. Knowledge of the specific sources of difficulty among the elderly in processing visual information would provide data that could be used to modify visually presented material so that it could be better utilized by the elderly population.

Statement of the Problem

There is evidence that perceptual noise impairs information processing in elderly people to a greater extent than in younger adults. Stroop studies indicate that elderly people have more difficulty ignoring irrelevant information (e.g., Comali et al., 1962). Stroop interference has been demonstrated predominantly at the response level in young adult subjects. In such response competition, word reading responses purportedly compete with the color naming responses that are required, resulting in longer naming latencies. Some interference may

also occur at a perceptual input level, with the written word distracting "attention" from the encoding of the color of the ink. Localization of Stroop interference effects has not been investigated with elderly people. The poorer Stroop performance by older people may imply an increase in response competition, but may also reflect a slowing at the perceptual input level, or increased difficulty at both of these sites.

In an information processing paradigm (Eriksen's Circular Display Paradigm), young subjects have been shown to require more time to identify an indicated target letter when noise letters are present, as opposed to when only a single letter is present. With this paradigm specific processes involved in the interference effects have only been investigated with young subjects. In young adults, this interference is maximal when the noise items are letters that require a response different from that required by the target (Eriksen & Hoffman, 1973; Hoffman, 1975). An intermediate level of interference is obtained when the noise items do not require a response or cannot be readily verbally labelled (Hoffman, 1975).

In addition to response competition and slowed encoding, another possible explanation of the interference effect is response inhibition. Eriksen and Eriksen (1974) have suggested that in young subjects immediate responses

are withheld or inhibited, perhaps to prevent responses to noise items from becoming overt. This is supported by their finding that blocks of trials containing only single target letters (pure blocks) result in shorter response latencies than single letter trials in blocks of trials containing some noise condition trials (mixed blocks).

The present study used an Eriksen-type paradigm to provide data relevant to the following questions: Does the presence of perceptual noise differentially slow the performance of elderly people via (1) increased impairment due to the effects of noise, (2) increased response competition, and (3) increased inhibition of responses.

Data relevant to the first question was provided by the comparison of a neutral-response noise condition with a no-noise condition (within a block of mixed trials). If the differences in reaction times between single letter and neutral response noise conditions are greater for the elderly than for young subjects, an age difference in the effects of perceptual noise would be indicated.

Data relevant to the second question was provided by comparisons of the effects of different types of noise items. Increased reaction times with different-response noise items over same-response noise items would indicate interference due to response competition. A differential slowing of the elderly with the different-response noise

would indicate an age difference in susceptibility to response competition.

A comparison of no-noise trials in pure versus mixed blocks of trials provided data relevant to question three. If elderly people took relatively longer when noise items were expected than when only a single target letter was expected, greater response inhibition would be inferred.

Another variable investigated was sex differences. Elias and Kinsbourne (1974) found an exaggerated sex difference in elderly subjects on the performance of verbal and nonverbal information processing tasks. Young females were slightly deficient in nonverbal processing, while young males were about equal on verbal and nonverbal. The elderly women showed a marked superiority of verbal as opposed to nonverbal processing, and were superior to elderly males on verbal stimuli. Elderly males were superior to elderly females on nonverbal processing. This report indicates that sex differences in elderly groups favoring females may be expected on a verbal task. To the extent that the present task required verbal processing, such a result would be expected.

CHAPTER II

PROCEDURE

Subjects

Ten males and 10 females were obtained from two age groups: 18-25 years (young age group: males, $\bar{x}$ = 20.3, females, $\bar{x}$ = 19.4 years), and 60-82 years (senior age group: males, $\bar{x}$ = 73.1, females, $\bar{x}$ = 72.0 years). All elderly subjects were community residents and were capable of driving their own cars. The young subjects were students in sophomore psychology classes who participated in the study for class credit. The elderly subjects were paid $10.00 for their participation. Because both groups received some form of payment, it was assumed that the groups were equivalently motivated. All subjects had normal or corrected to normal vision, and reported no difficulties seeing the stimuli. One elderly woman was excluded from the study because the frequency of errors made indicated difficulty either seeing the stimuli or learning the responses.

Apparatus

A Gerbrands three field tachistoscope was used to present the stimuli. Background illumination was set at 1.3 fL for all presentations. The subjects' console

consisted of a three position (double pole-double throw) toggle switch. Responses were timed in msec with a Lafayette Multichoice Reaction Timer.

Stimuli

Display cards were constructed by placing black capital letters (S, C, J, U, H, and K, from letraset 32-30-CLN, 446, 24 pt. Folio Bold press-on letters) on white 5 x 7 cards. Five letters were positioned on each card in a horizontal row, with the target letter in the middle position. A target indicator in the form of a bar was placed below the horizontal row and positioned vertically such that it was positioned .5 degrees of visual angle from the indicated target letter. The display letters were positioned approximately .5 degrees of visual angle apart, measured from edge to edge.

Procedure

Four target letters were divided into two sets: S-C and H-K. Half of the subjects in each group were asked to push the toggle switch to the left if the designated target letter was an H or a K, and to the right if the letter was an S or a C. Opposite directions were given to the remaining half of the subjects. The four experimental conditions were defined in terms of the noise context in which the target letter appeared. In condition SR (same-response), the

noise elements flanking the target were of the same response set, and thus required the same response as did the target. For example, if the target letter was an S, a C appeared on each side of the target. The target letter (e.g., S) was used to fill the outer two positions so that the entire display read SCSCS. In condition DR (different-response), the noise elements surrounding the target letter belonged to the opposite response set. For example, the target letter S was flanked by two H's, with K's occupying the outer positions (KHSHK). In condition NR (neutral-response), the noise letters were neutral with respect to the response. The letters U and J were alternated to fill the display surrounding the target letter (e.g., JUSUJ). In the no-noise conditions, the target letter appeared in an otherwise empty display. No-noise trials were administered in both mixed and pure blocks. Condition NNP (no-noise pure) consisted of blocks containing no-noise trials only. These blocks were given at the beginning of the session as warm-up trials, and at the end of the session as test trials. Condition NNM (no-noise mixed) consisted of no-noise trials presented in blocks of trials that also contained the various noise condition (mixed blocks). The order of presentation of the various noise conditions was randomized in each block.

Subjects were adapted to the low level of illumination in the room (a 5 watt bulb) for five minutes while the experimenter explained the purpose of the study and provided task instructions. After questions concerning the task instructions were answered, the experiment was begun. Before each trial, a verbal ready signal from the experimenter indicated that a trial was about to begin. Following this signal, the target indicator was presented. One second (1000 msec) after the onset of the target indicator, the display containing target and noise letters (when applicable) was presented. The target indicator remained visible throughout the presentation. The entire display remained on until the subject responded. Time from the onset of the letter display to the subjects' response on the toggle switch was recorded. Trials in which errors were made were repeated later in the block to obtain a correct response time. Only correct response times were used for data analysis.

The test format consisted of twelve blocks of trials with 16 trials per block. The first blocks of trials were no-noise trials presented in pure blocks (Condition NNP). Three blocks of practice trials in the NNP condition were given as warm-up trials. In each block, each of the four target letters was presented four times. Following the warm-up trials, one block of mixed noise condition trials

was given as practice. This was followed by seven test blocks of mixed noise condition trials. In each block, the four target letters were each presented in all four noise conditions (NN, NR, SR, DR). The same random order of experimental condition presentation was given to all subjects. Following these mixed blocks, a block of no-noise pure (NNP) test trials was given. Rest periods were given between blocks at the subjects' request. The test sessions lasted approximately 60 minutes.

CHAPTER III

RESULTS

The main hypotheses of the present study concerned age differences in the effects of (1) perceptual noise, (2) response competition, and (3) response inhibition. In addition to these age differences, the presence of the three effects was tested within each age and sex group, primarily to replicate previously reported findings (e.g., Eriksen & Eriksen, 1974).

The comparisons relevant to these hypotheses were tested by Dunn's a priori procedure, with alpha set at .05 for each set of three hypotheses (Kirk, 1968, pp. 79-81). For example, age differences in perceptual noise response competition, and response inhibition had an overall alpha of .05. The tests of the effects within ages was performed with the alpha divided equally among the six relevant comparisons (the three effects at both ages). The source tables containing the error terms for the a priori tests are presented in Table 1. The error term used to test the age differences was the pooled error term $[MS_{SWG} + MS_{B \times SWG}]$ (q - 1 / nqr. This error term was required because the comparison involved both an age and

TABLE 1

AGE X SEX X NOISE CONDITIONS ANALYSIS OF VARIANCE (LAST HALF)

Source	df	Sum of Squares	Mean Square	F Max	F Ratio	Probability
Sex	1	4762.87891	4762.87891	1.004	0.241	0.63184
Age	1	564984.50000	564984.50000	1.513	28.592	0.00004
Sex x Age	1	343.21997	343.21997	1.951	00.017	0.89112
S W Groups	36	711365.43750	19760.14844			
Noise	4	124280.62500	31070.15625	1.544	148.033	0.00000
Sex x Noise	4	2141.71997	535.42993	1.601	2.551	0.04099
Age x Noise	4	1746.69995	436.67480	2.934	2.081	0.08536
Sex x Age x Noise	4	245.17999	61.29500	3.981	0.292	0.88262
Noise x Subjects	144	30223.71875	209.88693			
Total	199	1440094.00000	7236.65234			

a noise group comparison (Figure 1). All d' values are reported in Tables 2 and 3.

Observation of the data indicated that a practice effect existed. From Figure 1 it can be seen that the different noise conditions maintained essentially the same relative positions in each of the age and sex groups, with the DR condition producing the longest reaction times, followed by NR or SR, and NNM, with NNP producing markedly shorter reaction times. Overall, the elderly responded about 100 msec slower than did the young subjects (Figure 2). This effect was analyzed as an Age by Sex by Blocks analysis of variance. Scores for each subject were means of blocks one, four, and seven, of the mixed noise condition test trials (there were 16 trials per block). From Table 4 it can be seen that the Age effect, the Blocks effect, and the Blocks by Age interaction were all significant beyond the $p < .001$ level. The Sex effect was not significant. Tukey's HSD post hoc tests (Kirk, 1968, pp. 88-90) were performed on the Age by Blocks interaction to test for the location of the differential age effect. These tests and Tukey's d' value is given in Table 5. The practice effect was significant for both young and elderly, both between blocks one and four and between blocks four and seven. Between blocks one and four, the elderly improved significantly more than the young. This was tested by a Scheffe's

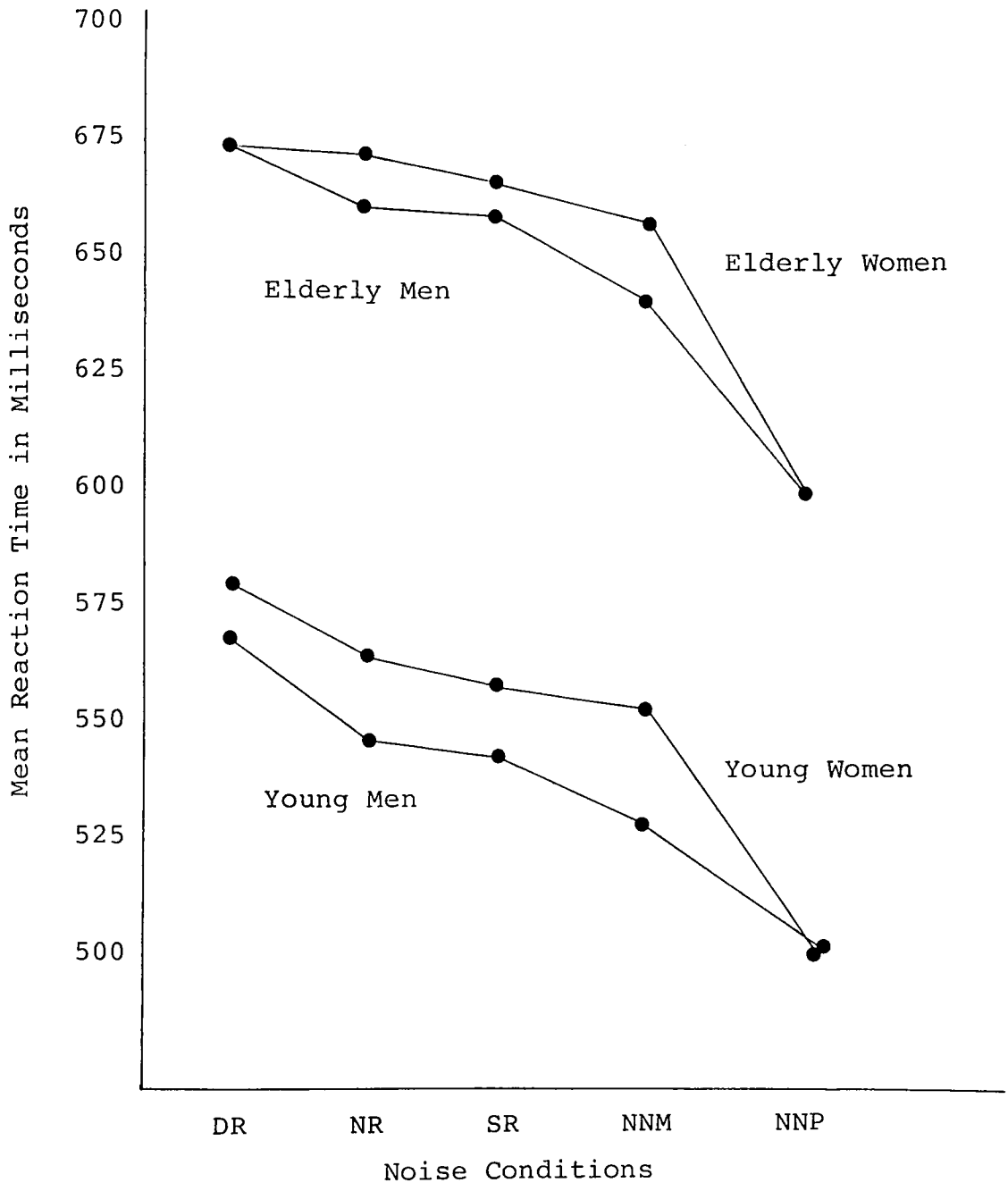

Fig. 1. Noise Condition Effects by Age and Sex (Last Half).

TABLE 2

AGE EFFECTS: MEAN RESPONSE TIMES IN MSEC (LAST HALF)

A. Noise

	NR	σ	NNM	σ	D	Dunn's d'
Young	554.15	59.55	542.10	57.99	12.05	12.09
Elderly	664.70	69.34	650.15	72.82	14.55*	12.09
Age Diff.					2.50	34.3

B. Response Competition

	DR	σ	SR	σ	D	Dunn's d'
Young	571.20	57.49	548.70	58.85	22.5*	12.09
Elderly	673.75	72.96	662.15	72.35	11.6	12.09
Age Diff.					-10.9**	34.3

C. Response Inhibition

	NNM	σ	NNP	σ	D	Dunn's d'
Young	542.10	57.99	501.30	42.59	40.8*	12.9
Elderly	650.15	72.89	598.20	57.13	51.95*	12.09
Age Diff.					11.15**	34.3

Note. The error term used to test the age differences was the pooled error term:

$$\frac{MS_{SWG} + MS_{B \times SWG}(q - 1)}{nqr}$$

*$p < .05$ by Dunn's procedure

**$p < .05$ by 95 percent confidence limits around the differences ($\bar{x} \pm 9.1$)

TABLE 3

SEX EFFECTS: MEAN RESPONSE TIMES IN MSEC (LAST HALF)

A. Noise

	NR	σ	NNM	σ	D	Dunn's d'
Women	616.00	87.10	605.10	85.55	10.9	12.09
Men	602.85	84.32	587.15	85.57	15.7*	12.09
Sex Diff.					4.8	34.3

B. Response Competition

	NR	σ	NNM	σ	D	Dunn's d'
Women	625.70	80.79	611.60	86.63	14.1*	12.09
Men	619.25	87.26	599.25	88.81	20.00*	12.09
Sex Diff.					-5.9	34.3

C. Response Inhibition

	NR	σ	NNM	σ	D	Dunn's d'
Women	605.10	85.55	549.20	70.19	55.90*	12.09
Men	587.15	85.57	550.30	71.36	36.85*	12.09
Sex Diff.					19.05**	34.3

Note. The error term used to test the sex differences was the pooled error term:

$$\frac{MS_{SWG} + MS_{B \times SWG}(q - 1)}{nqr}$$

*$p < .05$ by Dunn's procedure

**$p < .05$ by 95 percent confidence limits around the differences ($\bar{x} \pm 9.1$)

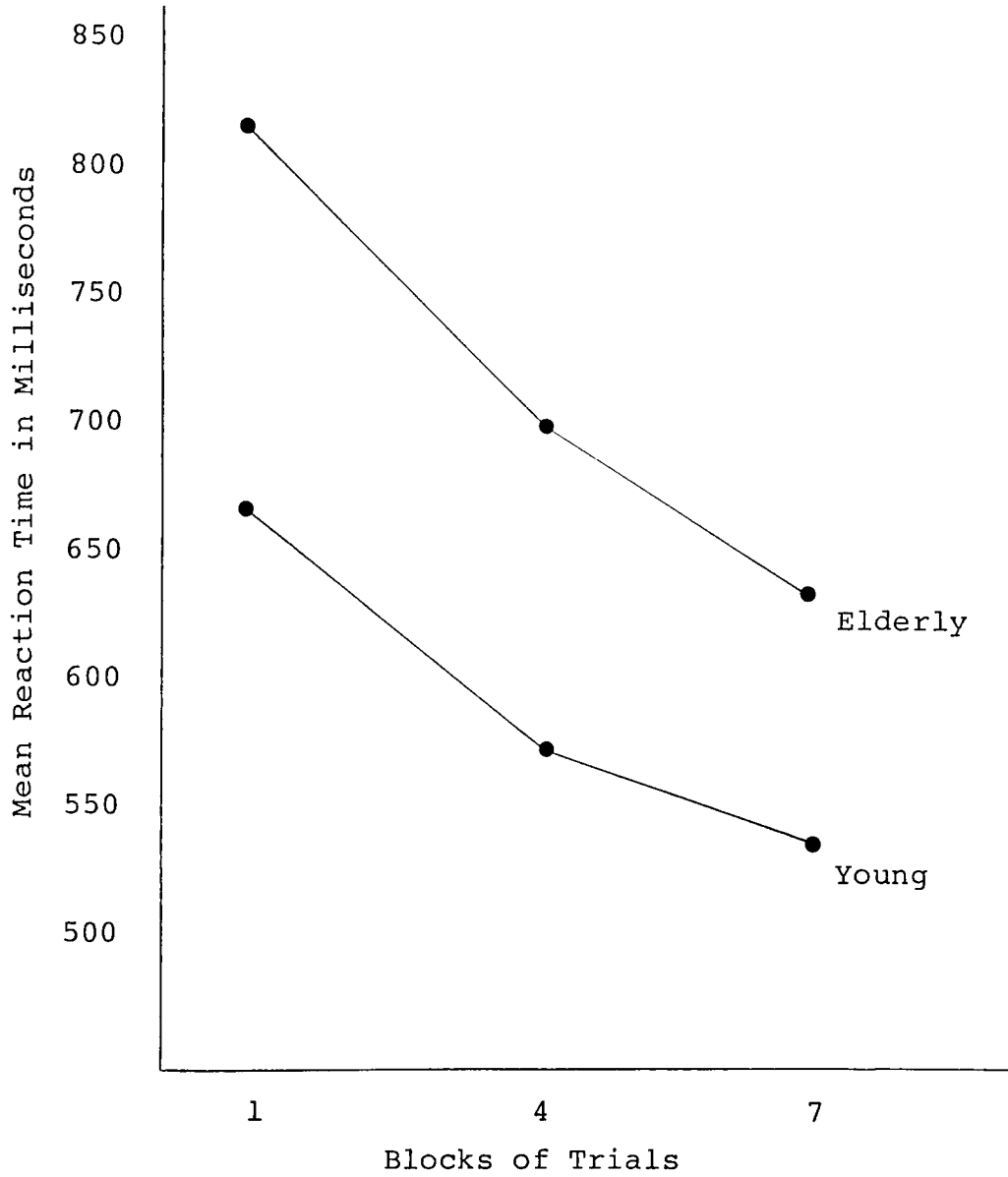

Fig. 2. Practice Effect by Age.

TABLE 4

AGE X SEX X BLOCKS ANALYSIS OF VARIANCE

Source	SS	df	MS	F
Sex (A)	7921.875	1	7921.8750	0.4731
Age (C)	461156.01	1	461156.01	27.5419*
AC	550.4063	1	550.4063	.0329
Error	602776.94	36	16743.804	
Blocks (B)	493451.25	2	246725.62	322.3734*
AB	684.4453	2	342.2227	.4472
BC	14327.613	2	7163.8067	9.3603*
ABC	264.8125	2	132.4063	.1730
Error	55104.570	72	765.3413	
Total	1636237.9	119	13749.899	

*p < .001

TABLE 5

PRACTICE EFFECT: TUKEY'S POST HOC TESTS
(MEAN REACTION TIMES REPORTED IN MSEC)

	Block of Trials		
	1	4	7
Young	660.65	579.25	531.70
Elderly	814.40	695.55	633.60

	Block Differences	
	1-4	4-7
Young	81.4*	47.55*
Elderly	118.85*	61.95*
Age Diff.	37.45**	14.40

*p < .05, Tukey's d' = 25.65 (df = 72)

**p < .05, Scheffe's d' = 21.2 (df = 72)

post hoc test for non-pairwise comparisons (Table 5). Although a practice effect existed between blocks four and seven, the effects were not different for young and elderly.

To eliminate any possible age bias due to the differential practice effect over the first half of the experiment, only trials from blocks four through seven were used for the a priori analyses. The results from the overall analyses are presented in Tables 6, 7, and 8. The presence of a practice effect did not interfere with the evaluation of the effects of perceptual noise and response competition because the noise conditions were randomized for each block of trials. The effects of the practice effects on response inhibition will be discussed under response inhibition.

Noise Effects

Perceptual noise effects were defined a priori as the difference in response latency between neutral-response noise (NR) and no-noise mixed (NNM) trials. It can be seen from Table 2, section A, that the perceptual noise effect was significant for the elderly group, and only narrowly missed attaining significance in the young group (actual D = 12.05, d' = 12.09). There was, however, no significant increase in the effects of perceptual noise

TABLE 6

AGE X SEX S NOISE CONDITIONS ANALYSIS OF VARIANCE (OVERALL)

Source	df	Sum of Squares	Mean Square	F Max	F Ratio	Proba-bility
Sex	1	4446.24219	4446.24219	1.029	.186	.672
Age	1	609960.1250	609960.1250	1.530	25.551	.001
Sex x Age	1	34.44499	34.44499	1.695	.001	.9687
S W Groups	36	859390.56250	23871.95703			
Noise	4	320644.50000	80161.12500	1.848	243.721	.001
Sex x Noise	4	3134.17993	783.54492	1.904	2.382	.053
Age x Noise	4	3475.09985	868.77490	3.827	2.641	.036
Sex x Age x Noise	4	48.28000	12.07000	4.711	.037	.995
Noise x Ss	144	47362.31641	328.90479			
Total	199	1848495.00000	9288.91797			

TABLE 7

AGE EFFECTS (OVERALL)

A. Noise

	NR	σ	NNM	σ	D	Dunn's d'
Young	587.23	64.2	577.40	62.9	9.83	15.14
Elderly	706.9	80.9	690.10	79.1	16.80*	15.14
Age Diff.					6.97	37.9

B. Response Competition

	NR	σ	SR	σ	D	Dunn's d'
Young	610.10	65.6	586.05	65.6	24.05*	15.14
Elderly	715.6	81.3	703.55	83.3	12.05	15.14
Age Diff.					12.00	37.9

C. Response Inhibition

	NR	σ	NNP	σ	D	Dunn's d'
Young	577.40	62.9	501.30	42.6	76.1*	15.14
Elderly	690.10	79.1	598.2	57.1	91.9*	15.14
Age Diff.					15.8	37.9

Note. The error term used to test the age differences was the pooled error term:

$$\frac{MS_{SWG} + MS_{B \times SWG}\,(q - 1)}{nqr}$$

*$p < .05$ by Dunn's procedure

TABLE 8

SEX EFFECTS (OVERALL)

A. Noise

	NR	σ	NNM	σ	D	Dunn's d'
Women	658.35	95.6	640.20	91.7	18.15*	15.14
Men	635.80	93.8	627.30	91.7	8.5	15.14
Sex Diff.					9.65	37.9

B. Response Competition

	DR	σ	SR	σ	D	Dunn's d'
Women	660.05	90.1	648.00	95.5	12.05	15.14
Men	659.65	92.8	641.60	96.8	18.05*	15.14
Sex Diff.					6.00	37.9

C. Response Inhibition

	NNM	σ	NNP	σ	D	Dunn's d'
Women	640.20	91.7	649.20	70.2	91.00*	15.14
Men	627.30	91.7	550.30	71.4	77.00*	15.14
Sex Diff.					14.00	37.9

Note. The error term used to test the age differences was the pooled error term:

$$\frac{MS_{SWG} + MS_{B \times SWG}\,(q - 1)}{nqr}$$

*$p < .05$ by Dunn's procedure

with age. Although the power of this test to detect a difference greater than 10 msec was less than .20 (Kirk, 1968, pp. 107-109), the difference also failed to attain significance when the confidence intervals were constructed. The power of this latter test was over .90 (Kirk, 1968, pp. 107-109). It is therefore concluded that the noise effect is present to a similar extent in both age groups.

In Table 5 section A it can be seen that the noise effect was significant for men, but not for women. However, there was no significant difference in this effect between men and women, indicating that the effect is present to a similar extent in both men and women, even though it did not attain significance in women.

Response Competition

Response competition was defined a priori as the difference in response latency between different-response (DR) and same-response (SR) noise trials. Table 2 section B illustrates the significant response competition effect in the young group and its absence in the elderly group. The age comparison by Dunn's procedure did not attain significance. However, 95 percent confidence limits about this difference indicate that the young showed more response competition than did the elderly.

The significant effects of response competition in both men and women can be observed in Table 3 section B.

The difference between the sexes on this effect can be seen to be not significant.

Response Inhibition

Response inhibition was defined a priori as the difference in response latency between no-noise mixed (NNM) and no-noise pure (NNP) trials. From Table 2 section C it can be seen that this effect was significant for both young and elderly. The age difference was significant only with the more powerful test, the 95 percent confidence limits. This indicated that the elderly showed significantly more response inhibition than the young.

In Table 3 section C it can be seen that both men and women showed significant effects of response inhibition, but that women showed significantly more slowing due to this effect than did men.

The presence of the practice effect poses some difficulty in the interpretation of the response inhibition effect. Because the NNP trials were presented after the mixed blocks containing the NNM trials, the practice effect is confounded with the response inhibition effect (NNM - NNP). However, since the practice effects were not significantly different between young and elderly between blocks four and seven, the age comparison of the effects of response inhibition remains valid if only these blocks are

used. Likewise, the lack of a differential practice effect for men and women allows the sex difference comparisons to be made. Therefore, although no definite conclusion can be reached concerning the presence or absence of the effects of response inhibition, it can be concluded that elderly show more response inhibition than young people, and women show more response inhibition than men.

Errors

Error latencies were not recorded, but the frequency of errors was in all cases fewer than five errors over the entire session (with the exception of one subject who was excluded from the analysis). Because the overall error rate was less than one percent, these data were not analyzed. Although this error rate is less than that reported by Eriksen and Eriksen (1974), a similar pattern of errors was found in the young groups. From Table 9 it can be seen that the present error rate in the DR condition was 1.6 percent and in the SR condition, .3 percent. Eriksen and Eriksen reported error rates of 16.6 percent and 2.7 percent for these two conditions, respectively. The elderly did not show this pattern of more errors for the DR condition. The lower error rate overall found in the present study may be attributable to the larger letters

TABLE 9

ERRORS PER NOISE CONDITION

Condition	Young (N=640)		Elderly (N=640		Overall (N=1280)	
	#	%	#	%	#	%
DR	10	1.6	3	.5	13	1.0
NR	4	.6	2	.3	6	.5
SR	2	.3	1	.2	3	.2
NN	0	0	2	.3	2	.2

used in this study, or to the use of binocular viewing instead of monocular viewing as used in the Eriksen study.

CHAPTER IV

DISCUSSION

The major hypothesis of the present study concerned the possible increased effects of perceptual noise with age. This hypothesis has received some support (Layton, 1975), but these studies have been criticized here because they do not allow the subjects to ignore the irrelevant information. The Rabbitt (1965) card sorting task required subjects to search cards containing both relevant and irrelevant letters for one of a predefined set of relevant letters. Sorting was then done on the basis of the relevant letter. Embedded figures tasks require the location of a predefined figure in a more complex figure. The difficulty here is in actively suppressing the competing "good gestalten" present in the complex figure in order to search for the target figure (Basowitz & Korchin, 1957). Such tasks require that all information be processed, labeled as relevant or irrelevant, and then either attended to or ignored, depending on the label assigned. In these tasks, age-related performance declines were found.

In the present task, which did not require processing of the irrelevant stimuli, no age differences in effects of perceptual noise were found. The age-related difficulty

appears to be in discriminating or labeling irrelevant and relevant items, not necessarily in ignoring irrelevant stimuli.

A question arises as to why the Stroop task shows age-related declines, whereas the present study does not. The Stroop task was initially thought to be a good test of the effects of perceptual noise. The task of naming ink color did not seem to require reading the printed words. The difference may lie in the difficulty of ignoring different types of irrelevant stimuli. The Stroop task requires ignoring an aspect of the stimulus presented (the printed word), while attending to another aspect (the color of the ink). The printed word cannot be ignored by a location cue, as could the irrelevant stimuli in the present study. The processing of the color of the stimulus word may necessitate the processing of the word itself, that is, perhaps a particular aspect of the stimulus cannot be processed in isolation. While processing of the irrelevant stimuli in the Stroop task is not required by the task instructions, it may be required by the nature of the stimuli. In the present paradigm, the target letter could be processed in isolation, within the limits of the minimal focus (within which everything is theoretically processed, according to Eriksen and Eriksen (1974). In short, stimulus

selection by location may be easier than selection by aspect of the stimulus.

The age-related decline in the Stroop task may be the result of subjects' processing all of the stimulus, then suppressing the irrelevant aspect, as opposed to only processing the relevant aspect. If so, the Stroop task would be better categorized as a test of response competition, not of effects of perceptual noise.

Thus the differences between the findings of the present study and the Stroop task can be attributed to (1) differences in task difficulty, or (2) the Stroop task may test primarily response competition. Regarding explanation (1), the present noise task was sufficiently difficult to produce effects in young as well as elderly people. Age differences, where they exist, seem to be robust effects, e.g., the overall 100 msec age difference in reaction times in the present study. It would seem then, that since the task was sufficiently difficult to produce detectable response slowing, an age-related difficulty in ignoring irrelevant items, if it exists, could have been detected. In this light, the task difficulty explanation does not seem likely.

Explanation (2) attributes the age-related effects found in the Stroop task to response competition rather than to perceptual noise effects. Since a large portion

of the Stroop interference effects has been found attributable to response competition (Klein, 1964; Ray, 1974; Liu, 1975), this seems to be a reasonable explanation. This explanation is also consistent with the present finding of no age difference in the effects of perceptual noise.

Eriksen's interpretation of the noise effect in young subjects involves an inability to inhibit detailed processing of any stimuli falling within an attentional field of approximately one degree of visual angle (Eriksen & Eriksen, 1974). Processing of such a display could be done in either serial or parallel fashion according to Eriksen and Eriksen. Competition for feature analyzers of "processing energy" would account for delayed encoding if the stimuli were processed in parallel, i.e., if much of the display were processed simultaneously. It is also possible that the display is processed serially, i.e., the letters are processed sequentially. If the processing is serial, delayed encoding of the target would result from lack of precision in localizing the target or in determining the order of the items to be processed. The efficiency of serial processing would be dependent upon the discriminability of the target indicator. That is, if the location information is not adequately processed, this would lead to more imprecision in determining the first letter to be processed. If the processing is in parallel, even

adequate processing of the target indicator would not eliminate the effects of the irrelevant information present. In serial processing, if adequate location information is given, location imprecision should be reduced to a minimum, thereby insuring that the target letter is the first to be processed. This should minimize, if not abolish the effects of irrelevant noise.

The prolonged presentation of the leading indicator does not, however, abolish the noise effect. In young subjects, Colegate et al. (1973) reported increasing voicing latencies with increased number of items on a display with Stimulus Onset Asynchronies (SOA's) of up to 350 msec. Eriksen and Eriksen (1974), Eriksen and Hoffman (1973) and Hoffman (1975) have reported slowed reaction times to same-response noise trials as compared with no-noise trials when the target indicator was continuously present and the trials were initiated by the subject. With 200 msec SOA's young adults have been shown to have time to locate and process the target indicator (Eriksen & Collins, 1969). The presence of a noise effect with SOA's longer than 200 msec, which allows more time for location processing, supports the parallel processing interpretation. The present finding of a significant noise effect with the use of an SOA of 1000 msec provides further support of the parallel processing hypothesis, at least for the young subjects.

The finding of no age differences in this effect implies that the SOA of 1000 msec was ample time for both young and elderly to process the location information. It seems likely that elderly and young people alike are processing the display (or at least portions of it) in parallel, and that such processing leads to similar delays in responding to a designated target letter. Another plausible, but less parsimonious, explanation is that the 1000 msec SOA did not provide adequate time for the elderly to process the location of the target, as it did for the young. It would follow from this that the young subjects must be processing in parallel, because adequate target information did not eliminate the noise effect. The elderly subject, however, could be processing in a serial fashion, since the noise effect could be the result of inadequate target localization. All that can be definitely concluded is that the presence of the noise effect indicates that some processing of the noise items occurred and that this slowed responding to the target in both young and elderly subjects.

The second hypothesis of the study concerned age-related slowing due to response competition. Elderly people perform more poorly on the Stroop test than do young people, and this task has been shown to have a large component of response competition (Klein, 1964; Ray, 1974;

Liu, 1975). From this, it would seem reasonable to predict that elderly people would be more susceptible to response competition. Response competition in the present study was defined as the difference in response time between opposite response noise (DR) trials and neutral noise (NR) noise trials. In this study, significant effects due to response competition were found in the young groups, but not in the elderly groups. In the age comparison, the young showed significantly more susceptibility to response competition than the elderly. These results clearly do not support the prediction made.

Several differences in the requirements of the Stroop tasks and the present task may provide insight into this difference. As mentioned previously, it may be easier to ignore noise items with the present paradigm because the location of the target is precued. It is possible that location processing may be easier than the color processing required by the Stroop task. The Stroop task required ignoring the printed word while processing the color of the ink. Response competition arises between the well learned response of reading words and the task of naming the color of the ink. The present task requires suppression of letter identification, which may not be as difficult, and is definitely not as well learned a response as is reading words.

The task was difficult enough to produce a response competition effect in the young group, so task difficulty is not a sufficient explanation of the present results. It is the lack of response competition in the elderly groups that remains to be explained. Several explanations are possible.

1. The young may be parallel processing to the point that irrelevant items cause response competition. The elderly could be serial processing, so that fewer of the irrelevant items receive full processing, resulting in less response competition. The presence of similar effects of perceptual noise in young and elderly argues against the existence of a fundamentally different processing strategy such as a shift to serial processing. Although this possibility cannot be disregarded, it is not satisfactory without further support for the existence of serial processing predominance in the elderly.

2. The different-response noise provides more target discriminability than does the same-response noise because members of the same response set have several features in common, which might contribute to the confusability of the target. This additional discriminability might benefit the elderly more than the young, especially if the 1000 msec delay between the onset of the target indicator and the onset of the display provides insufficient time for them

to process the location of the target adequately. This explanation would imply that elderly responses to neutral-response trials should be faster than to same-response trials, because the neutral-response trials offer more target discriminability than same-response trials. However, response times to these two conditions are only minimally different, indicating that the age difference in processing is not likely due to differences in perceived target discriminability. It seems likely that if increased target discriminability aided the elderly, it would also aid the young.

3. A third explanation involves a strategy difference between young and elderly. Members of each response set (H-K and S-C) have several critical features in common, as can be seen from Table 10. This feature similarity between items that require the same toggle switch response makes responding on the basis of these shared features an efficient strategy in the NN, SR, and NR conditions. This strategy allows the subject to process less of the information before responding, resulting in faster responses. In the DR condition, however, such a strategy would produce response competition. In this condition, four of the five letters on the display are members of the response set opposite that of the target letter. Features of the different-response set noise would trigger

TABLE 10

LETTER FEATURES AS RATED BY THE GIBSON SYSTEM

Features	H	K	S	C
Straight				
Horizontal	+			
Vertical	+	+		
Diagonal /		+		
Diagonal \		+		
Curve				
Closed				
Open V				
Open H			+	+
Intersection	+	+		
Redundancy				
Cyclic Change			+	
Symmetry	+			+
Discontinuity				
Vertical	+	+		
Horizontal				
Totals	5	5	2	2

Note. Gibson, 1969, p. 88.

incipient responses which must be suppressed before an accurate response can be made to the target.

Young subjects are likely to be operating on such a feature-cue strategy. Eriksen and Eriksen (1974) found effects of response competition in young subjects when the noise items had features that resembled, but were not identical to, the opposite response set. This would account for part of the age difference in overall speed of response, as well as the response competition effect seen in the young.

The elderly may process the letters more fully before making a response. Feature cues may not be the basis of their responding, or may play a lesser role in their responding. In general this would lead to slower responding, but it would also decrease the incipient responses to the different-response noise.

An analogous difference in processing between elderly and young people is seen in a study by Rabbitt and Birren (1967). A choice response task was given in which the sequence of responses was largely predictable. The predictable sequences were rarely interrupted by unpredictable interruptive signals. Overall the elderly were slower and made more errors. On a specific type of error, however, the performance of the elderly was superior. In these errors the predicted response was made instead of the

correct response to the interruptive signal. The young subjects were apparently taking advantage of the predictable sequences to improve their reaction times, but at the cost of overlooking interruptive signals because of this minimal processing of the stimuli. The elderly apparently analyzed each signal even though this was not necessary to make the predictable responses. This additional processing undoubtedly slowed the elderly people, but it resulted in fewer continuation errors.

In the present study a feature-cue strategy may be the most efficient for responding quickly with the correct response to the target item under most of the noise conditions. However, when the features of the noise items produce competing responses, this strategy for responding becomes inefficient, producing longer latency response times, as seen in the longer times for the younger subjects. The elderly subjects by not using the feature-cue strategy, would not have the speed advantage of that strategy. This could explain part of the overall slower response latencies in the elderly group. Also, without the feature-cue strategy, the elderly would not be susceptible to feature-cue response competition. Accordingly, no response competition effect was seen in the elderly.

If the above explanation of the age difference in response-competition holds, the question of differential

difficulty with competing responses has not been answered. The use of the feature-cue strategy made the young susceptible to response competition, but the elderly may not have been exposed to response competition because their strategy was not based primarily on feature-cues.

When both the elderly and the young process the competing information, the elderly may indeed have more difficulty with response competition than the young. The elderly show more interference effects in the Stroop task, which has been attributed to response competition. This implies that both the young and the elderly process this irrelevant information, even though they are not required to do so.

The third hypothesis of this study concerned possible increased response inhibition in the elderly. Response inhibition is interpreted by Eriksen and Eriksen (1974) as a suppression or withholding of responses until the precise location of the target can be ascertained. This concept is similar to Eisdorfer's (1968) concept of response suppression in elderly people, which attributes poorer performance in paced tasks to performance rather than learning deficits. Likewise, elderly people have been reported to be more conservative in reporting auditory signals in a signal detection task (Rees & Botwinick, 1971). In the present study the elderly showed more response

inhibition than did the young. Interpretation of this effect, however, should be conservative because of the potential confounding of the effects of practice with response inhibition. Although there was no significant differential practice effect between young and elderly, a trend of greater practice effects in the elderly exists and is confounded with this effect.

This same qualification applies in the interpretation of the response inhibition effect between the sexes, even though there was no significant differential practice effect for men and women. That women show more response inhibition is generally congruent with the concept of field dependence. It has been widely reported that women are more field dependent than men, at least in young adult groups (Schwartz & Karp, 1967). The concept of field dependence is taken from tasks such as the Rod and Frame Test, Body Adjustment Test, and Embedded Figures Task. In each case it represents an inability to extract relevant information from the context in which it is embedded. This definition would lead to a prediction of greater effects of perceptual noise in women, but this effect was not found. Instead, women showed greater response inhibition; that is, they were differentially slower on no-noise mixed trials than on no-noise pure trials. In the mixed blocks, the no-noise trials did not provide the expected noise items. Instead,

only a single letter appeared. This may have produced a distraction that slowed responding. Persons less field dependent might be less distracted by the lack of noise items.

The present non-search paradigm does not appear to have been used previously with older subjects. Therefore there are no previous studies of this type against which to compare the results. Because of this it was considered important to replicate the effects observed by Eriksen in younger subjects. Eriksen has reported effects of noise (Eriksen & Hoffman, 1972a, 1972b; Colegate, Hoffman, & Eriksen, 1973; Eriksen & Hoffman, 1973; Eriksen & Eriksen, 1974), response competition (Eriksen & Hoffman, 1973; Eriksen & Eriksen, 1974), and response inhibition (Eriksen & Eriksen, 1974). The results observed in the present study did replicate those found in Eriksen's laboratory.

This replication is particularly noteworthy in light of one major difference between the Eriksen studies and the present one. Eriksen's designs generally involve using few (about four) subjects for several experimental sessions. Larger sample sizes than this were required here to study age and sex differences in these effects. Also, due to easy fatigue of the elderly, extended or repeated sessions are not practical in any aged group. For these reasons, in the present study, forty subjects were tested for a

single session. The replication of Eriksen's work with the young group in the present study lends credibility to the present methodology as well as extending Eriksen's findings.

To summarize, there seems to be no age difference in the effects of perceptual noise, although both young and elderly groups showed response slowing in the presence of perceptual noise. The age-related declines in tasks discussed by Layton (1975) can be attributed to difficulty discriminating or labeling irrelevant and relevant items, instead of difficulty ignoring irrelevant information. The present task did not require processing of the irrelevant stimuli, and no age differences were apparent.

Age and Sex differences were both found in response inhibition. However, this design does not seem to be a good test of response inhibition, since any differential practice effect is confounded with this measure.

The young subjects showed more response competition in this task than did the elderly. This could be the result of a strategy or processing difference. The young may responding on the basis of feature-cues, a strategy which allows them to respond quickly and accurately to the target item in most noise conditions. However, in the different-response noise condition, where the feature cues of the noise items are of the opposite response set, the feature-cue strategy produces response competition. The elderly

subjects may avoid the competition by not relying as much on feature cues. This strategy is less efficient overall, and may reflect the inability of the elderly to utilize the inherent structure within a task.

Several questions have been raised by the present study.

1. What are the task or stimulus conditions that produce response competition?

2. Are the elderly more distracted by a background similar to the target? This could be tested by having subjects vocalize targets in several different backgrounds.

3. Is the young group's susceptibility to response competition in this study due to reliance on feature cues? This could be tested with a paradigm similar to the present one with the letters in each response set not resembling each other, e.g., K-S, H-C. This would eliminate the advantage of the feature-cue strategy, and therefore would be predicted to reduce response competition in the young group, but have little effect on the performance of the elderly.

4. How long does it take the elderly to process the location of the target? This could be tested by varying the delay between the onset of the target indicator and the onset of the display.

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APPENDIX

TABLE 11

RAW DATA AND MEANS (LAST HALF)

Elderly

Women

	DR	NR	SR	NNM	NNP
	647	652	632	643	562
	720	739	719	706	633
	756	753	776	764	670
	717	723	739	722	656
	722	685	679	667	610
	598	585	598	574	525
	656	650	647	631	579
	535	529	530	518	489
	702	693	662	694	634
	687	697	685	656	622
$\bar{X}$	674.0	670.6	666.7	657.5	598.0

Men

	DR	NR	SR	NNM	NNP
	636	646	630	615	577
	552	535	542	529	517
	778	735	772	744	698
	652	640	633	631	586
	739	670	677	675	620
	706	700	692	714	654
	724	742	734	688	634
	742	723	726	707	604
	677	649	625	606	592
	529	548	545	519	502
$\bar{X}$	673.5	658.8	657.6	642.8	598.4

TABLE 11--Continued

Young

Women

	DR	NR	SR	NNM	NNP
	534	517	523	519	485
	549	530	531	518	460
	506	483	500	490	438
	581	540	516	536	502
	615	604	607	591	516
	468	459	459	453	458
	633	616	593	612	525
	669	667	670	661	564
	574	568	550	532	502
	645	630	616	615	554
$\bar{X}$	557.4	561.4	556.5	552.7	500.4

Men

	DR	NR	SR	NNM	NNP
	521	503	494	494	476
	568	544	552	546	518
	576	548	536	533	505
	551	546	539	535	486
	577	565	548	534	498
	470	459	446	436	421
	606	597	583	577	535
	553	537	529	527	510
	672	656	661	633	599
	556	514	521	500	474
$\bar{X}$	565.0	546.9	540.9	531.5	502.2

TABLE 12

RAW DATA AND MEANS (OVERALL)

Elderly

Women

DR	NR	SR	NNM	NNP	Age
685	680	659	677	562	76
764	775	746	749	633	68
831	852	853	810	670	73
765	771	784	776	656	78
780	742	736	719	610	75
650	651	632	618	525	80
695	692	689	667	579	67
559	555	551	541	489	68
731	717	704	717	634	73
736	743	724	694	622	62
$\bar{X}$ 719.6	717.8	707.8	696.8	598	72.0

Men

DR	NR	SR	NNM	NNP	Age
686	682	682	668	577	75
560	550	555	545	517	79
808	774	805	767	698	73
689	684	689	670	586	76
780	719	725	703	620	60
751	749	747	760	654	69
780	775	791	740	634	63
778	787	773	769	604	82
725	678	663	670	592	76
559	562	563	542	502	78
711.6	696.0	699.3	683.4	598.4	73.1

TABLE 12--Continued

Young

Women

	DR	NR	SR	NNM	NNP	Age
	556	540	532	533	485	19
	582	562	552	543	460	19
	540	528	532	526	438	20
	596	574	551	564	502	18
	653	642	633	622	516	18
	505	496	498	482	458	20
	663	646	633	634	525	19
	715	709	703	702	564	20
	613	608	590	577	502	18
	702	684	658	653	554	23
$\bar{X}$	612.5	598.9	588.2	583.6	500.4	19.4

Men

	DR	NR	SR	NNM	NNP	Age
	555	528	532	522	476	19
	589	570	571	568	618	19
	609	571	578	561	505	19
	595	585	572	563	486	25
	617	590	574	570	498	21
	498	466	484	476	421	20
	688	692	685	650	535	24
	603	583	581	577	510	18
	732	621	717	690	599	19
	591	550	545	535	474	19
$\bar{X}$	607.7	575.6	583.9	571.2	502.2	20.3